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BACK TO THE BASICS: WHAT DOES THE MARKET TELL US ABOUT HARVEST GRAIN BASIS

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BACK TO THE BASICS: WHAT DOES THE MARKET TELL US ABOUT
HARVEST GRAIN BASIS

A Thesis
Presented to
the Graduate School of
Clemson University

In Partial Fulfillment
of the Requirements for the Degree
Master of Science
Applied Economics and Statistics

by
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Accepted by:
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ABSTRACT

Grain marketing in the United States is a complex system; therefore producers require information on grain markets to effectively manage risk. Futures markets provide the mechanism for price risk management based on the national supply and demand signals. However price risk is managed on the local level, therefore the relationship between local cash price and futures price, basis, must be understood.

The market forces which explain grain basis are the cost of storage and the transportation cost. The current body of research in grain basis uses the storage component of basis as the driving force. This approach is applicable to regions where there is a large volume of production in comparison to demand. There are regions where grain production is deficit to demand. In these regions the driving force is hypothesized to be the transportation cost, in accordance with the Law of One Price. South Carolina is an example of a market where the demand for grain is larger than the grain production.

This study hypothesizes that the harvest grain basis for corn, soybeans and wheat in South Carolina is a function of the local market expectations, transportation cost, and national market size. The local market expectation is represented by the implied basis measured in dollars/bushel, which is the cash forward contract less the harvest futures contract. Second the transportation cost is represented by the nearby home heating oil contract in cents/gallon on the NYMEX. Lastly, the log of open interest in the harvest futures contract measures the percent change in national market size.

This study objective is to provide the producer of South Carolina and other grain deficit markets with the tools needed for successful price risk management and to further the current body of research in grain basis behavior and forecasting.

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CHAPTER ONE

INTRODUCTION

The process of grain marketing in the United States is a complex system of production, storage, transportation, and demand. The use of futures markets in grain marketing provides the mechanism for price discovery and price risk management for the commodities they represent.

The current futures market system is the result of several evolutions in grain marketing. Illinois farmers in the mid-19th century wanted to market their grain in Chicago; however, deferred delivery became necessary because the Illinois River was not navigable, due to freezing conditions, in the months following harvest. As a result, lenders were not willing to assume the risk of stored grain as collateral for loans. To alleviate this problem, the market needed to create a way to transfer the risk, so contracts were formed between local merchants and Chicago businessman to mitigate the risk for merchants. These forward contracts specified that future delivery would consist of a standard quality product and agreed upon price. Soon, the businessmen realized they could transfer the risk by trading these contracts. This process later evolved into the futures exchanges we see today, for example the Chicago Mercantile Exchange.

The cash forward contract used in today's market is a personalized contract between a buyer and seller tailored to an exact commodity and trading conditions; therefore, this type of contract is currently used at the local level. The varying standards

of cash forward contracts depend upon the specific price, quantity, quality, and delivery date which is unique to each contract. Cash forward contracts also provide a barometer for predicted local supply and demand (Leuthold, et al 1989). Due to the individualized nature of the contracts, neither the buyer nor the seller has the ability to sell the contract to a third party.

A futures contract is “A transferable, legally binding agreement to make or take delivery of a standardized amount of a commodity, or standardized minimum quality grades, during a specific month, under terms and conditions established by the federally designated contract market on which trading is conducted”(Leuthold, et al 1989 p. 394). One of the major benefits of futures contracts is the ability to trade contracts. Futures markets provide a place for buyers and sellers to trade; however, these markets are non-personal; the buyers and sellers have no direct interaction because all transactions are processed by a clearing house that matches the buy (long) positions with the sell (short) positions. Futures contracts are defined by fixed standards. For example, the Chicago Board of Trade corn contract is for 5000 bushels and of No. 2 yellow corn delivered to a specific location. These defined standards allow market participants to actively trade contracts; a seller can become a buyer and vice versa, enabling a participant to freely enter and exit the market. The contracts traded between two parties are legally binding and enforceable; these two characteristics provide insurance against the risk of default.

The challenge a producer has with solely using futures contracts for price discovery and risk management is that future contract prices are a reflection of the national level of supply and demand, while price risk has to be managed on the local

level. Some cash markets exist which are dominant in grain production and therefore closely mirror the national market; for instance, the Midwestern markets are an example. However, there are markets which have a marginal role in the formation of national grain supply; the southeastern markets are examples of this type. Yet producers in these marginal production markets still require tools for price risk management.

The relationship between the national and local grain markets is illustrated by the difference between cash and futures prices, called basis. Basis is described by Paul Peterson et al (2004) as the residual between two prices; for example, cash price less futures price for a particular commodity. Discussing the origination of basis, Manfredo and Sanders (2006) state; “While conventional wisdom suggests that basis is determined at the local market level...” there is some empirical evidence of some interaction between locations within the grain marketing chain. The authors argue that basis is not realized at the local level. Manfredo and Sanders suggest that grain basis at local grain markets is determined further down the supply chain. For example, “Gulf (port) basis shocks cause simultaneous movements in the Memphis basis,” but “basis shocks in Little Rock did not transmit to Memphis” (Manfredo et al 2006 p.6). This example indicates that communication in price discovery for grain is transmitted one direction, downstream, which would hold true with transportations cost and the Law of One Price. Regardless of the origination of the cash price information, the difference between cash and futures price is affected by time, space, and quality.

The component of basis reflecting the time differential between cash and futures prices in grain marketing is represented by the cost of storage. In defining the cost of

storage, Holbrook Working (p.1256) states that the price differential between prices representing two different delivery dates but with the same location reflect the cost of carrying that stock from one point in time to another. Working states that the cost of storage is a function of supply and demand; “if the return for a service is determined freely and competitively, it will carry according to demand and supply conditions”(p.1256). Storage is a market determined cost derived from the interaction of suppliers of storage (i.e. grain elevators) and demanders of storage (i.e. grain producers). Fluctuations in the cost of storage can be derived from the fact that storage is a rival and excludable service; therefore, it is a competitive service. An understanding of the cost of storage would allow a producer to better manage price risk over the course of the marketing year by limiting the cost.

When discussing the storage component of basis, costs vary in the temporal dimension while location and quality remain constant; however, when examining transportation costs, time and quality are held constant and geographical locations are varied. The Law of One Price “guarantees no arbitrage opportunities and is necessary for spatial price efficiency” (McNew 1996 p.1). The Law of One Price holds if the pricing differential between two geographic buying locations differs only by the cost incurred to transfer a commodity from one location to another. An understanding of transportation cost allows a producer to better manage price risk by comparing prices using spatial analysis.

Basis has important implications when using futures for price risk management through hedging. When producers use futures for hedging, they are able to lock in their

selling price by selling a futures contract at the hedge initiation. The target selling price is determined as following:

$$1.1 \quad TP_t = F_{t|k}^T + E(S_t - F_t^T)$$

Where TP_t represents the target price a producer expects to receive at time t (when the hedge is lifted), $F_{t|k}^T$ is the current price of the futures contract maturing at time T , where $T \approx t$, and k describes the week in the calendar year when the hedge is initiated. $E(F_t^T - S_t)$ is the expected difference between cash price, S_t , and futures contract maturing at time T price, F_t^T , at time t .

When producers lift the hedge, they sell the grain in the cash market and buy back the futures contract, releasing the producer from the responsibility of the contract. The realized price, the price the producer receives, for the grain differs from the target price by the difference between the expected basis and realized basis. The utilization of futures for hedging effectively exchanges price risk for basis risk. Therefore, the overall goal of this study is to develop a tool that enables a producer to manage basis risk by accurately predicting harvest basis. Specifically, this study will develop a harvest basis forecasting model, using ordinary least squares, for selected South Carolina locations based on information publically available when a hedge is initiated. The information provided through this study will allow producers the ability understand harvest grain basis, in markets that are based on factors other than storage. Also, this study will use market information that is not traditionally utilized in basis forecasting models.

Literature Review and Conceptual Framework

The need to understand and manage basis risk has resulted in a focus in researching basis and an attempt to create an accurate basis forecasting model. Table 1 shows some of the most relevant studies in explaining basis and basis forecasting. Researchers have been trying to understand and predict the behavior of basis for decades. These previous studies on basis forecasting have focused on using historical averages, components of basis, and new information to predict basis.

The historical average basis model has been a widely used method to predict basis. Dhuyvetter and Kastens (1998) constructed seven models using historical averages; each model adding an additional year of information. The authors concluded that the most accurate basis forecasts for wheat were based on a four year average, while corn and soybean basis forecast utilized a seven year average. Taylor, Dhuyvetter, and Kastens (2004) found a three year moving average worked best for soybeans and wheat and a two year moving average was most suitable for corn basis forecast; though, the authors state that no true “rule of thumb” for commodity basis forecasting. Hauser, Garcia, and Tumblin (1990) used two separate models: a previous year average and a three year average. Hatchet et al (2009) split the marketing year into two parts, thus focusing on a pre-harvest and a storage basis prediction. The optimal historical average for pre-harvest time period the for corn and soybeans was one to two year average; while a four year historical average fit wheat best. Hatchet further suggested that when making the decision on which moving average to use, remember, “When a location or time period does not undergo structural change longer moving averages produce optimal forecast, but

when it appears that a structural change has occurred, the previous year's basis should be used" (Hatchett et al 2009 p.20).

In basis analysis of marginal production markets, the focus should only be on factors that affect either the cash or futures market. Basis is the residual between the two prices, and if both markets are affected, then the impact may cancel out. Grain, by its production characteristics, is dependent on the weather; therefore, weather can be considered one of the dominant influencing factors. For example, a local level issue shows that excessive rain during harvest can impede farmers from getting crops to market. This would cause a delayed supply for the local consumers of grain, in turn causing users to find supply from other unaffected regions. A new market for grain entering the area can also cause a deviation from historical levels; for instance, an ethanol plant increases pricing competition for a short run limited grain supply. Similarly, market conditions on the national level can be affected by the national weather patterns. These weather conditions, however, cover a much larger geographic area and are focused in heavy grain producing regions (i.e. corn belt, wheat belt, etc).

Researchers supplement moving average forecast models with current information based on the elements that affect basis. Proxies for transportation, storage, and other current information are some of the variables used not only in forecasting the change in basis but also in forecasting basis itself. Transportation costs have been accounted for in many ways; most are dependent on the primary mode of transportation in the studied region. Curtis and Kahl (1986) used the U.S. rail rate index for farm products as a variable to explain the cost of importing grain to South Carolina. Jiang and Hayenga

(1997) used the St. Louis barge rate for northeast Iowa to account for grain exporting through the river systems. Similar to transportation cost, storage cost can be quantified in various ways. Jiang and Hayenga (1997) quantified the cost of storage as the prime interest rate times Northeast Iowa corn cash price (reflecting the opportunity cost of stored corn). In an earlier study, Hauser et al (1990) used the futures price spread between two delivery dates; based on Working's theory, "relations between prices for delivery at the two different dates are commonly regarded as depending on the 'cost' of carrying the stocks."(p.1296) Working used the opportunity cost and price spread approach to reflect storage cost. Grain production is not constant throughout a year; therefore, there exists some economic benefit to storage. Convenience yield is the benefit of storage when a processor has a constant supply of grain. To measure convenience yield, Ward and Dasse (1977) used the ratio of current inventory to historical "normal" inventories. Current market information can be a powerful variable for prediction of basis. Taylor, Dhuyvetter, and Kastens (2004) developed a model which predicted how current basis deviates from three year historical average, while Ward and Dasse (1977), in discussing frozen orange juice concentrate, used market liquidity and the possibility of a freeze to account for market activity. Using current information in basis, prediction models allow for the adjustments of real time market changes.

There has been extensive research conducted in the area of basis analysis and forecasting; however, this research has focused primarily on the mid-west and large grain producing regions. This research is powerful information for these markets, but it leaves a deficit for the marginal markets, such as the southeast. These marginal markets have

unique market characteristics; for example, South Carolina is seen as a grain deficit state. According to Piggott et al (2005), the estimated market for grain as animal feed in South Carolina for 2002 was approximately 60 million bushels, while corn and wheat production was 7 to 12 million bushels, which amounted to about one third of the demand for the product. Therefore, it can be hypothesized that most of the locally grown grain is consumed within a short post-harvest window, leaving little in storage. This grain deficit characteristic of the South Carolina market demonstrates why storage based models of basis, commonly utilized in the mid-western markets, would not be appropriate in South Carolina.

Based on the notion that basis is the difference between cash and futures; this study focuses on the factors that affect either the cash or futures prices, but not both.

We assume that the cash price, and underlying factors that affect cash price, represent the local market signal. One of the factors that can affect the local market is local demand, quantified most commonly in animal consuming units, but local demand is limited to data availability. Other local market information may include weather conditions, production to storage ratio (see Jiang and Hayenga, 1997), and deviations in basis from historical averages (see Hatchett et.al., 2009). This study will use the cash forward contract price as a forward measurement for the local market. This contract issues a price for local delivery at harvest, and it is hypothesized that the cash forward bid is an all-inclusive local market signal, accounting for current and future local market conditions.

Open interest of the harvest futures contract was used as a measurement of the market size for the harvest contract. The change in size of the futures market is believed to influence the futures price and not the cash, resulting in a change in the harvest basis. The volume of the harvest contract was considered as a measurement of the market size, but due to correlation issues, open interest was chosen. Also, implied volatility could measure the national market, but this option was eliminated due to the availability of public information.

Another factor that affects the difference between the local and national market is transportation cost. The transportation component of basis is reflected in most studies by the form of transportation the local market utilizes, i.e. rail, river or road. In South Carolina, most modes of transportation between the local and external markets rely on diesel fuel. Therefore, the nearby home heating oil futures (HHO) contract price, which is roughly equivalent to diesel fuel, was hypothesized to reflect transportation cost.

As a result, the conceptual model employed in this study will hypothesize that the changes in South Carolina harvest basis can be explained by the local market factor of implied basis, the national market factor open interest, and the transportation cost.

The knowledge of future values and movements in grain basis enables producers to better manage price risk. Hayenga (2001) states, “the academic world too often focuses on other academics as our primary customers,” leaving the general public attempting to digest complex formulas and variables. The availability and cost of acquiring data to properly reproduce results is a critical element of research that is for public use. In previous literature, independent variables used in regression are costly or

involve complex calculations. From the beginning, this research was conducted with the primary objective of serving the average producer in need of price risk management. A secondary objective is to expand the literature on basis forecasting to include the southeastern markets.

To meet the goal of this study and follow the objectives set forth, ordinary least squares regression was used to analyze various components and variables to aid in predicting harvest basis while utilizing information readily available to the general public at the time a hedge is initiated.

CHAPTER TWO:

DATA and METHODS

This research was developed to aid the producer in price risk management by predicting harvest basis. All variables in this study are based on a weekly average; weekly average is defined as a business week (Monday-Friday). The three main grain crops in South Carolina were chosen, i.e. corn, soybeans and wheat.

Annual harvest basis data was calculated for all South Carolina locations which reported to USDA-AMS. From this database, two locations were chosen for each crop based on the most consistent data sets. For corn, Hamer and Monetta were both processors; for soybeans, Estill and Kershaw both processors; and for wheat, Columbia designated a processor and Hamer a county elevator.

The harvest months (t) were chosen based on the production cycle in the marketing year of these crops in the state. The harvest is defined by a four week time period; for corn, weeks 41-44; for soybeans, weeks 40-43; and for wheat, weeks 21-24 (except Columbia in 2005 where weeks 25-28 were used due to late harvest), as described in Table 2. Once the harvest month for each crop was defined, the harvest futures contract was determined based on the notion that the contract maturity $T \approx t$, but not expiring prior to t : December for corn, October for soybeans, and July for wheat. The futures prices for the three crops were obtained from the Commodity Research Bureau. Daily observations of the high and low futures prices for Chicago Board of Trade harvest

contracts were averaged to determine the average daily futures bid for each crop. From the average daily futures quote, the weekly averages were calculated.

The planning horizon of six months was established based on the producer's ability to better understand crop conditions and potential yield. Also, the availability of the cash forward bid data showed that this was the time period when the producers are hedging price risk at the local level. The months in the planning horizon, like the harvest months, were determined from weeks of the year instead of calendar months, as demonstrated in Table 2.

Average cash and futures prices are used in this study to measure South Carolina harvest grain basis as shown in equation 2.1.

$$2.1 \quad \overline{HB}_t = \overline{S}_t - \overline{F}_t^T$$

The weekly average harvest basis for four week period during harvest month t is \overline{HB}_t for a specific commodity and location. The cash price is represented by \overline{S}_t and the futures price is \overline{F}_t^T with a maturity of time T, for a specific commodity and location. The four weeks of harvest basis observations were then averaged to determine the average harvest basis for the month of harvest for each crop and location.

As previously stated in the conceptual framework, the independent variables were assessed on availability of public information and the applicability toward theory of basis components. In accordance with the conceptual framework, the independent variables were divided into two categories, variables that affect the cash price or local level and variables that affect the futures price or national level.

Then, implied basis of the cash forward to harvest futures was calculated using the weekly average of the cash forward contract less the weekly average of the harvest futures contract.

$$2.2 \quad \overline{IB}_k^T = \overline{CF}_k^t - \overline{F}_k^{T,t}$$

The implied basis, \overline{IB}_k^T , is the average cash forward price for week k, k = week of the year 1...52, at time t less the harvest futures, as defined in equation 2.1. The implied basis was used to reflect the current expectations of the harvest market at the local level.

To account for national market signals, the open interest of the harvest futures contract was utilized as independent variable. This variable was hypothesized to quantify the level of market size and to illustrate supply and demand on the national level. The magnitude of the open interest measurement, however, was much larger in comparison to the other independent variables. Therefore, the log of open interest was calculated. This allowed for a more practical interpretation of regression coefficients.

To account for transportation cost, the weekly average of nearby home heating oil from the NYMEX was calculated from the daily high/low average.

From this analysis, regulated by the availability of public information, a hypothesis was developed based on the measures of harvest grain basis and the factors that affect grain basis, as described above. The hypothesized harvest basis model for South Carolina developed in this study is illustrated in equation 2.3.

$$2.3 \quad HB_k^T = IB_k^T + HHO_k + \text{Log}OI_k^T$$

To examine how the South Carolina harvest grain basis changes from year to year, a first difference model was constructed as described in equation 2.4.

$$2.4 \quad (\overline{HB}_{t,i} - \overline{HB}_{t,i-1}) = (\overline{IB}_{k,i} - \overline{IB}_{k,i-1}) + (\overline{HHO}_{k,i} - \overline{HHO}_{k,i-1}) + (\overline{LogOI}_{k,i} - \overline{LogOI}_{k,i-1})$$

The dependent variable harvest basis is represented by $(\overline{HB}_{t,i} - \overline{HB}_{t,i-1})$, which indicates the difference from marketing year i less harvest basis from marketing year i-1.

The independent variables; implied basis, $(\overline{IB}_{k,i} - \overline{IB}_{k,i-1})$, nearby HHO, $(\overline{HHO}_{k,i} - \overline{HHO}_{k,i-1})$, and the log of open interest, $(\overline{LogOI}_{k,i} - \overline{LogOI}_{k,i-1})$, are calculated as the difference from year i to year i-1 during week k in the marketing year.

A second difference model was constructed to examine how the current year basis deviated from the average of the previous two years, equation 2.9.

$$\text{Equation 2.5} \quad \overline{HB}_{t,i} - \frac{HB_{t,i-1} + HB_{t,i-2}}{2} = \overline{IB}_{k,i} - \frac{IB_{k,i-1} + IB_{k,i-2}}{2} + \overline{HHO}_{k,i} - \frac{HHO_{k,i-1} + HHO_{k,i-2}}{2} + \overline{LogOI}_{k,i} - \frac{LogOI_{k,i-1} + LogOI_{k,i-2}}{2}$$

The dependent variable $\overline{HB}_{t,i} - \frac{HB_{t,i-1} + HB_{t,i-2}}{2}$ measured the difference of observed harvest basis in current year i to the previous two year average. The independent variables; implied basis $\overline{IB}_{t-k,i} - \frac{IB_{i-1} + IB_{i-2}}{2}$, nearby HHO $\overline{HHO}_{t-k,i} - \frac{HHO_{i-1} + HHO_{i-2}}{2}$, and log OI $\overline{LogOI}_{t-k,i} - \frac{LogOI_{i-1} + LogOI_{i-2}}{2}$ measured the difference from marketing year i to the previous two year average at week t-k in the marketing year.

Descriptive Statistics

Table 3 illustrates the descriptive statistics for dependent and independent variables. These statistics were collected for the three grain commodities for the specific study locations for the 2001-2008 marketing years.

Both corn locations suffered from small sample sizes. Hamer had 89 observations and Monetta had 72 observation. The availability of cash and cash forward prices

allowed for a limited study for both locations. The average corn harvest basis at Hamer during the study period was 10.5 cents under; in sharp contrast, the average harvest basis at Monetta was 11.9 cents over. While the magnitude is almost equal, the numerical difference is vast. However, the standard deviations for both locations were almost the same, 9.4 cents for Hamer and 12.8 cents for Monetta. The observed minimum and maximum (-0.280, 0.020) for Hamer illustrates that a producer is more likely receive a weaker basis at this location, while a producer at Monetta will be more likely to receive a stronger basis due to the minimum of 10 cents under and a maximum of 35 cents over. Hamer and Monetta are both listed as processors but are in vastly different areas both geographically and agriculturally. The Hamer location is in Dillon County ranked 9th in the state for 2007 Corn harvested for grain as reported by USDA-NASS. The Monetta location in Saluda County did not rank in 2007. Average implied basis followed the trend of the harvest basis, Hamer -0.090 \$/bushel and Monetta 0.119 \$/bu. The mean nearby HHO for Hamer and Monetta had some variation 1.589 cents/gallon and 1.110 cents/gallon, respectively; the Log OI for Hamer and Monetta was 5.478 % and 5.38% respectively. This small variation in the mean between locations is expected due to the nearby HHO and Log OI which are both national signals. Therefore, it is assumed that the individual location or commodity would have very little effect, and any variation in the mean, standard deviation, or maximum/minimum can be attributed to the number of observations for a given commodity and location.

The sample size for soybeans at Estill was 133 observations while Kershaw had the largest sample size of 177 observations. The mean soybean harvest basis at Estill was

7.7 cents over, and Kershaw was 4.6 cents over; both locations had a strong average harvest basis. Kershaw, however, had a large standard deviation for harvest basis of 13.5 cents/bushel compared to a harvest basis standard deviation of 7.1 cents/bushel at Estill. The harvest basis at Kershaw was as strong as 23 cents over and as weak as 17 cents under. The mean implied basis for Estill was predictably similar to the mean harvest basis at 7.9 cents/bushel; however, the standard deviation of implied basis was much larger, 11.4 cents/bushel. The magnitude of the standard deviation coupled with the difference between the maximum of 26 cents over and minimum of 60 cents under illustrates the variability in the expected implied basis. The mean implied basis at Kershaw was 3.7 cents under which is the opposite direction of the mean harvest basis and therefore contradictory to expectations. Kershaw's implied basis standard deviation was 21.5 cents/bushel while the maximum was 26 cents under and the minimum was 1.94 dollars under. This vast difference in the implied basis shows the gaps between the harvest futures and cash forward contract. Similar to the corn locations, both Estill and Kershaw are both processors and are in different regions of the state. The Estill location is in the Savannah Valley of the state in Hampton County which ranked 12th in state for soybean production in 2007, while the Kershaw location is located in the central region in Kershaw County which in 2007 ranked 24th in the state.

The wheat locations, Columbia and Hamer, had the most consistent sample sizes of 155 and 159 respectively. The average wheat harvest basis for Columbia, listed as a processor, was 22.6 under. The average harvest basis at Hamer, listed as a county elevator, was 60.9 cents under. Both Columbia and Hamer had substantial harvest basis

standard deviations and variation. The standard deviation at Columbia was 41.3 cents/bushel with a harvest basis as strong as 17.6 cents/bushel to as weak as -1.1 dollars/bushel. At Hamer, the harvest basis varied even more, the standard deviation was 60.5 cents/bushel, but the strongest basis was still .27 cents under and the weakest was -2.160. This shows a huge potential difference between the cash and futures markets confirmed in the implied basis. The implied basis variation at Columbia was the strongest at 19 cents over and weakest at 2.50 dollars under, and Hamer the strongest basis was 2.70 dollars over and weakest at 2.50 dollars under. This large variation is hypothesized to be the result of abnormally high commodity prices before the recession of 2008. Unlike corn and soybeans, the wheat locations differ in location definition. The difference in location definition and price signal differences allow for the inference that the Hamer buying location is a middle market for the Columbia processor.

CHAPTER THREE:

RESULTS and DISCUSSION

Annual Harvest Grain Basis Model

The harvest grain basis for South Carolina was hypothesized to be the function of the implied basis, nearby HHO contract, and the log of the open interest of the harvest contract. The following results are from the ordinary least squares analysis for corn, soybeans, and wheat for selected South Carolina locations.

Corn

Estimation results shown in Table 3 indicate that the R^2 was .897 for Hamer; therefore, 89.7% of the variation in harvest basis at Hamer can be explained by the independent variables. The R^2 at Monetta, however, was .333, meaning that only 33.3% of the variation in harvest basis is explained by the independent variables.

The harvest basis for corn at Hamer was affected by the nearby HHO contract and log open interest variables, while the harvest basis at Monetta was affected by the implied basis. The differences in the factors which influence harvest basis between locations suggest that the two markets use different signals to adjust harvest basis.

The implied basis at Monetta was 0.674 dollars/bushel. As previously defined, the implied basis represents the local expectations of the of the harvest time market. The implied basis coefficient indicates that for every dollar/bushel rise in the implied basis, the harvest basis becomes stronger by 0.674 dollars/bushel at Monetta. Further support of the regression estimation the elasticity to the mean result was 0.883%. This suggests

that a one percent increase in the implied basis should translate to a 0.883% increase in the harvest basis. This illustrates that a strong implied basis throughout the marketing year signals an expected strong harvest basis.

The nearby HHO coefficient for Hamer was -0.077 cents/gallon. This means that for every one cent/gallon rise in the nearby HHO contract, the harvest basis will become more negative and weaken by 0.077 dollars/bushel at Hamer. The nearby HHO is the explanatory variable for transportation cost; therefore, the inverse relationship between the harvest basis and nearby HHO is expected. As transportation cost increases, the difference between cash and futures should widen, thus making a negative basis more negative and a positive basis smaller.

The Log Open Interest coefficient was -0.079% at Hamer. The log open interest is used as the measure of the percentage change in size of the national market; therefore, a one percent change in the log of the open interest will translate to the harvest basis becoming weaker by 0.079 dollars/bushel at Hamer. This illustrates that as market participation increases; the harvest basis at Hamer becomes weaker. The weaker basis illustrates the widening difference between cash and futures prices. As a result, it can be hypothesized that increased market participation on the national level widens the difference between cash and futures prices.

Soybeans

The estimation results for soybeans at Estill had an R^2 of .391, indicating that the independent variables explained 39.1% of the variation in the harvest basis. The R^2 at

Kershaw was .391, illustrating the independent variables and explaining 39.1% of the harvest basis.

The harvest basis at Estill was influenced by the implied basis and the log of open interest. Kershaw was also influenced by the implied basis, but unlike Estill, the Kershaw harvest basis was influenced by the nearby HHO contract. This could indicate that the Kershaw harvest basis is more sensitive to the transportation cost.

The implied basis coefficient at Estill was 0.304 dollars/bu. and 0.312 dollars/bu. at Kershaw. The close magnitude of implied basis at both locations implies that both locations have similar market forces influencing cash forward contract price. Also, both coefficients are positive, signaling that a strong cash forward contract will translate into a strong harvest basis.

The nearby HHO coefficient for Kershaw was -0.037 cents/gallon. Similar to the Hamer corn model, the inverse relationship between harvest basis and the cost of transportation, reflected in the HHO price, is expected. A one cent/gallon increase in the cost of transportation will translate to an increase in the harvest basis at Kershaw by 0.037 dollars/bushel in the harvest basis.

The log of open interest coefficient for Estill was -0.058%. Like the Hamer corn model, the log of open interest has an inverse relationship with harvest basis, implying a negative reaction to change in the national market size. According to our results, the harvest basis at Estill will weaken by 0.058 dollars/bushel for every one percent increase in the size of the market.

Wheat

The estimation results in Table 3 for wheat at Columbia had an R^2 of 0.812; therefore, 81.2% of the variation in harvest basis was explained by the independent variables. Hamer reported an R^2 of .909; therefore, 90.9% of the variation in harvest basis was explained by the independent variables.

The implied basis at Columbia was 0.251 dollars/bushel and implied basis at Hamer was 0.580 dollars/bushel. This would estimate that as the implied basis increases by one dollar/bushel, the harvest basis strengthens by 0.251 dollars/bushel at Columbia and 0.580 dollars/bushel at Hamer. The positive implied basis coefficient shows that a strong implied basis should translate into a strong harvest basis. The difference in the magnitude of the implied basis coefficient may be the result of the market definition. The Columbia location is a processor, while the Hamer location is a county elevator.

The nearby HHO coefficient was -.316 cents/gallon and Hamer was -.458 cents/gallon. As the nearby HHO contract increases by one cent/gallon, the harvest basis at Columbia and Hamer will weaken respectively by 0.316 dollars/bushel and 0.458 dollars/bushel. Since the nearby HHO is used as a proxy for transportation cost, this negative relationship is expected. Because Hamer is defined as a county elevator, the response to transportation cost is expected to be higher than a processor's (i.e. Columbia). This is due to Hamer's dependence on transportation to reach the next market in the grain supply chain. However, contradictory to the regression results the elasticity to the mean suggest that a one percent increase in the nearby HHO would translate to a stronger basis

by 1.771% and 0.417 % for Columbia and Hamer wheat respectively. This result requires further investigation.

The log of open interest coefficient at Hamer was 0.295%. A one percent change in the log of open interest would translate into a 0.0295 dollar/bu. stronger basis at Hamer. This difference in magnitude and direction from the corn and soybean models could be attributed to the location definition. The Hamer wheat location is a county elevator market, while all other locations are processors. Therefore, because the log of open interest is representing the changes in the size of the national market, one can determine as market size increases, the harvest basis at Hamer will become stronger.

First Difference Model

The first difference model illustrates the average movement of basis from the previous year to the current year. Another way to view this is the average annual change in basis from year to year.

Corn

Hamer harvest basis had a mean response of -0.033 dollars/bushel and an R^2 of .788. This illustrates that on average, the observed harvest basis at Hamer would change from year i to year $i+1$ by -0.033 dollars/bushel, and the independent variables explained 78.8% of the variation of the first difference in harvest basis. Monetta had a mean response of -0.056 dollars/bushel and an R^2 of 0.355. This illustrates that on average, the observed harvest basis at Monetta would change from year i to year $i+1$ by -0.056

dollars/bushel and the independent variables explained 35.5% of the variation in the first difference harvest basis.

The intercept for the first difference model at Hamer and Monetta was 0.031 dollars/bushel and -0.126 dollars/bushel, respectively. The intercept shows the movement in harvest basis when the independent variables are zero. The Hamer harvest basis would strengthen from year to year by 0.031 dollars/bushel, and the harvest basis at Monetta would weaken by 0.126 dollars/bushel.

The first difference of the harvest basis at Hamer was influenced by the first difference of the nearby HHO contract and the first difference of the log of open interest. The Monetta harvest basis was influenced by the first difference of the implied basis and the first difference of the log of open interest. The first difference of harvest basis at Hamer and Monetta are both influenced by the first difference of the log of the open interest, suggesting the annual percentage change of market size influences the harvest basis at both locations. The first difference in implied basis coefficient for Monetta was 1.272 dollars/bushel. This suggests that for a dollar change of implied basis from year i to year $i+1$, the change in harvest basis from year i to year $i+1$ will be 1.272 dollars/bushel at Monetta. This shows that as implied basis strengthens from year to year, the harvest basis does also.

The nearby HHO first difference coefficient for Hamer was -0.109 cents/gallon. Therefore, for a one dollar change in the nearby HHO price from the previous year, the harvest basis will change by -0.109 dollars/bushel. The harvest basis from year to year

will weaken at Hamer as the nearby HHO contract increases in dollar value. The weaker basis at Hamer reflects the increased cost to the processor.

The first difference of the log of open interest coefficient for Hamer was -0.220 % and for Monetta 0.477 %. This shows that for a one percent increase in the open interest from the same time in the previous year, the harvest basis will weaken at Hamer by 0.220 dollars/bushel and strengthen at Monetta by 0.477 dollars/bushel. The annual movement in harvest basis at Hamer will weaken, and Monetta will strengthen in comparison to the previous year as market size increases from the previous year.

Soybeans

Estill had a mean response of -0.073 dollars and an R^2 of 0.380. This illustrates that on average, the observed harvest basis at Estill would change from year $i-1$ to year i by -0.073 dollars/bushel, and the independent variables explained 38.0% of the variation in the first difference harvest basis. Kershaw had a mean response of 0.046 dollars/bushel and an R^2 of 0.331. This explains that on average, the observed harvest basis at Kershaw would change from year i to year $i+1$ by 0.046 dollars/bushel, and the independent variables explained 33.1% of the variation of the first difference harvest basis.

The intercept for the first difference model at Estill and Kershaw was -0.012 dollars/bushel and 0.065 dollars/bushel, respectively. The intercept shows the predicted movement in harvest basis when the independent variables are zero. The Estill harvest basis would weaken from year to year by 0.012 dollars/bushel, and the harvest basis at Kershaw would strengthen by 0.065 dollars/bushel.

The first difference of the harvest basis at Estill was influenced by the first difference of the implied basis and the first difference of the log of open interest. The Kershaw harvest basis was influenced by the first difference of the implied basis, the first difference of the nearby HHO, and the first difference of the log of open interest. The first difference of harvest basis at Estill and Kershaw are both influenced by the first difference of the implied basis and the first difference of the log of the open interest, but Kershaw was influenced by the first difference of the nearby HHO. This suggests that Kershaw harvest basis will weaken from the previous year as transportation cost increases.

The first difference implied basis value for Estill and Kershaw is respectively 0.255 dollars/bushel and 0.312 dollars/bushel. This means that for a dollar change of implied basis from year $i-1$ to year I , the change in harvest basis from year $i-1$ to year i will be 0.255 dollars/bushel at Estill and 0.312 dollars/bushel at Kershaw. This shows that as implied basis strengthens from year to year, the harvest basis will also.

The nearby HHO first difference coefficient for Kershaw was -0.037 cents/gallon; therefore, for a one dollar change in the nearby HHO contract from the previous year, the harvest basis at Kershaw will weaken by 0.037 dollars/bushel. This is in agreement with the theory that an increase in transportation cost will weaken basis.

The first difference of the log of open interest for Estill was 0.454 % and for Kershaw 0.062%. This shows that for a one unit increase from the previous year in the log of open interest the harvest basis at Estill will strengthen by 0.454 dollars/bushel and at Kershaw the harvest basis will strengthen by 0.062 dollars/bushel from the previous

year. This annual movement in harvest basis at both Estill and Kershaw implies that as market size increases from year to year, the observed harvest basis at both locations will strengthen.

Wheat

Columbia had a mean response of -0.161 dollars/bushel and an R^2 of 0.505. This explains that on average, the observed harvest basis at Columbia would change from year i to year $i+1$ by -0.161 dollars/ bushel, and the independent variables explained 50.5% of the variation in the first difference harvest basis. Hamer had a mean response of -0.258 dollars/bushel and an R^2 of 0.802. This explains that on average, the observed harvest basis at Hamer would change from year i to year $i+1$ by -0.258 dollars/bushel, and the independent variables explained 80.2% of the variation in the first difference harvest basis.

The intercept for the first difference model at Columbia and Hamer was 0.449 dollars/bushel and 0.003 dollars/bushel, respectively. The intercept shows the predicted movement in harvest basis when the independent variables are zero. The Columbia harvest basis would strengthen from year to year by 0.449 dollars/bushel, and the harvest basis at Hamer would strengthen by 0.003 dollars/bushel.

The factors which affect the first difference harvest basis at Columbia and Hamer are the same: the implied basis, the nearby HHO, and the log of open interest. Similar to the harvest basis model, the log of open interest has a positive log of open interest coefficient. This may further illustrate that the reaction to market size may be dependent on the market definition.

The first difference implied basis coefficient for Columbia and Hamer was 0.098 dollars/bushel and 0.547 dollars/bushel, respectively. This indicates that for a dollar change of implied basis from year $i-1$ to year i , the change in harvest basis from year $i-1$ to year i will shift by 0.098 dollars/bushel at Columbia and 0.547 dollars/bushel at Hamer. Columbia and Hamer harvest basis should strengthen in comparison to the previous years' observed harvest basis as implied basis strengthens.

The nearby HHO first difference coefficient for Columbia was -0.408 cents/gallon and for Hamer -0.509 cents/gallon. Therefore, for a one dollar change in the nearby HO contract from the previous year, the harvest basis from the previous year at Columbia will change by -0.408 dollars/bushel, and Hamer will change by -0.509 dollars/bushel from the previous year. The harvest basis at both locations will weaken as nearby HO increases on a yearly trend. This is in agreement with the theory of basis where an increase in transportation cost will weaken basis.

The first difference of the log of open interest coefficient for Columbia was -0.051 % and for Hamer 0.304 %. This shows that for a one unit increase from the previous year in the log of open interest, the harvest basis at Columbia will weaken by 0.051 dollars/bushel, and at Hamer the harvest basis will strengthen by 0.304 dollars/bushel from the previous year. This annual movement in harvest basis at Columbia implies that as futures market size increases from year to year, the observed harvest basis will weaken. Hamer will, however, experience a stronger basis as market participation increases from year to year.

Second Difference Model

The second difference model is the average movement of the harvest basis from the previous two year average. Similar to previous studies which use the historical average incorporating current information, this estimation illustrates how the independent variables influence the deviation of the harvest basis from the two year average.

Corn

Hamer harvest basis mean response was -0.053 dollars/bushel and an R^2 of 0.505. On average, the harvest basis should change from the previous two year average by -0.053 dollars/bushel, and the independent variables explain 50.5% of the variation in the second difference harvest basis. Monetta had a mean response of -0.008 dollars/bushel and R^2 of 0.469. On average, observed harvest basis would have an expected change of -0.008 dollars/bushel from the previous two year average, and the independent variables explain 46.9% of the variation in the second difference harvest basis.

The second difference intercept at Hamer was 0.022 dollars/bushel and 0.031 dollars/bushel at Monetta. This illustrates that the harvest basis at both Hamer and Monetta should strengthen from the previous two year average when the independent variables are zero.

The independent variables which effect the harvest basis deviation at Hamer were the nearby HHO and the log of the open interest. For Monetta, the variables were the implied difference and the log of open interest. The absence of the nearby HHO at Monetta was consistent with the previous two models, implying the limited role the transportation cost plays in this market.

The second difference implied basis coefficient was 0.878 dollars/bushel at Monetta. Therefore, as the implied basis becomes stronger, relative to the previous two year average, the harvest basis will become stronger, relative to the two year average.

The nearby HHO second difference coefficient at Hamer was -0.137 cents/gallon and for Monetta -0.172 cents/gallon. This shows that when the nearby HHO contracts moves by one cent/gallon, the harvest basis will weaken from the previous two year average at Hamer by 0.137 dollars/bushel and at Monetta 0.172 dollars/bushel. This illustrates that as the cost of transportation increases from the previous two year average, the harvest basis will weaken at both locations by about the same magnitude.

The second difference log of open interest coefficient for Hamer was -0.262% and for Monetta 0.754%. Therefore, when the log open interest increases by one percent, the harvest basis should weaken from the previous two year average at Hamer by 0.262 dollars/bushel and strengthen by 0.754 dollars/bushel at Monetta. This shows that the market size has an adverse affect on the harvest basis at Hamer location, but market size strengthens the harvest basis at Monetta. The opposite reaction to market size between locations may derive from differing market forces due to geographical differences.

Soybeans

Estill harvest basis mean response was -0.029 dollars/bushel and an R^2 of 0.459. Therefore, the average harvest basis should change from the previous two year average by -0.029 dollars/bushel, and the independent variables explain 45.9% of the variation of the second difference harvest basis. Kershaw harvest basis mean response was -0.009 dollars/bushel and an R^2 of 0.259. Therefore, on average, the observed harvest basis

would have an expected change of -0.009 dollars/bushel from the previous two year average, and the independent variables explain 25.9% of the variation in the second difference harvest basis.

The second difference intercept at Estill was -0.044. This illustrates that the harvest basis at Estill should weaken from the previous two year average when the independent variables are zero.

The factors which affect the second difference harvest basis at Estill and Kershaw were the same, the implied basis and the nearby HHO. The effect of the implied basis is consistent with the previous models.

The second difference implied basis coefficients were 0.464 dollars/bushels and 0.268 dollars/bushel for Estill and Kershaw, respectively. As a result, when implied basis changes by one dollar, the harvest basis will change from the previous two averages at Estill by 0.464 dollars/bushels and at Kershaw by 0.268 dollars/bushel, illustrating that as the implied basis strengthens; the harvest basis will also strengthen.

The nearby HHO second difference coefficient at Estill was 0.067 cents/gallon and for Kershaw -0.063 cents/gallon. This shows when the nearby HHO contract moves by one dollar, the harvest basis will strengthen from the previous two year average at Estill by 0.067 dollars/bushel and harvest basis will weaken at Kershaw by 0.063 dollars/bushel.

The second difference log of open interest coefficient for Kershaw - 0.040%; therefore; when the log of open interest increases by one percent, the harvest basis should weaken from the previous two year average at Kershaw by 0.040 dollars/bushel. This

illustrates the signals that the Kershaw location receives from the national market size in opposite directions.

Wheat

Columbia harvest basis mean response was -0.225 dollars/bushel and an R^2 of 0.484. On average, the harvest basis should change from the previous two year average by -0.225 dollars/bushel, and the independent variables explain 48.4% of the variation in the harvest basis. Hamer harvest basis mean response was -0.355 dollars/bushel and an R^2 of 0.830. On average, observed harvest basis would have an expected change of -0.355 dollars/bushel from the previous two year average, and the independent variables explain 83.0% of the variation in the harvest basis.

The wheat second difference harvest basis was consistent with the previous two models. The independent variables which effect harvest basis at Columbia and Hamer were implied basis, nearby HHO, and log of open interest.

The second difference implied basis coefficients were 0.148 dollars/bushels and 0.661 dollars/bushel for Columbia and Hamer, respectively. As a result, when implied basis changes by one dollar, the harvest basis will strengthen from the previous two year average at Columbia by 0.148 dollars/bushels and at Hamer by 0.661 dollars/bushel.

The nearby HHO second difference coefficient at Columbia was -0.316 cents/gallon and for Hamer -0.377 cents/gallon. This shows when the nearby HHO contracts move by one dollar, the harvest basis will weaken from the previous two year average at Columbia by 0.316 dollars/bushel and at Hamer 0.377 dollars/bushel. This

illustrates that Columbia and Hamer will be adversely affected by an increase in transportation cost.

The second difference of log open interest coefficient for Columbia was -0.078% and for Hamer 0.186%. Therefore, when the log of open interest increases by one percent, the harvest basis should weaken at Columbia from the previous two year average by 0.078 dollars/bushel and strengthen at Hamer by 0.186 dollars/bushel. This illustrates that market activity will affect Columbia and Hamer in opposite directions. This further strengthens the hypothesis that based on market definition, market size affects markets differently.

Early Planning Horizon

The early planning horizon consisted of the first three months of the planning period.

Corn

Hamer average harvest basis was -0.106 dollars/bushel and for Monetta was .109 dollars/bushel. For the early planning horizon, the expected harvest basis would be 10.6 cents/bushel under for Hamer and 10.9 cents/bushel over for Monetta.

The implied basis value at Monetta was 0.770 dollars/bushel, and this implies that for a dollar increase in implied basis, the harvest basis would strengthen 0.770 dollars/bushel or 77.0 cents/bushel at Monetta. The implied basis coefficient for both locations is positive; therefore, both locations harvest basis will strengthen as implied basis strengthens.

The nearby HHO value was -0.077 cents/gallon at Hamer. This implies that for a dollar increase in the nearby HHO contract, the harvest basis at Hamer would weaken by

0.077 dollars/bushel. The negative value of the nearby HHO follows logic, due to the inverse relationship of the cost transportation and basis. Since the nearby HHO is used as a proxy for transportation cost, as the cost of transportation increases, the basis would weaken.

The log of open interest for Hamer was -0.080%. This implies that for a one percent increase in the log of open interest, the harvest basis would weaken by 0.080 dollars/bushel for Hamer. Since the open interest is the measure of market size, the harvest basis for Hamer would weaken as the market increases in size.

Soybean

Estill harvest basis was 0.078 dollars/bushel and for Kershaw was 0.045 dollars/bushel. For the planning period during the early planning horizon, the expected harvest basis would be 0.078 dollars/bushel under and for Estill and 0.045 dollars/bushel over for Kershaw.

The implied basis coefficient at Estill was 0.108 dollars/bushel and for Kershaw 0.592 dollars/bushel. This implies that for a dollar increase in implied basis, the harvest basis would shift by 0.108 dollars/bushel at Estill and 0.592 dollars/bushel at Kershaw. The implied basis coefficient for both locations is positive; therefore, for both locations, as the implied basis strengthens, the harvest basis will strengthen also.

The log of open interest for Estill was -0.112%. This implies that for a one percent increase in the open interest, the harvest basis would weaken by 0.112 dollars/bushel for Estill. Since the open interest is the measure of market size, harvest basis at Estill will become more negative as the market size increases.

Wheat

The mean harvest basis for Columbia was -0.255 dollars/bushel and for Hamer was -0.655 dollars/bushel. Therefore, for the early planning horizon, the expected harvest basis at Columbia would be 0.255 dollars/bushel under and 0.655 dollars/bushel under for Hamer.

The implied basis coefficient at Columbia was 0.170 dollars/bushel and for Hamer 0.705 dollars/bushel. This implies that for a dollar increase in implied basis, the harvest basis would strengthen by 0.170 dollars/bushel at Columbia and 0.705 dollars/bushel at Hamer. The implied basis coefficient for both locations is positive; therefore, as the implied basis strengthens, the harvest basis should also.

The nearby HHO coefficient was -0.334 dollars/gallon at Columbia and -0.571 cents/gallon at Hamer. This implies that for a dollar increase in the nearby HHO contract, the harvest basis at Columbia would weaken by 0.334 dollars/bushel and by 0.571 dollars/bushel at Hamer. The negative values at both locations follow logic, due to the inverse relationship of the cost transportation and basis. Since the nearby HHO is used as a proxy for transportation cost, as the cost of transportation increases, the basis would weaken.

The log of open interest coefficient for Columbia was -0.297% and for Hamer 0.434%. This implies that for a one percent increase in the log of open interest, the harvest basis would weaken by 0.297 dollars/bushel for Columbia and strengthen at Hamer by 0.515 dollars/bushel. Since the open interest is the measure of market activity,

the harvest basis at Columbia and Hamer would have opposite reaction with additional market participation.

Late Planning Horizon

The late planning horizon consisted of the last two to three months of the planning period. Monetta and Hamer did not provide a large enough data set to allow for proper analysis.

Soybeans

The average harvest basis at Estill was 0.076 and 0.047 at Kershaw. This exhibited roughly the same magnitude and direction of harvest basis as the early planning horizon.

The implied basis coefficient at Estill was 0.605 dollars/bushel and for Kershaw 0.247 dollars/bushel. This implies that for a one dollar increase in implied basis, the harvest basis would strengthen by 0.605 dollars/bushel at Estill and 0.247 dollars/bushel at Kershaw. The implied basis coefficient for both locations is positive; therefore, both locations have a stronger harvest basis and stronger implied basis.

Wheat

The late planning horizon harvest basis mean response for Columbia was -0.243 dollars/bushel and for Hamer -0.654 dollars/bushel. These locations also had similar harvest basis in the early planning horizon.

The implied basis value at Columbia was 0.265 dollars/bushel and for Hamer 0.692 dollars/bushel. This implies that for a one dollar increase in implied basis, the harvest basis would strengthen by 0.146 dollars/bushel at Columbia and 0.692 dollars/bushel at Hamer. The implied basis coefficient for both locations were positive; therefore, both locations illustrate that the when the implied basis strengthens the harvest basis should also.

The nearby HHO coefficient was -0.270 cents/gallon at Columbia and -0.202 cents/gallon at Hamer. This implies that for a one cent increase in the nearby HHO contract, the harvest basis at Columbia would weaken by 0.0270 dollars/bushel and at Hamer by 0.202 dollars/bushel. The negative values at both locations follow logic due to the inverse relationship of the cost transportation and basis. Since the nearby HO is used as a proxy for transportation cost, as the cost of transportation increases, the basis would weaken.

In summary, the overall estimation results demonstrate that the independent variables are useful in explaining the harvest basis. The independent variables explained anywhere from 30.4% to 90.7% of the variation in the harvest basis; 31.3% to 79.7% in the first difference harvest basis and 25.9% to 83.0% of the second difference harvest basis. Furthermore, the direction of the impact of the independent variables on the harvest basis was consistent with expectations, with the exception of Hamer wheat.

CHAPTER FOUR:

SUMMARY and CONCLUSION

This research was developed to aid the producer of South Carolina to develop better understanding and the ability to forecast grain basis. A producer who has the knowledge of future basis movements will be able to more effectively market grain and manage risk. Therefore, the primary objective of this research was to develop a model which could help predict harvest basis for producers in the state of South Carolina, as well as to contribute to the established research in basis forecasting.

Most of the previous grain basis research has primarily focused on the major grain producing regions of the United States. These studies have utilized models based on the cost of storage in explaining and forecasting grain basis (e.g. Jiang and Hayenga, 2004; Hauser, Garcia, and Tumblin, 1990; Siaplay, Anderson, and Brorsen, 2007). Utilizing the theory of storage in basis behavior and forecasting models is applicable to markets where production exceeds use. This is not the case for South Carolina, where use outweighs production. Therefore, this study hypothesized the transportation component, supported by the law of one price, to be the foundation of grain basis in a marginal grain production market. It was hypothesized that increases in transportation cost (represented by the price of the nearby HHO futures contract) will cause the grain basis to weaken because as costs rise, the difference between cash and futures (basis) should become larger; in other words, the level of the cash price relative to the futures will become lower or “weaker”.

Previous research papers have also used historical average and current information to help predict basis (e.g. Dhuyvetter and Kastens,1998; Hauser, Gracia and Tumblin, 1990; Zhang and Houston,2005; Taylor, Dhuyvetter, and Kastens,2004; and Hatchett, Brorsen, and Anderson,2009 ;). These studies utilized some form of current information to reflect fluctuations in basis over time. In this study, we utilize the current information that is forward looking, i.e., the local cash forward contract bid less the harvest futures price. This relationship was defined for this study as implied basis. The implied basis allows a perspective to view current information as a snapshot of how the current market conditions view future market conditions. It was hypothesized that the strong implied basis at the initiation of a hedge would translate to a strong harvest basis.

The determination of grain basis is driven by market forces at both the local and national level. The national market contributes to the formation of the harvest basis through futures price. In addition to futures price of the harvest contract as part of the implied basis as described above, this study investigated whether changes in the size of the futures market measured as log of the open interest of the harvest futures contract affect basis. It was hypothesized that the larger size of the futures market may drive futures prices away from the signals relevant to the cash market, thus weakening the basis.

The hypotheses were tested using data for the three major grain crops: corn, soybeans, and wheat. For the study period 2001-2008, two locations were chosen for each crop: Hamer and Monetta for corn, Estill and Kershaw for soybeans, and Columbia and Hamer for wheat. The main limiting factor for the data in this study was the

availability of cash forward price data points. This limitation, however, should be expected in a grain deficit market due to the seasonal pricing of the cash forward bid.

All data utilized in this research is available to the general public free of cost through the web. The models were estimated separately for each location and commodity using OLS. The hypothesized relationships were analyzed for 1) the levels of harvest basis and independent variables, 2) the changes in harvest basis and independent variables from one year to the next, and 3) the changes in harvest basis and independent variables from the average of the previous two years. The annual harvest grain basis models behaved fairly consistently across commodities and were consistent with expectations.

The nearby HHO was hypothesized to have a negative relationship with annual harvest basis. The estimation results from the first and second difference models further confirmed the hypothesized relationship of transportation cost (nearby HHO) and the harvest basis. The negative impact of an increase in the nearby HHO was found in the following models: corn at Hamer, soybeans at Kershaw, and wheat at Columbia and Hamer. The range of this impact on harvest basis was -0.037 dollars/bushel for soybeans at Kershaw to -0.458 dollars/bushel for wheat at Hamer for a one cent /gallon increase in the nearby HHO. This illustrates the impact of transportation cost increases on the harvest basis for wheat at Hamer will be larger in respect to Kershaw. Also, the magnitude of the impact transportation has on harvest basis was much larger for the wheat locations, Columbia -0.316 cents/gallon and Hamer -0.458 cents/gallon, in comparison to Hamer corn (-0.077cents/gallon) and Kershaw soybeans (-0.037

cents/gallon). This shows the importance of transportation to these markets regardless of market definition. As previously stated, the first and second difference models supported the hypothesis of the negative impact of transportation cost on harvest basis. The second difference model for Estill was the exception. The impact of transportation cost on harvest basis was positive for Estill. This implies that the harvest basis will strengthen as transportation cost increases. Transportation did not have an impact on Estill harvest basis in the annual or first difference model; therefore, this result is likely to be driven by sample size. The hypothesized impact of transportation cost on harvest basis was supported by the estimation results for corn, soybeans, and wheat.

The implied basis was hypothesized to have a positive impact on the harvest basis; a strong implied basis should translate to a strong harvest basis. This hypothesis was supported by the annual model. The implied basis had a positive impact on the harvest basis in the models for Monetta, Estill, Kershaw, Columbia, and Hamer wheat. The impact of the implied basis on harvest basis ranged from 0.251 dollars/bushel at Columbia to 0.675 dollars/bushel at Monetta. Also, the magnitude of implied basis at Hamer was more than double that of Columbia. This is likely the result of market definition; Hamer is a county elevator and Columbia is a processor. The wheat being bought at Hamer could be sold at Columbia, with Hamer playing the role of a middle market. The difference between Columbia and Hamer wheat implied basis widened in the first and second difference models, further supporting this hypothesis.

The impact of the log of open interest on harvest basis was hypothesized to be negative; the larger the futures market in size, the weaker the basis. This hypothesis was

predicated on the concept that as the futures market increases in size, it is driven less by fundamental supply and demand factors. This shift in the national market does not translate to the local market, which is based on local supply and demand forces, thus widening the basis. This was supported in the annual model at Hamer for corn and Estill. The impact of the log of open interest weakened harvest basis at these two locations. The first difference and second difference models supported this hypothesis at Hamer for corn. However, there was one discrepancy in the annual model; the Hamer wheat location had a positive coefficient value. This was also the case in the first and second difference models. This would imply that as the market size increases, the harvest basis will strengthen. This is hypothesized to be the result of the Hamer location; using this signal as speculation of the increase in prices and being a county elevator, a middle market, they react accordingly.

Our analysis of the relationship between harvest basis and independent variables was also conducted for early versus late planning horizon by splitting the planning horizon for each year in half (first three months vs. last three months). This analysis allows for a perspective of changes in relationships across the planning horizon. For example, we found that the implied basis at Estill and Kershaw was significant in the early planning and late planning period. This exhibits the importance of the cash forward bid throughout the planning period. Also, the log of open interest was significant for Columbia and Hamer wheat in the early planning period, but not for the late planning period. This illustrates the role of the national market signals are important early, but

towards harvest, the role is insignificant. Overall, this approach added perspective by viewing the independent variables which affect harvest basis within a marketing year.

A continuation of this research may answer some questions left unanswered. Further research may illustrate why there is a different behavior in the log of open interest at the one county elevator compared to the processors. Identifying additional locations may add information that this study did not focus on. Additional market forces may be identified that follow the principle of information that is free and easily accessible to the public. Expanding the marketing years would further the understanding and forecasting ability of grain basis in the grain deficit markets. Also, to further research the effect the Recession of 2008 had on the forecasting ability of the hypothesized model.

APPENDICES

Appendix A

Previous Research

Table 1. Review of Previous Literature on Grain Basis Forecasting

Paper	Author(s)	Elements	Current Information	Moving Average
Incorporating Current Information into historical average based forecast to improve crop price basis forecast	Taylor, Dhuyvetter and Kastens		Current basis deviates from historical average	3 year for wheat and soybeans 2 year for corn
Optimal Length of Moving Average to use when forecasting Basis	Hatchett, Brorsen and Anderson			4 year for wheat 1-2 year corn and soybeans
A regional comparison of U.S. cotton basis patterns	Seamon, Kahl and Curtis		Seasonal point that basis is measured	
Forecasting Crop Basis: Practical Alternatives	Dhuyvetter and Kastens		Futures spread Time Horizon	4 year for wheat 5-7 year for corn and soybeans
Corn and Soybean basis Behavior and Forecasting: Fundamental and alternative approaches	Jiang and Hayenga	Storage Cost (Prime Interest * Corn Cash) Transportation Cost (St. Louis Barge Rate)	Production to storage ratio Export Volume Grain Consuming Animal Units	Nearby basis
Basis Expectations and Hedging effectiveness	Hauser, Garcia and Tumblin	Implied Storage Cost is price spread between March and May futures	Forward/Futures Price Spread	1-3 year average for soybean
Effects of Price Volatility and Surging South American Soybean Production on Short-Run Soybean Basis Dynamics	Zhang and Houston	Storage Cost (3 and 6 month T-bill)	Stock-to-use ratio	3 year average soybean
Empirical Contributions to Basis Theory: The Case of Citrus Futures	Ward and Dasse	Storage Cost (Convenience Yield)	Market Liquidity Freeze Bias Variables Estimated	
A Comparative Analysis of the Corn Basis in Feed Grain Deficit and Surplus Areas.	Kahl and Curtis	Storage Cost (average monthly cash * 90 day t-bill) Transportation Cost (U.S. Rail Index for farm products)	Estimated Corn Inventory Estimated Soybean Inventory Grain Consuming Animal Units	

Appendix B

Planning Horizon

Table 2. Planning Horizon and Harvest Months for Selected South Carolina Locations, 2001-2008 Marketing Years

Commodity:		Corn	Soybean	Wheat
Horizon	Month		Weeks	
Early Planning Horizon	Month 1	22-25	18-21	1-4
	Month 2	26-29	22-25	5-8
	Month 3	30-33	26-29	9-12
Late Planning Horizon	Month 4	34-37	30-33	13-16
	Month 5	38-40	34-37	17-20
	Month 6		38-40	
Harvest Month		41-44	40-43	21-24 *

* Columbia 2005 harvest period was weeks 25-28 due to assumed late harvest

Appendix C

Descriptive Statistics

Table 3. Annual Harvest Grain Basis Descriptive Statistics for Selected South Carolina Locations, 2001-2008 Marketing Years

Statistic/Variable	Harvest Basis (\$/bu)	Implied Basis (\$/bu)	Nearby HO (cents/gal)	Log OI (%)	Harvest Basis (\$/bu)	Implied Basis (\$/bu)	Nearby HO (cents/gal)	Log OI (%)
Commodity		Corn						
Location	Hamer				Monetta			
Mean	-0.105	-0.090	1.589	5.478	0.091	0.119	1.110	5.380
Std Dev	0.094	0.112	0.961	0.224	0.084	0.128	0.498	0.424
Max	0.020	0.610	3.970	5.790	0.350	0.300	2.050	5.720
Min	-0.280	-0.310	0.640	4.950	-0.100	-0.080	0.640	4.820
Observations	89	89	89	89	72	72	72	72
Commodity		Soybean						
Location	Estill				Kershaw			
Mean	0.077	0.079	1.354	5.200	0.046	-0.037	1.550	5.091
Std Dev	0.071	0.114	0.580	0.239	0.135	0.215	0.905	0.256
Max	0.160	0.260	2.820	5.500	0.230	0.260	3.970	5.500
Min	-0.310	-0.600	0.640	4.500	-0.170	-1.940	0.640	4.500
Observations	133	133	133	133	177	177	177	177
Commodity		Wheat						
Location	Columbia				Hamer			
Mean	-0.250	-0.322	1.401	4.794	-0.653	-0.573	1.393	4.757
Std Dev	0.413	0.594	0.739	0.332	0.605	0.610	0.738	0.506
Max	0.176	0.190	3.640	5.430	-0.270	2.700	3.640	5.430
Min	-1.100	-2.540	0.520	3.800	-2.160	-2.500	0.520	4.830
Observations	155	155	155	158	159	159	158	159

Notes: Implied basis is a weekly average forward contract price less harvest futures (December for corn, November for Soybeans, and July for Wheat) price in \$/bu, Nearby HO is a weekly average price of the nearby home heating oil contract on NYMEX in cents/gallon, and Log Open Interest is the natural logarithm of the weekly average open interest for the harvest futures contract for the respective commodity measured by open contracts. Dependent variable is the harvest time (average of weeks 41-44 for corn, 40-43 for soybeans, and 21-24 (FY 2005 Columbia weeks 25-28) for wheat, basis for the respective commodity in \$/bu. One asterisk (*) denotes significance at the 10% level, two asterisks (**) denote significance at the 5% level, three asterisks (***) denote significance at the 1% level.

Appendix D

Elasticity at the Mean

Table 4. Elasticity at the Mean Results for Annual Harvest Grain Basis Forecasting Model for Selected South Carolina Locations, 2001-2008 Marketing Years.

Commodity Statistic\ Location	Corn		Soybean		Wheat	
	Hamer	Monetta	Estill	Kershaw	Columbia	Hamer
Implied Basis	0.011	0.883	0.312	-0.251	0.323	0.509
Nearby HHO	1.162	-0.903	-0.204	-0.003	1.771	0.417
Log Open Interest	4.116	1.419	-3.930	0.015	0.537	-0.916

Appendix E

Estimation Results

Table 5. Annual Harvest Grain Basis Forecasting Model for Selected South Carolina Locations, 2001-2008 Marketing Years.

Commodity Statistic\ Location	Corn		Soybean		Wheat	
	Hamer	Monetta	Estill	Kershaw	Columbia	Hamer
Intercept	0.450 ***	0.010	0.365 ***	-0.201	0.412	-1.085 ***
Implied Basis	0.013	0.675 ***	0.304 ***	0.312 ***	0.251 ***	0.580 ***
Nearby HO	-0.077 ***	-0.074	-0.012	-0.037 **	-0.316 ***	-0.458 ***
Log Open Interest	-0.079 **	0.024	-0.058 **	0.062	-0.028	0.295 ***
R-squared	0.897	0.333	0.391	0.391	0.812	0.909
Adjusted R-squared	0.893	0.304	0.377	0.380	0.808	0.907
Number of observations	89	72	133	177	155	158

Notes: Implied basis is a weekly average forward contract price less harvest futures (December for corn, November for Soybeans, and July for Wheat) price in \$/bu, Nearby HO is a weekly average price of the nearby home heating oil contract on NYMEX in cents/gallon, and Log Open Interest is the natural logarithm of the weekly average open interest for the harvest futures contract for the respective commodity measured by open contracts. Dependent variable is the harvest time (average of weeks 41-44 for corn, 40-43 for soybeans, and 21-24 (FY 2005 Columbia weeks 25-28) for wheat, basis for the respective commodity in \$/bu. One asterisk (*) denotes significance at the 10% level, two asterisks (**) denote significance at the 5% level, three asterisks (***) denote significance at the 1% level.

Appendix E (cont.)

Table 6. First Difference Model Annual Harvest Grain Basis Forecasting Model for Selected South Carolina Locations, 2001-2008 Marketing Years.

Commodity Statistic\ Location	Corn		Soybean		Wheat	
	Hamer	Monetta	Estill	Kershaw	Columbia	Hamer
Intercept	0.031 ***	-0.126 ***	-0.012 ***	0.065 ***	0.449 ***	0.003
1st Difference Implied Basis	0.001	1.273 ***	0.255 ***	0.284 ***	0.098 ***	0.547 ***
1st Difference Nearby HHO	-0.109 ***	0.145	0.030	-0.100 ***	-0.408 ***	-0.509 ***
1st Difference Open Interest	-0.221 ***	0.477 **	0.454 ***	-0.224 ***	-0.051 ***	0.304 ***
R-squared	0.788	0.355	0.380	0.331	0.505	0.802
Adjusted R-squared	0.778	0.313	0.362	0.317	0.494	0.797
Number of observations	70	50	107	154	136	139

Notes: Implied basis is a weekly average forward contract price less harvest futures (December for corn, November for Soybeans, and July for Wheat) price for year t less the average for year (t-1) in \$/bu, Nearby HHO is a weekly average price of the nearby home heating oil contract on NYMEX for year t less the average for year (t-1) in cents/gallon, and Log Open Interest is the natural logarithm of the weekly average open interest for the harvest futures contract for the respective commodity(December for corn, November for soybeans, and July for Wheat) for year t less the average for year (t-1) for open contracts. Dependent variable is the harvest time (average of weeks 41-44 for corn, 40-43 for soybeans, and 21-24 (FY 2005 Columbia weeks 25-28) for wheat, basis for the respective commodity for year t less the average for year (t-1) in \$/bu. One asterisk (*) denotes significance at the 10% level, two asterisks (**) denote significance at the 5% level, three asterisks (***) denote significance at the 1% level.

Appendix E (cont.)

Table 7. Second Difference Model Annual Harvest Grain Basis Forecasting Model for Selected South Carolina Locations, 2001-2008 Marketing Years.

Commodity Statistic\ Location	Corn		Soybean		Wheat	
	Hamer	Monetta	Estill	Kershaw	Columbia	Hamer
Intercept	0.022 *	0.031 **	-0.044 ***	0.041	0.707 ***	0.002
2nd Difference Implied Basis	0.005	0.877 ***	0.464 ***	0.268 ***	0.148 ***	0.661 ***
2nd Difference Nearby HHO	-0.137 ***	-0.172	0.067 ***	-0.063 *	-0.316 ***	-0.377 ***
2nd Difference Open Interest	-0.262 ***	0.754 **	0.019	-0.040	-0.078 ***	0.186 **
R-squared	0.532	0.514	0.479	0.277	0.497	0.834
Adjusted R-squared	0.505	0.469	0.459	0.259	0.484	0.830
Number of observations	56	37	82	124	116	119

Notes: Implied basis is a weekly average forward contract price less harvest futures (December for corn, November for Soybeans, and July for Wheat) price for year t less the average for the previous two years in \$/bu, Nearby HHO is a weekly average price of the nearby home heating oil contract on NYMEX for year t less the average for the previous two years in cents/gallon, and Log Open Interest is the natural logarithm of the weekly average open interest for the harvest futures contract for the respective commodity(December for corn, November for soybeans, and July for Wheat)for year t less the average for the previous two years in open contracts. Dependent variable is the harvest time (average of weeks 41-44 for corn, 40-43 for soybeans, and 21-24 (FY 2005 Columbia weeks 25-28) for wheat, basis for the respective commodityfor year t less the average for the previous two years in \$/bu. One asterisk (*) denotes significance at the 10% level, two asterisks (**) denote significance at the 5% level, three asterisks (***) denote significance at the 1% level.

Appendix E (cont.)

Table 8. Planning Horizon (Early -First Three Months , Late - Last Two/Three Months of Planning Period) Annual Harvest Grain Basis Forecasting Model for Selected South Carolina Locations, 2001-2008 Marketing Years.

Statistic\ Location	Corn		Soybean		Wheat	
	Hamer	Monetta	Estill	Kershaw	Columbia	Hamer
Intercept	0.454 ***	0.226	0.632 ***	0.076	1.630 ***	-1.500 ***
Implied Basis	0.005	0.770 ***	0.108 *	0.592 ***	0.170 **	0.705 ***
Nearby HHO	-0.077 ***	-0.041	-0.003	-0.014	-0.334 ***	-0.571 ***
Log Open Interest	-0.080 ***	-0.027	-0.112 **	0.001	-0.300 ***	0.434 ***
R-squared	0.898	0.361	0.263	0.558	0.831	0.909
Adjusted R-squared	0.895	0.329	0.228	0.542	0.825	0.905
Number of observations	87	64	67	90	92	94
Intercept	na	na	0.200	-0.433	0.204	-0.130
Implied Basis	na	na	0.605 ***	0.247 ***	0.265 ***	0.692 ***
Nearby HHO	na	na	0.020	-0.033	-0.270 ***	-0.202 ***
Log Open Interest	na	na	-0.038	0.105	0.008	0.042
R-squared	na	na	0.715	0.320	0.836	0.983
Adjusted R-squared	na	na	0.702	0.296	0.828	0.983
Number of observations	na	na	66	87	63	64

Notes: Implied basis is a weekly average forward contract price less harvest futures (December for corn, November for Soybeans, and July for Wheat) price for the respective planning horizon, Nearby HHO is a weekly average price (cents per gallon) of the nearby home heating oil contract on NYMEX for the respective planning horizon, and Log Open Interest is the natural logarithm of the weekly average open interest for the harvest futures contract for the respective commodity(December for corn, November for soybeans, and July for Wheat)for the respective planning horizon. Dependent variable is the harvest time (average of weeks 41-44 for corn, 40-43 for soybeans, and 21-24 (FY 2005 Columbia weeks 25-28) for wheat, basis for the respective commodity for the respective planning horizon. One asterisk (*) denotes significance at the 10% level, two asterisks (**) denote significance at the 5% level, three asterisks (***) denote significance at the 1% level.

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