VSR PERFORMANCE IN THE CHICAGO WHEAT FUTURES CONTRACT

by

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ABSTRACT

The Chicago wheat futures contract has received attention in recent years regarding non-convergence with SRW wheat cash prices. In 2009 the CME Group announced their decision to implement a market based mechanism to set daily storage rates at registered delivery locations for the Chicago wheat contract. The new market based mechanism is a variable storage rate (VSR) that monitors Chicago wheat futures spreads relative to financial full carry. The running average of the futures spread at the end of the contract observation period determines future changes to existing storage rates.

The objective of this study is to determine whether or not the adoption of VSR mechanisms has had an impact on SRW wheat basis convergence in the Toledo, OH switching district. The Chicago wheat contract months that were studied using OLS regression models include July 2010, September 2010, December 2010, and March 2011. A final OLS regression model examining the cumulative data collected from these four contract months concludes the research. The explanatory variables used to study SRW wheat basis convergence in Toledo includes days to delivery, all wheat ending stocks as a percentage of use for the United States, and VSR. In two of the regression models for the contract months studied VSR found to have a statistically significant impact, i.e., the December 2010 and March 2011 models. In the cumulative regression model covering all four wheat contract months VSR was also found to have a statistically significant impact on SRW wheat basis convergence. The regression models in this analysis appear to contain some degree of multicollinearity, a statistical condition in which the explanatory variables tend to move

collinearly or “together” with each other. Multicollinearity oftentimes can result in deceptively high and inconsistent statistical results in econometric models.

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CHAPTER I: INTRODUCTION

The Chicago wheat futures contract is considered by many agribusiness professionals to be the benchmark exchange for global wheat trade. For several years this contract has been criticized by industry members for being what they consider to be a dysfunctional commodity futures contract. In terms of volume, Chicago wheat is the most heavily traded when compared to wheat contracts on the Kansas City Board of Trade and Minneapolis Grain Exchange. The importance of having a properly functioning Chicago wheat contract is essential for those businesses that manage cash wheat positions against the Chicago wheat contract because of their reliance on contract hedging effectiveness. There are six classes of wheat grown in the United States with only three classes that produce significant volume. Of these three major wheat classes, Soft Red Winter (SRW) wheat comprises only 20% of annual domestic production yet is primarily hedged and traded both in the U.S. and globally on the CBOT (Gensler 2009). This distortion is one argument that has fueled the widely publicized debate regarding recent convergence problems in SRW wheat cash prices and the CBOT wheat contract. Whether or not this distortion of cash wheat trading versus futures trading is a cause of contract malfunction, the importance of the Chicago wheat contract for price discovery in the global wheat market should not be taken lightly.

Convergence can be defined in this context as when wheat futures converge with local cash prices to near parity taking into account location differentials at specified delivery points as contract expiration approaches. Recent convergence problems have caused many market participants to discredit hedging effectiveness in the Chicago contract. Convergence issues have also led many industry members to question the effectiveness of the Chicago wheat contract delivery system and its use as a price discovery mechanism. Convergence problems in the Chicago contract have fueled hearings in the U.S. Congress to explore potential causes and solutions. While these issues surrounding SRW wheat convergence are not inclusive of all problems in the Chicago wheat contract, they establish the depth and complexity of wheat convergence issues. Although debate still exists as to the underlying causes of convergence issues, changes have been made in the Chicago contract to help convergence occur. In their most recent attempt to correct the lack of SRW wheat convergence, the Chicago Mercantile Exchange (CME), who is the parent company of the CBOT, implemented new provisions in an attempt to force convergence through the use of a variable storage rate (VSR). Although implemented less than one year, the VSR is widely thought to have changed the complexity and market structure of futures spreads and the role of the delivery system as the necessary link between the cash and futures market.

The objective of this research is to determine whether VSR has had a positive effect on convergence in the Toledo, OH switching district since its inception beginning with the July 2010 contract. This research will specifically examine four consecutive contract months in the Chicago wheat contract beginning with July 2010. With VSR as the first explanatory variable in this study, additional explanatory variables including days to delivery and all U.S. wheat ending stocks as a percentage of use will be incorporated in the analysis to attempt to explain the range of factors influencing SRW wheat convergence. With VSR still in its infancy, this research will aide in development of preliminary conclusions regarding VSR effectiveness on convergence.

CHAPTER II: LITERATURE REVIEW

There are few pieces of economic research directly related to convergence issues in the Chicago wheat contract. The research that is available has been conducted by a select few industry experts. The reason why only a limited amount of economic research is available on the subject is because of the complexity and dynamics of futures spreads, the delivery system, and the SRW wheat cash market. Problems identified with poor convergence in SRW wheat and the Chicago wheat contract have been ongoing, but only in the past three years have industry participants proactively sought to correct the problem. In a December 4, 2009 press release, the CME Group announced that several changes were to be made to the Chicago wheat contract which "are designed to improve convergence between wheat futures and cash prices at contract expiration" (CME Group 2009). The changes to be implemented beginning with the July 2009 wheat contract included:

- Increased storage rates from July 18 to December 17 each year. The new CBOT storage rate during this period would increase to $0.08 per bushel. During the remainder of the year, storage rates would remain at $0.05 per bushel.

- The addition of three new delivery territories against the CBOT wheat contract. These new delivery territories include shuttle loading facilities in a 12-county area of Northwest Ohio, barge loading facilities on the Ohio River from Cincinnati to the Mississippi River, and barge loading facilities on the Mississippi River from St. Louis to Memphis.

- Lowering the vomitoxin level for delivery at par at the respective delivery location from 3 parts per million (PPM) to 2 PPM. Wheat containing a level of 3 PPM vomitoxin would be deliverable at a $0.12 discount and wheat containing a level of 4 PPM vomitoxin would be deliverable at a $0.24 discount. The new vomitoxin requirements would take effect beginning with the September 2011 contract.

Perhaps the most aggressive change to the wheat contract in the CME announcement on December 4, 2009 was the addition of new delivery points against the Chicago wheat contract. In a 1981 article published by the Food Research Institute Studies, Roger Gray and Anne Peck warn of the inherent dangers in what was then considered a flawed wheat contract. At the time, Chicago, IL was the only delivery point for Chicago wheat futures. In an attempt to keep the wheat contract fluid and functioning properly, Gray and Peck recommended additional delivery points be added to the contract so that a proper representation of the flow of grain would keep the cash market and futures market coupled, or converged (Gray and Peck 1981). Although this article may be considered outdated given the dynamics of current convergence issues, the same principles regarding the importance of proper location of delivery points to better represent the natural flow of grain appears to still hold credibility as is in evidence by the changes made by the CME Group in December, 2009.

The changes implemented in December 2009 were the first major changes to the wheat contract in recent history but they would not be the last. It was clear to market participants that these recently proposed changes would not be enough to correct convergence issues. In a March 2009 Marketing and Outlook Research Report, Irwin et al., discuss poor convergence performance in corn, soybean, and wheat futures contracts. The article concludes that although the storage rates for CBOT corn and soybean contracts appear to be set correctly, "major" changes must be implemented in the CBOT wheat contract to correct convergence issues. The authors attribute two primary reasons for a lack of convergence in the wheat contract. The first reason cited is the existence of wide futures spreads between lead and the first deferred contracts, representing a high percentage of full carry. These wide futures spreads are a signal to commercial hedgers to "carry" grain rather than sell into the cash market. Structural issues related to the wheat contract are the second set of factors to which lack of convergence is attributed (S. H. Irwin, P. Garcia and L. D. Good, et al. March 2009). The authors do not define structural issues but infer that a possible cause of non-convergence is because of incorrectly designated delivery points. The authors address the reason why spreads trade at a high percentage of full carry. The primary factor is because of low storage rates set by the CME, and through surveys with commercial grain storage companies they concluded that a consensus exists that wheat storage rates are too low. Secondly, increased money flows into the commodity sector as an investment alternative have artificially inflated the value of wheat. As contract expiration approaches, long-only index funds sell their position in the nearby contract and repurchase the deferred contract, causing the futures spread to widen. They conclude with a possible solution, which is to increase the maximum storage rate charged by delivery locations. By increasing the maximum storage rate that can be charged to holders of certificates, a disincentive exists for them to own wheat contracts because of higher storage rates and wider futures spreads. The authors conclude that this would eventually drive any traders who are not hedging against a cash position out of the market.

In a letter written to the Chairman of the Commodity Futures Trading Commission dated November 8, 2010, by Scott Irwin, Chairman of Agricultural Marketing at the University of Illinois and Aaron Smith, Associate Professor at the University of California, Davis, it was argued that holders (longs) of delivery certificates are not motivated to take delivery of the physical commodity because a "wedge" exists from the difference in marginal costs incurred with storage of the physical commodity and the marginal costs of carrying shipping certificates. Irwin and Smith indicate that this "wedge" in wheat carrying costs exists for two reasons. The first is because storage costs associated with holding shipping certificates is less than storage costs in the physical market. Second, interest costs, or the cost of capital, differ from those of the buyer (long) and those of the seller (short). More specifically, Irwin and Smith argue that interest rates tend to be lower for grain merchants such as elevators than for commodity speculators. If any of these scenarios occur, holders of certificates will stand for physical delivery (Irwin and Smith, Commodity Futures Trading Commission 2010).

In a September 2010 paper authored again by Irwin et al., the authors further examined the roll of index fund participation in the commodity market in an attempt to explain spreads and non-convergence in wheat futures. Their study focused on index funds and if their participation in the commodity markets inflated futures prices and widened futures spreads. Using the Granger causality test to determine whether a linear relationship exists between two time series, the authors failed to reject the null hypothesis that index fund positions force commodity spreads wider. The authors recommended further analysis of Chicago wheat contract specifications largely because a) the wheat contract is the most "generically" used wheat contract traded, and b) the Chicago wheat contract delivery points are largely tributary to SRW wheat production points (S. H. Irwin, P. Garcia and D. L. Good, et al. 2010).

In their most recent attempt to correct convergence issues in the CBOT wheat contract, the CME Group approved the use of a variable storage rate (VSR) mechanism which would replace seasonal storage rates. The VSR is designed to be a market-based regulator of storage charges in the delivery system. The details of implementation of VSR in the Chicago wheat contract include monitoring of nearby futures spreads relative to financial full carry. In its current form, the new VSR mechanism includes the following conditions:

- If the nearby and following wheat option month spread averages 80% or more of financial full carry during the designated observation period, then the maximum storage charge on all outstanding wheat shipping certificates will increase 10/100s of one cent per bushel per day. The next observation period will determine if maximum storage charges will change.

- If the nearby and following wheat contract month spread averages between 50% and 80% of financial full carry during the designated observation period, then the maximum storage charge on all outstanding wheat shipping certificates will remain the same. The next observation period will determine if maximum storage charges will change.

- If the nearby and following wheat option month spread averages less than 50% of financial full carry during the designated observation period, then the maximum storage charges on all outstanding wheat shipping certificates will decrease 10/100s of one cent per bushel per day. The next observation period will determine if maximum storage charges will change.

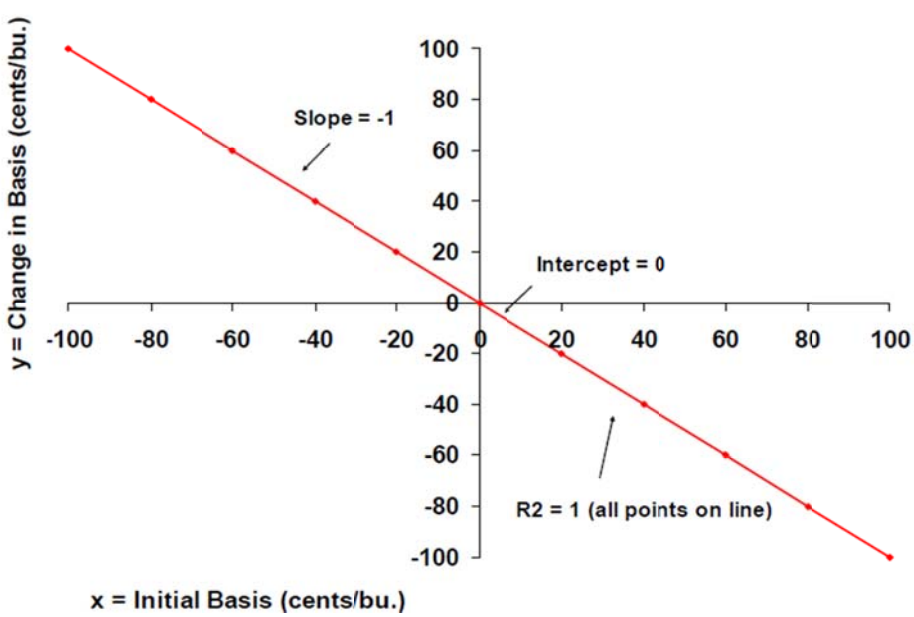
In a report issued by the CME Group on July 22, 2010 it was stated that "since the announcement of the VSR in November 2009, convergence between cash and futures prices at expiration has improved dramatically" (CME Group 2010). The CME Group report also acknowledges that VSR is not the sole reason for improved wheat convergence and that a change in supply and demand fundamentals of SRW wheat and the variety of wheat delivered against the Chicago wheat contract have also helped to bring about improved wheat convergence (CME Group 2010). To date since its inception only increases in VSR rates have taken place.

CHAPTER III: CONCEPTUAL MODEL

3.1: Basis Linearity

The delivery system is the essential link that ties the futures market and cash market together. In a properly functioning delivery system the cash price and the futures price should “converge” at expiration to near price parity. This means that for an elevator that can make delivery at option ($0.00), as contract expiration approaches the cash price should “converge” and theoretically equal the futures price of the underlying futures contract. For an elevator who has a location differential of a $0.20 discount to the underlying futures contract, the cash value of the commodity will equal the futures price less the $0.20 discount at contract expiration. The Chicago wheat futures contract has been criticized in recent years because of the large price spread that exists between the cash and futures market price at contract expiration. Figure 3.1 provides a graphical representation of how a delivery system with perfect convergence or predictability should function.

Figure 3.1: Perfect Predictability



Source: Irwin, et al., 2008

The graph shows that a perfectly predictable delivery system should have a slope of -1 with the origin representing basis at contract expiration. For example, if cash basis is -$1.00 per bushel in Toledo sixty days prior to contract expiration it can be expected that basis should appreciate by $1.00 per bushel over the same sixty day period. [If this graph was positively sloping it would have a slope of +1.] The delivery system should force convergence at contract expiration through arbitrage. According to Irwin a taker of delivery will stand for delivery of the physical commodity through the delivery process if the cash price of the commodity exceeded the futures price and subsequent futures purchased. Likewise, if the futures price of the commodity exceeded the cash price, the cash commodity would be purchased in the open market, futures sold, and delivery made (Irwin and Smith, Commodity Futures Trading Commission 2010). This theory of riskless arbitrage by market participants is why convergence should be forced in the delivery system.

It is generally accepted among market participants that a delivery system will never converge in a perfectly consistent manner over a prolonged period of time. This is due largely to supply and demand factors that have implications on local elevator basis as well as expenses associated with physical storage of the commodity. The primary expense associated with delivery houses that have certificates issued are quality control expenses. Quality control expenses are not inclusive of the expenses incurred by delivery houses, but do comprise a cost that all market participants experience in the Chicago wheat delivery system. Irwin and Smith argue that since delivery is not costless, a proper functioning delivery system will converge within an acceptable “zone of convergence” (Irwin and Smith, Commodity Futures Trading Commission 2010). To define an exact numeric range that conclusively encapsulates this zone of convergence is challenging given recent convergence problems that have occurred with the Chicago wheat contract.

3.2: Cost of Carry

For any user of a cash commodity that stands for delivery during the delivery process a corresponding number of delivery certificates must be issued by the entity making delivery. For a grain elevator the decision to issue shipping certificates against the underlying commodity contract is largely centered on a concept known as Cost of Carry. Cost of Carry can be defined as the compensation the futures market pays the holder, or storage facility, to "carry" grain. For a grain elevator to store grain the futures market must compensate the storage facility for costs incurred. Grain elevators typically store grain in carry markets. In carry markets, grain owned tomorrow is worth more than grain owned today. An example would be wheat trading in the March contract that is valued more than wheat in the previous December contract. The difference in contract month prices creates a price "spread" that commercial hedgers, such as grain elevators, attempt to capture as compensation for commodity storage. This is done by hedging through purchasing of the nearby contract month and simultaneously selling the deferred contract month, otherwise known as bull spreading. For the Chicago wheat contract, the existence of large price spreads in nearby contracts have been a key issue pointed out by those critical of the effectiveness and function of the VSR mechanism.

Some of the costs associated with storing grain include interest or opportunity cost, quality control costs, and market risk costs. Storage costs are variable with each elevator due to different internal interest rates and quality control procedures. Thus, the cost to carry grain for each elevator can and should be different. To entice the commercial elevator to "carry" grain, the futures market must provide the holder of grain with a sufficient return on investment. The formula for Cost of Carry can be represented as:

$$\text{Cost of Carry} = (f_2 - f_1) / (s + i),$$

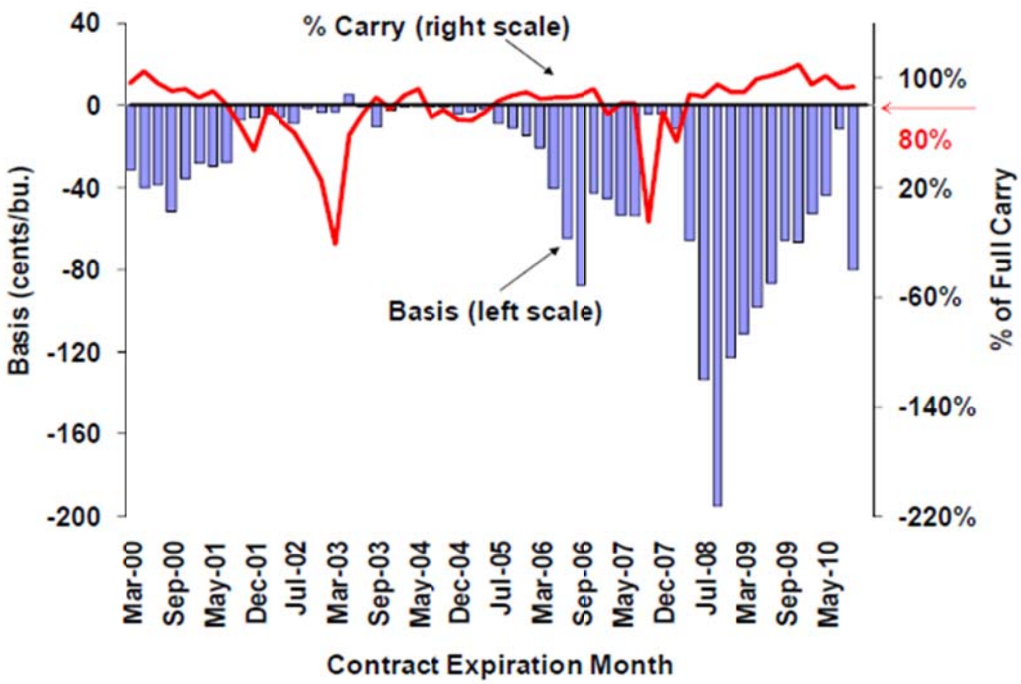
where f_2 = deferred futures price, f_1 = nearby futures price, s = storage rate for calculation period, and i = internal interest rate for calculation period. For example, suppose that May Chicago wheat last settled at $8.16 and July Chicago wheat last settled at $8.29. Assuming storage is constant at $0.00465 per day and there are 61 days that the May wheat contract trades until First Notice Day, this implies that storage expense alone equals $0.2837 per bushel for the May/July wheat contract spread period. As previously stated, in this example May Chicago wheat last settled at $8.16. Assuming an annualized interest rate of 2.5% yields a yearly monetary interest cost of $0.204, then over a 61 day period interest expense equals $0.034. We can then conclude that the formula for "Full Carry" can be defined as:

$$\text{Full Carry} = (s + i)$$

In this example Full Carry is $0.3177 per bushel for the May/July contract period. This represents the theoretical maximum of futures carry that the market will pay for a holder of grain to carry wheat from the May contract to the July contract. To obtain the current amount of carry the market is paying a holder of wheat, dividing the futures carry $(f_2 - f_1)$ by $(s + i)$ returns a value of 0.40. It can be concluded that the futures market is compensating at a value of 40% of full carry at 2.5% interest. In this example for an elevator that is registered to make delivery, it is then economically profitable for them to do so. By making delivery, the elevator will collect the set storage rate of $0.00465 per day or

$0.2837 for the 61 day period rather than bull spreading lead contract months and only capturing $0.13 of market carry. While making delivery in a properly functioning delivery system always runs the risk of being executed, or loaded out, a lack of convergence in the Chicago wheat contract in recent years has virtually eliminated this risk. This is because cash prices at expiration, most notably the Toledo switching district, have traded significantly under cash prices at the delivery location. Figure 2.2 illustrates this lack of convergence at contract expiration.

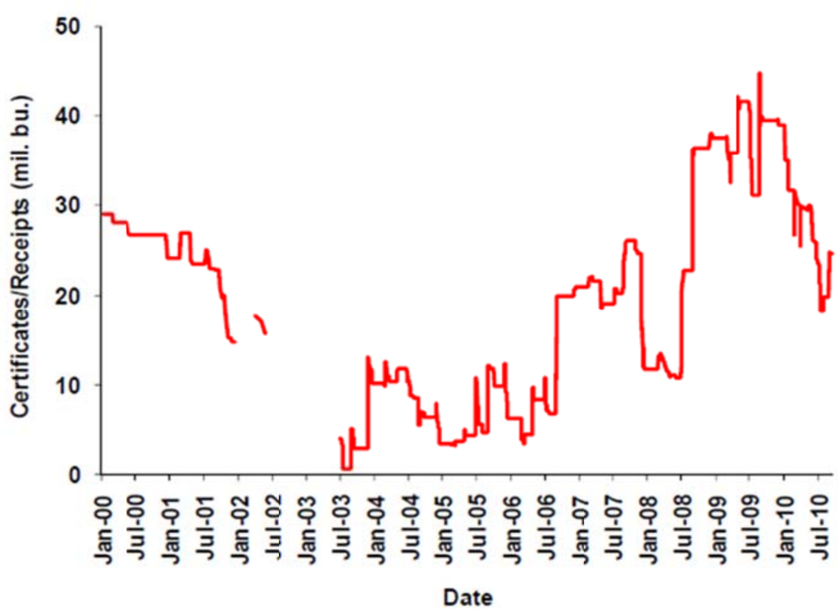
Figure 3.2: Basis and Fully Carry at Contract Expiration



Source: Irwin et al., 2008

As a result of weak cash basis at contract expiration delivering entities, primarily grain elevators, have issued the maximum amount of shipping certificates they are registered for and collected storage from those whom remain long (i.e., holding long positions) in the futures contract going into delivery. For those that do not want to take physical ownership of the commodity through the delivery process, they must pay the delivering location storage costs. Large quantities of shipping certificates issued without physical load-out signals a lack of demand which has aided in futures price spreads trading at historically wide levels. This has fueled the case for those who indicate there is a lack of convergence in the Chicago wheat contract. Figure 2.3 provides a graphical representation regarding the historical amount of shipping certificates issued in the Toledo switching district at contract expiration.

Figure 3.3: Outstanding Wheat Certificates at Contract Expiration – Toledo, OH



Source: Irwin et al., 2008

As can be seen from the illustration, the Toledo switching district has had in excess of 20 million bushels issued for delivery over the past 3 years. In a properly functioning delivery market this should not be the case, but rather there should be a cyclical trend in the quantity of wheat deliveries which is more accurately represented by the time period from July 2003 to July 2006 in which there was oftentimes less than 10 million bushels worth of certificates issued. This reason why the amount of certificates issued should be cyclical is because of supply and demand economics where excess supply decreases prices and tight supplies increase prices.

CHAPTER IV: METHODS

4.1: Objectives

The objective of this research is to use Ordinary Least Squares regression models to determine whether or not implementation of the VSR in the Chicago wheat contract has had a statistically significant impact on SRW wheat convergence in the Toledo, OH switching district. In this study we are examining four consecutive Chicago wheat contract months, beginning with the July 2010 contract and ending with the March 2011 contract. Each contract will be tested individually with the final regression model estimated from the cumulative data for the four contract months.

4.2: Location

In all regression models the Toledo, OH switching district will be the location used to test for statistical significance regarding the impact of VSR on SRW wheat convergence. All registered deliverable elevators in the Toledo, OH district can issue certificates at option (+$0.00) versus the respective contract month. In addition to making delivery at option, a $0.06 per bushel load-out fee is paid by the holder of the certificate should they choose to take possession of the physical commodity.

4.3: Dependent Variable

The dependent variable for this research will be SRW wheat basis at the Toledo, OH switching district. Daily futures price data were gathered from the Luckey Farmers website, i.e., www.luckeyfarmers.com. Cash price data for this variable were obtained from the USDA Agricultural Marketing Service (AMS) via their online data procurement function, and includes bids from local elevators and processors. A range of cash prices and associated basis values were reported for each day because of multiple elevators in the switching district, thus the midpoint of the corresponding reported daily cash price and basis bids was selected.

4.4: Independent Variables

For each regression model there are three explanatory variables that will be used in an attempt to determine whether or not VSR has had a statistically significant impact on wheat basis convergence in the Toledo, OH switching district.

4.4.1: Variable Storage Rate (VSR)

Variable storage rate (VSR) is the current monthly storage rate as determined by the VSR market-based measurement of financial full carry. VSR data begins with the period leading up to the July 2010 contract and concludes with the March 2011 contract. During these four contract periods VSR has triggered higher in each observation period. The pre-analysis expectation is that as VSR increases, wheat basis will narrow or converge towards +0. Since VSR is represented as a positive number and basis is represented as a negative number in relation to futures, it is hypothesized that the VSR coefficient would be positive (i.e., basis becomes less negative as VSR grows larger in value). Figure 4.1 provides a graphical representation of the VSR rate, CBOT wheat futures, Toledo cash price, and Toledo basis during these four contract month periods. As illustrated in Figure 4.1, it appears graphically that convergence did occur at the Toledo switching district for July 2010, December 2010, and March 2011 CBOT wheat contracts. However, it does not appear that convergence occurred during the September 2010 CBOT wheat contract period.

4.4.2: Days to Delivery

The independent variable, days to delivery, is the amount of days remaining until the first delivery date for each futures contract. In large carry markets it can be expected that anyone long the basis would expect basis to firm as the delivery period approaches. This is directly related to the concept of perfect predictability discussed earlier. The days to delivery in this research represents a linear relationship that measures the narrowing of Toledo basis as the delivery period approaches. The expectation of this variable is that as days to delivery is reduced; cash prices will converge with futures. Since days to delivery is represented as a decreasing negative number series and basis is also represented as a negative relative to futures, it is expected that the model coefficient of the days to delivery explanatory variable will be positive. In other words, as days to delivery approaches zero, basis will become less negative, i.e., narrowing and approaching zero.

4.4.3: United States All Wheat Ending Stocks as a Percent of Total Use

All wheat ending stocks as a percentage of use is the ratio represented in percentage of projected U.S total all wheat ending stocks divided by projected U.S. total wheat use for each marketing year. Marketing year ending stocks-to-use estimates are taken from data reported by the USDA in its monthly World Supply-Demand Use Estimates (WASDE) reports. All wheat ending stocks as a percentage of use is included in these models instead of ending stocks-to-use for SRW wheat in an attempt to represent total U.S. wheat market conditions as is represented with Chicago wheat futures contracts. Also, trends in U.S. SRW wheat ending stocks-to-use during this time period nearly paralleled the increasing stepwise upward trend pattern of the VSR. The use of U.S. ending stocks-to-use for all wheat use instead of the same measure for U.S. SRW wheat only helped to reduce the potential existence of multicollinearity in model estimation. The expectation for this explanatory variable is that as all wheat ending stocks as a percentage of use declined over this time period, wheat basis would tend to narrow in the Toledo switching district, i.e., as wheat supplies become tighter or more scarce, competitive pressures from increased demand for wheat will tend to cause cash prices to be bid up relative to futures – leading to a narrowing of wheat basis. Given that we are representing the ending stocks-to-use explanatory variable as a positive number series with each 1-percent ending stocks- to-use explanatory represented as 1 whole number, and basis as a negative value relative to futures (cash prices lower than futures), we would expect or hypothesize that this model coefficient would be negative. That is, wheat basis is expected to widen or become more negative as U.S. wheat ending stocks-to-use increases, and conversely that basis becomes narrower or more positive as U.S. wheat ending stocks-to-use decreases. Figure 4.2 provides a graphical representation of this variable.

Figure 4.1: Toledo SRW VSR/Basis Trends

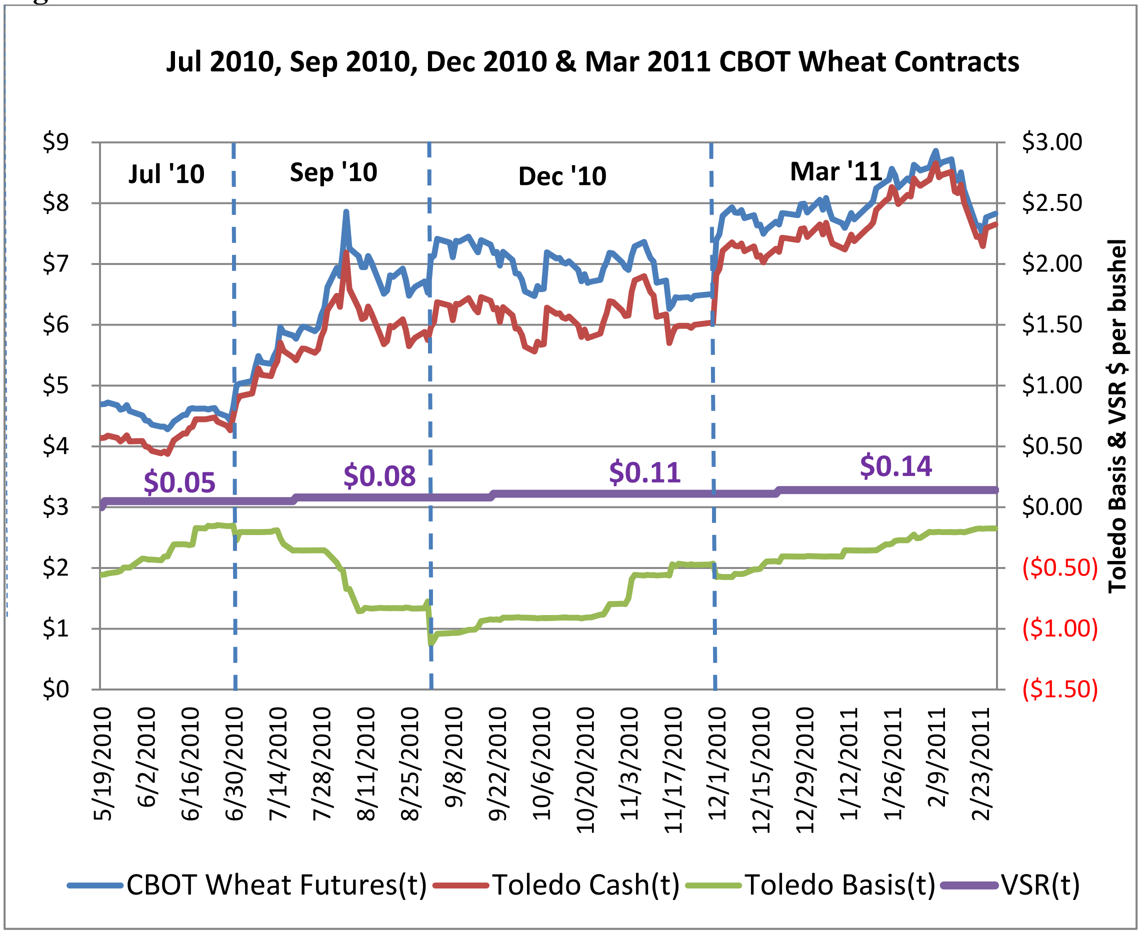
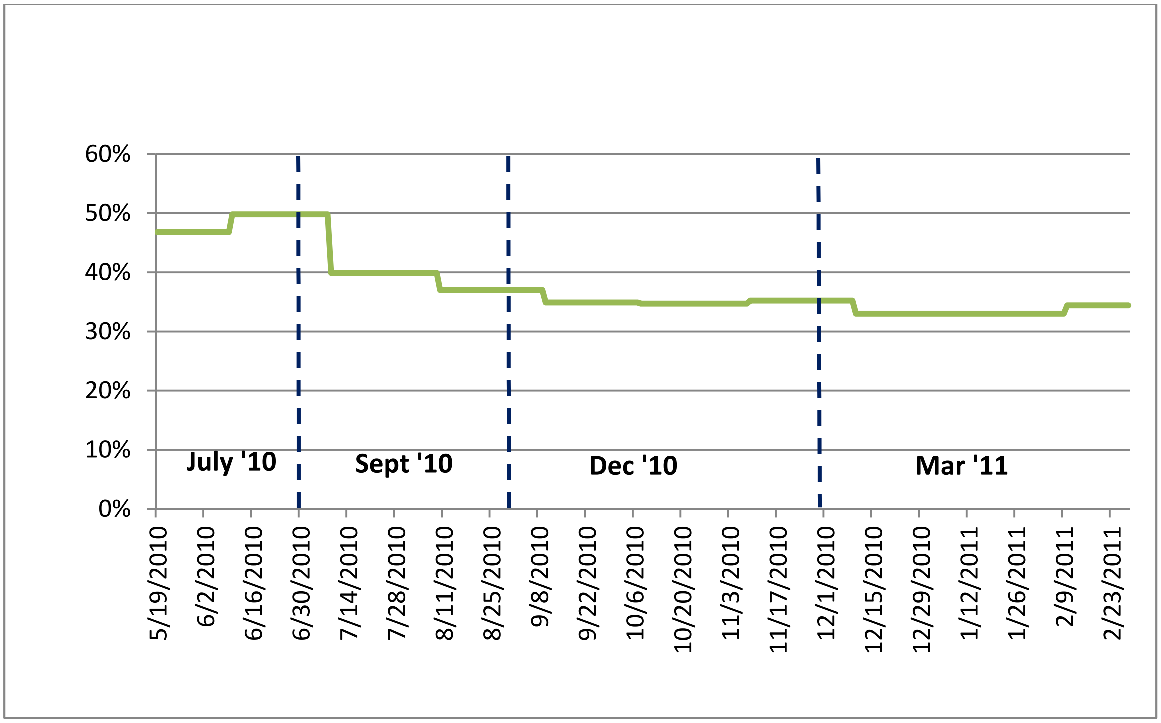


Figure 4.2: All Wheat Ending Stocks as a Percentage of Use



4.5: Ordinary Least Squares (OLS) Regression Models

For this research the statistical analysis procedure used will be Ordinary Least Squares (OLS) regression. OLS regression is a statistical technique that calculates the statistical impact of a model's independent variables in such a manner so that the sum of the squared residuals is minimized (Studenmund 2006). The sum of squared residuals is simply the unexplained variation around the estimated regression equation. An example of an OLS regression equation using multiple independent variables would take the following format:

$$Y_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \ldots + \beta_K X_{Ki} + \varepsilon_i$$

where Y_i represents the *i-th* observation of the dependent variable, X_i represents the *i-th* observation of the independent variable, ε_i represents the *i-th* observation of the stochastic error term, and $\beta_{0,}\beta_{1,}\beta_2$ to β_K represent the regression coefficients to be estimated.

4.5.1: July 2010 Pre-model Expectations

To determine whether or not the variables represented in the Toledo basis model have helped to cause cash-futures convergence during the time period leading up to delivery for the July 2010 wheat contract, the following model is estimated:

$$\text{July'10}\textit{Basis}_i = \beta_0 + \beta_1 \textit{DaysDlvy}_i - \beta_2 \textit{Stocks}_i + \varepsilon_i,$$

where Y = *July'10Basis* = Toledo daily basis during July 2010 contract,

where X_1 = *DaysDlvy* = Days remaining until July 2010 delivery period, and

where X_2 = *Stocks* = U.S. all wheat ending stocks as a percentage of use.

It is expected in this regression equation that with each unit decrease in *DaysDlvy* (i.e., as the days to delivery decline or become less negative), *July'10Basis* will increase holding all other variables in the model constant. It is also expected that with each one unit decrease in U.S. wheat ending stocks-to-use, *July'10Basis* will increase holding all other variables in the model constant. The VSR variable was not included in the July 2010 model since it held a constant value of $0.05 per bushel for all but the first day of the model pre-delivery period.

4.5.2: September 2010 Pre-model Expectations

To determine whether or not the variables represented in the Toledo basis model have helped to cause cash-futures convergence during the time period leading up to delivery for the September 2010 wheat contract, the following statistical model is estimated:

$$Sept'10Basis_i = \beta_0 + \beta_1 DaysDlvy_i - \beta_2 Stocks_i + \beta_3 VSR_i + \varepsilon_i,$$

where Y = Sept'10Basis = Toledo daily basis during September 2010 contract,

where X_1 = DaysDlvy = Days remaining until September 2010 delivery period,

where X_2 = Stocks = U.S. all wheat ending stocks as a percentage of use, and

where X_3 = VSR = VSR daily storage rate during September 2010 contract.

The expected effects for *DaysDlvy* and *Stocks* are the same as in the July 2010 model. Finally, it is expected that with each unit (i.e., 1 cent per bushel) increase in *VSR*, *Sept'10Basis* will narrow, or become less negative, holding all other variables in the model constant.

4.5.3: December 2010 Pre-model Expectations

To determine whether or not the variables represented in the Toledo basis model have helped to cause cash-futures convergence during the time period leading up to delivery for the December 2010 wheat contract, the following statistical model is estimated:

$$Dec'10Basis_i = \beta_0 + \beta_1 DaysDlvy_i - \beta_2 Stocks_i + \beta_3 VSR_i + \varepsilon_i,$$

where Y = *Dec'10Basis* = Toledo daily basis during December 2010 contract,

where X_1 = *DaysDlvy* = Days remaining until December 2010 delivery period,

where X_2 = *Stocks* = U.S. all wheat ending stocks as a percentage of use, and

where X_3 = *VSR* = VSR daily storage rate during December 2010 contract.

The expected effects for *DaysDlvy*, *Stocks*, and *VSR* are the same as in the September 2010 model above. In particular, it is expected that with each unit (i.e., 1 cent per bushel) increase in *VSR*, *Dec'10Basis* will narrow, or become less negative, holding all other variables in the model constant.

4.5.4: March 2011 Pre-model Expectations

To determine whether or not the variables represented in the Toledo basis model have helped to cause cash-futures convergence during the time period leading up to delivery for the March 2011 contract, the following statistical model is estimated:

$$March'11Basis_i = \beta_0 + \beta_1 DaysDlvy_i - \beta_2 Stocks_i + \beta_3 VSR_i + \varepsilon_i$$

where Y = *March'11Basis* = Toledo daily basis during March 2011 contract,

where X_1 = *DaysDlvy* = Days remaining until March 2011 delivery period, where X_2 = *Stocks* = U.S. all wheat ending stocks as a percentage of use, and

where X_3 = *VSR* = VSR daily storage rate during March 2011 contract.

The expected effects for *DaysDlvy*, *Stocks*, and *VSR* are the same as in the December 2010 model above. As has been stated above, it is expected that with each 1 unit (i.e., 1 cent per bushel) increase in *VSR*, *March'11Basis* will narrow, or become less negative, holding all other variables in the model constant.

4.5.5: Consolidated Contract Pre-model Expectations

To determine whether or not the variables represented in the Toledo basis model have helped to cause cash-futures convergence during the entire time period analyzed in this study, i.e., the time periods leading up to delivery for the July 2010, September 2010, December 2010, and March 2011 wheat contracts, the following statistical model is estimated:

$$ConsBasis_i = \beta_0 + \beta_1 DaysDlvy_i - \beta_2 Stocks_i + \beta_3 VSR_i + \varepsilon_i,$$

where Y = *ConsBasis* = Toledo daily basis during July 2010, Sep 2010, Dec 2010, and Mar 2011 contract,

where X_1 = *DaysDlvy* = Days remaining until each contract delivery period,

where X_2 = *Stocks* = U.S. all wheat ending stocks as a percentage of use, and

where X_3 = *VSR* = VSR daily storage rate during each contract.

The expected effects for *DaysDlvy*, *Stocks*, and *VSR* are the same for the consolidated overall model as for the individual contract models above.

CHAPTER V: DATA RESULTS AND ANALYSIS

5.1: Regression Model Results

The previous chapter discussed the variables and methodology used to study the impact of VSR and other variables on Chicago wheat contract convergence in the Toledo switching district for the July 2010 thru March 2011 wheat futures contract. This chapter will discuss the results and interpretation of each regression model analysis performed on the Chicago wheat contract. The chapter will conclude with a discussion regarding regression model limitations pertaining to this study.

5.1.1: July 2010 Wheat Contract Model

The model estimation results for the July 2010 wheat contract are presented in table 5.1. It must be noted in this model that the VSR variable was not included because VSR did not change appreciably during the July 2010 wheat contract. The regression output shows an F value of 322.54 and is found to be statistically significant at the 1 percent level. The F value gives an indication that the overall model is a good fit when attempting to explain the variability in basis convergence in the July 2010 wheat contract. The adjusted R-squared for the model was 0.96. This means that approximately 96% of the variability in basis is explained by days to delivery (DaysDlvy) and ending all wheat stocks as a percentage of use (Stocks). The coefficient signs were consistent with hypothesized pre-analysis expectations, and both explanatory variables were statistically significant at the 5% level. It was hypothesized that as days to delivery decreases, basis will narrow as contract expiration approaches. This is due to the risk premium grain storage facilities command in carry markets to entice selling in the lead contract month rather than bull spreading hedges across to forward contract months. The model coefficient for Days to delivery was positive at 1.41, and can be interpreted that for each day closer to delivery, basis narrows by 1.41 cents holding all other variables in the model constant. The coefficient on ending stocks as a percentage of use was a negative 9.13 and can be interpreted to mean that for each 1% decrease in U.S. all wheat stocks, wheat basis narrows, or in this model becomes less negative, by 9.13 cents holding all other variables constant. This also is in agreement with our hypothesis that as the supply of United States wheat of all classes becomes tighter or more scarce, basis must narrow to raise cash price and help ration demand. Days to delivery is significant at the 1% level of significance while wheat ending stocks as a percentage of use is significant at the 5% level of significance.

Table 5.1: July 2010 Regression Model Output

	B	**T**	**P-Value**		
Intercept	414.85	1.98	0.06	**N**	30
Days to delivery	1.41	10.88***	0.00	**F**	322.54
Ending stocks % of use	(9.13)	(2.03)**	0.05	**Prob > F**	0.00
				R^2	0.98
				Adj R^2	0.96

Statistically significant at the: * 10% level, ** 5% level, * 1% level**

5.1.2: September 2010 Wheat Contract Model

The results for the September 2010 regression model are presented in Table 5.2. VSR was included in this model, and during this contract changed from $0.05 per bushel per month to $0.08 per bushel per month. The regression output shows an F statistic of 130.38 and is significant at the 1% level, indicating an overall good fit to the model in regards to explaining wheat basis variability. The adjusted R^2 for the model is 0.95 indicating that 95% of the variability in wheat basis is explained by days to delivery, U.S. all wheat ending stocks as a percentage of use, and VSR. The coefficient signs reported for this model were not as expected in this contract prior to model estimation. Days to delivery was negative and can be interpreted that for each one day closer to delivery basis widens 1.21 cents. Days to delivery was found to be statistically significant at the 1% level of significance. The coefficient for U.S. all wheat ending stocks as a percentage of use had a positive sign and was statistically significant at the 1% level. According to these results, for each 1% decrease in U.S. all wheat ending stocks as a percentage of use, basis widens by 1.83 cents. Finally, the coefficient for VSR was negative and indicates that for each 1 cent increase in VSR, Toledo wheat basis widens 3.09 cents per bushel. VSR is statistically significant at only the 10% level of significance.

Table 5.2: September 2010 Regression Model Output

	β	**T**	**P-Value**		
Intercept	(104.24)	(8.02)	0.00	**N**	43
Days to delivery	(1.21)	(4.63)***	0.00	**F**	130.38
Ending stocks % of use	1.83	3.72***	0.00	**Prob > F**	0.00
VSR	(3.09)	(1.77)*	0.08	**R^2**	0.95
				Adj R^2	0.91

Statistically significant at the: * 10% level, ** 5% level, * 1% level**

5.1.3: December 2010 Wheat Contract Model

During the time period leading up to delivery for the December 2010 Chicago wheat contract, VSR rates increased from $0.08 per bushel per month to $0.11 per bushel per month. The results from the output regression for the December 2010 wheat contract are reported in Table 5.3. The regression output F statistic of 163.36 shows an overall good fit to the model and is statistically significant at the 1% level. The adjusted R-squared for the model is 0.89, and can be interpreted as indicating that 89% of the variability in the December 2010 Chicago wheat contract can be explained by the independent variables in the model. Only days to delivery had the expected sign from the output results. For each 1 day closer to delivery basis narrows by 1.38 cents, with this effect being statistically significant at the 1% level. Ending stocks as a percentage of use with a positive sign can be interpreted as indicating that for each 1% decrease in all wheat U.S. stocks, basis widens 4.13 cents. This effect was statistically significant at the 1% level. Lastly, like the September contract, the sign of the December VSR coefficient was opposite from what was hypothesized. According to the model, for each 1 cent increase in VSR basis widens by 1.26 cents. It should be noted that during the period leading up to delivery for the December 2010 contract, sharp price rallies occurred in the U.S. wheat market largely tied to significant news events unfolding in Eastern Europe and Russia regarding extreme wheat production losses, quality deterioration and export restrictions. This could have had the impact of causing widening of basis levels to compensate in the cash market for sharp speculative driven increases in wheat futures contracts.

Table 5.3: December 2010 Regression Model Output

	β	**T**	**P-Value**		
Intercept	(175.17)	(4.04)	0.00	**N**	62
Days to delivery	1.38	15.10***	0.00	**F**	163.36
Ending stocks % of use	4.13	3.77***	0.00	**Prob > F**	0.00
VSR	(1.26)	(1.20)**	0.023	R^2	0.89
				Adj R^2	0.89

Statistically significant at the: * 10% level, ** 5% level, * 1% level**

5.1.4: March 2011 Wheat Contract Model

During the time period leading up to delivery for the March 2011 contract, storage rates increased by $0.03 per bushel to $0.14 per bushel in response to VSR adjustment mechanisms. The March 2011 contract regression results are reported in Table 5.4. An F statistic of 702.90 indicates an overall good fit when explaining wheat basis variation via the March 2011 model, and is significant at the 1% level. The adjusted R-squared in this model is 0.97, indicating that 97% of the variation in March 2011 contract basis can be explained by days to delivery, ending stocks as a percentage of use, and VSR. The coefficient on days to delivery is significant at the 1% level of significance. The sign for this coefficient is positive which is consistent with pre-estimation hypotheses. For each 1 day closer to delivery basis narrows 0.67 cents in the model. The coefficient for U.S. ending stocks as a percentage of use was not statistically significant in this model. The coefficient for VSR was positive as expected and statistically significant at the 1% level of significance. For each 1 cent increase in VSR, basis narrows in Toledo by 1.06 cents per bushel holding all other variables in the model constant.

Table 5.4: March 2011 Regression Model Output

	β	T	P-Value		
Intercept	(38.36)	(2.63)	0.01	**N**	59
Days to delivery	0.67	19.35***	0.00	**F**	702.90
Ending stocks % of use	0.26	0.56	0.58	**Prob > F**	0.00
VSR	1.06	3.35***	0.00	R^2	0.97
				Adj R^2	0.97

Statistically significant at the: * 10% level, ** 5% level, * 1% level**

5.1.5: Consolidated Wheat Contract Model

In this regression model the time period spanning the four Chicago wheat contract months since VSR began to be used were consolidated and the results are reported in Table 5.5. An adjusted R-square of 0.79 can be interpreted as indicating that 79% of the variation in wheat basis during these four contract months can be explained by the independent variables in the explanatory model. The coefficient for days to delivery in this model is positive which is what was expected and is statistically significant at the 1% level of significance. The coefficient for U.S. all wheat ending stocks as a percentage of use was opposite of hypothesized. With this explanatory variable, for each 1% decrease in stocks as a percentage of use wheat basis widened 4.17 cents. The coefficient for the VSR variable was positive and consistent with what was hypothesized. For each 1 cent per bushel increase in VSR the wheat basis in Toledo narrowed by 7.38 cents per bushel for these Chicago wheat contracts in these explanatory models.

Table 5.5: Consolidated Regression Model Output

	B	**T**	**P-Value**
Intercept	(274.63)	(8.84)	0.00
Days to delivery	0.60	6.16***	0.00
Ending stocks % of use	4.17	7.59***	0.00
VSR	7.38	7.14***	0.00

N	195
F	33.627
Prob > F	0.00
R^2	0.35
Adj R^2	0.34

Statistically significant at the: * 10% level, ** 5% level, * 1% level**

5.2: Model Limitations

It is important to be aware that multicollinearity may affect some of these model estimation results – especially for the final combined model. Multicollinearity occurs when explanatory variables "trend together", leaving their specific individual impacts on the model hard to distinguish. Multicollinearity oftentimes gives deceptively high R-squared values, F-statistics, and unexpected coefficient values. Referring to Figures 4.1 and 4.2 it can be confirmed that a trend or collinear relationship may exist between VSR and ending all wheat stocks as a percentage of use. While VSR is increasing in a linear trend depicted in Figure 4.1, all wheat ending stocks illustrated in figure 4.2 is decreasing in a linear trend. Furthermore, the explanatory variable days to delivery, while not shown is these graphs, is essentially a stepwise increasing linear trend for each of the four contracts, which may further exasperate the presence of multicollinearity in these model estimation results. While it is likely that this econometric problem does exist to some degree in these models, these results provide an element of support for the underlying hypothesis that VSR has had a statistically significant positive effect upon wheat basis convergence on the March 2011 wheat contract individually and upon all four contracts collectively. While VSR appears to have had a statistical impact on the March 2011 contract individually, the September 2010 and December 2010 contracts had a statistically significant negative effect when tested independently. In sum, while there is some evidence that supports the hypothesis that VSR has had a statistically significant impact on the contracts studied, there is also evidence that refutes the hypothesis as evidence by the September 2010 and December 2010 contracts and statistical inferences for all models could be misleading due to the potential existence of multicollinearity.

CHAPTER VI: SUMMARY AND CONCLUSION

It has been widely publicized in the agribusiness sector that the Chicago wheat contract in recent years has not performed as designed. The deficiency in the Chicago wheat contract is due primarily to a lack of convergence between SRW cash wheat prices and the Chicago wheat futures contract prices. While debate exists as to the underlying cause of non-convergence in the Chicago wheat contract, due to the complexity and dynamics of supply and demand factors influencing global wheat prices, a correct solution has been a challenge to first figure out and then to implement. In the contracts most recent change the CME Group took proactive measures based on industry and university recommendations to move towards a market based mechanism to set maximum storage rates at delivery points called VSR, an acronym for Variable Storage Rate. VSR is calculated on a daily basis during the set contract observation periods where the lead futures month spreads for Chicago wheat are measured relative to financial full carry. The average of the spread relative to financial full carry at the end of the observation period determines if storage rates decrease, increase, or stay the same. To date, only increases in VSR rates have taken place.

The objective of this research was to determine if VSR has had an impact on SRW wheat basis convergence in the Toledo, OH switching district. In this study three explanatory variables were used in analytical models, consisting of days to delivery, all wheat ending stocks as a percentage of use, and VSR. The Chicago wheat contract months that were observed and analyzed include July 2010, September 2010, December 2010, and March 2011. A final regression consisted of the combined cumulative data from these four contract months. In total, the results of five OLS regression models were performed.

Looking at figure 4.1 it appears that convergence occurred or firmed into delivery for the July 2010, December 2010 and March 2011 wheat contracts while it did not occur during the September 2010 contract. The results of the regression models were at least partially consistent with pre-model expectations. It seems likely that all of the models in this study were affected to at least a small degree by the econometric issue of multicollinearity which can be a contributing factor to incorrect and misleading statistical output. However, even though the basis models appear to have an element of multicollinearity that may be affecting their results to greater and/or lesser degrees, there still appears to be some value in the findings. It does appear that days to delivery has had an effect on Toledo SRW wheat convergence as evidenced by the statistically significant results for the July 2010, December 2010, and March 2011 contract and cumulative contract regression. Only for the March 2011 and cumulative contract regressions did VSR have consistent coefficient signs with pre-model expectations.

Additional VSR observation data will be helpful for future studies regarding SRW wheat convergence in the Toledo district. Additional data would help to mitigate the effect of any instances where multicollinearity could be present. Because of the linear nature associated with supply and demand economics modeling SRW wheat basis convergence is complex. Only continued data collection, informed observation of basis trends and market conditions, and well developed empirical models and associated hypothesis testing will help alleviate modeling problems and provide answers to the effectiveness of VSR or other tools designed to bring about improved cash-futures convergence for Chicago wheat and other wheat futures exchanges.

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