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Basis Trading Strategies and Returns to Storage

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ABSTRACT

This thesis research evaluates post-harvest grain marketing strategies such as basis trading and basis trading with pre-spreads at different cost of carry coverage levels. Although this empirical analysis is done from grain elevators perspective for storing corn and soybeans, these strategies are also applicable to farmers seeking post-harvest period marketing strategies to hedge stored grain. However, considering the volume of grains stored by elevators, and hence the high levels of price risk associated with this business model, the marketing strategies considered in this thesis are most pertinent to grain elevators.

Paired t-test results indicate that corn basis trading at harvest and pre-spreading at 150% cost of carry level at pre-harvest time yield statistically similar mean net returns to post-harvest storage (up to 185 days), whereas other corn pre-spreading levels such as 125% and 100% yield significantly lower mean net returns. In addition, basis trading corn results in lower net returns variance than storing it un-hedged, and hence, a less risky post-harvest strategy.

Results for soybean storage indicate adverse outcomes from basis trading and pre-spreading strategies over long storage periods, as cumulative mean net returns tend to significantly decrease beyond trading day 40 of storage period. Although variances of net returns do not significantly change over the 60 day storage period, they do so after this period, especially when hedged with May and July soybean futures contracts. However, soybean results support the use of pre-spreading100 with more deferred contracts approximately for 40 day storage period, where mean returns are significantly higher than basis trading returns. We highlight outcomes from un-hedged storage and find significantly positive mean net returns beyond 60 days. For grain elevators in North Central Illinois un-hedged soybean storage generated significantly

positive and increasing returns over a 60-185 day storage period. Although un-hedged corn storage also yielded positive returns 60% of the time (between storage days 60-175), wide confidence intervals close to zero indicate that, on average, net returns over these days are only marginally significant.

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DEDICATION

I dedicate this thesis to my parents. All parents get happier with every small achievement of their children.

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I. INTRODUCTION

The grain industry is composed of different businesses which each play a role in moving grain from the field to the market. They produce, handle, distribute and process millions of bushels of grain each year to bring consumers food and other products (Lorton & White, 2006). In this industry both the grain producers (farmers) and processors play an important role. However, they have different interests which create a gap in efficient movement of grain: the producer wants a higher price, while a processer wants a lower price; the producer is not ready to sell when a processor wants to buy. To fill that gap the grain elevator plays a vital role by storing grain and acting as a buyer to producers and a seller to processors.

A grain elevator's main job is to store grain in its designated grand facilities and provide access to grain throughout the year. Thus, the farmer can sell at high price and the processor/consumer can buy at low price at his convenience. In order to offer such a win-win opportunity to both parties, the grain elevator needs to have a specific skill and business strategy. Otherwise it might go bankrupt itself. A combination of such skills and strategies is embodied in basis trading - a merchandising marketing strategy commonly practiced by elevators.

Basis trading involves simultaneous use of both spot and futures markets. It not only makes grain prices affordable to both sides, but also provides reasonable profits to grain elevator as well. Futures market/contracts can be used by hedgers, arbitrageurs and speculators for any type of commodity that is traded at Chicago Board of Trade for a specific amount of commodity and delivery date. Corn and soybean contracts are usually 5000 bushels per contract.

There are two main types of grain elevators – terminal and country – which can also be divided into sub-categories. Terminal elevators have larger capacities than country elevators, and they are usually located close to major marketing areas, whereas country elevators are located in rural areas close to farmers. Country elevators usually buy grain from farmers only, while terminal elevators buy from both farmers and other country elevators.

Each new crop year or harvest time, farmers and grain elevators have to make grain sale/purchase and storage decisions. Storage is undertaken with the motivation to earn more margins at a later period. A farmer may disregard storage decision and risks related with it, as he can sell all of his production to an elevator. Thus, in this case the elevator takes the full risk of price volatility and storage cost. As stated earlier, grain elevators use basis trading and merchandising skills to eliminate potential risk and losses related to their grain trading business. Knowledge of hedging and basis trading enable grain elevators to use futures market as a price discovery and risk management tool. We will provide some explanation of hedging and basis trading concepts, and how they are useful for elevators.

Hedging and Basis trading

Formal definition of hedging given by Chicago Board of Trade (1985) is when a futures position "is intended as a temporary substitute for the sale or purchase of the actual (cash) commodity". Thus, hedging is using futures market to eliminate price risk (either when buying or selling a commodity) and protect profit margins. For example, in a classical pre-harvest hedge, a farmer may sell part of his future harvest if futures prices are desirable (exceeds his production costs) to him. Then when actual harvest time arrives, he can offset (buy back previous futures contract at a lower price) his futures sale and sell his entire harvest in spot market. In this example we assumed that delivery of futures contract does not take place, but in rare cases it can take place. However, Working (1953) explains that users of futures markets do not hedge solely for the reason of price risk reduction, but rather to benefit from favorable moves in cash-futures price relations and earn extra margins. After harvest, if there is any amount of crops left unsold, then farmer needs to make storage decisions in which another type of hedging procedure needs to be considered. When storage is undertaken, then besides the price risk, storage cost risk is also associated with it. However, storing is not the main job of a farmer, but it is of an elevator.

Elevators need to account for price and storage cost risk, because as any type of cost, storage cost should be covered by the price of a product. Buying most of the harvest from farmers all over the country and storing them for later access and abundance is indeed a risky business. When buying grain from a farmer, grain elevators simultaneously sell futures contract for the same quantity of the grain bought- this is price risk hedging from elevators side. Thus, potential price risk is eliminated and replaced with basis risk. The difference between that cash price elevator bought the grain at and futures price he sold is called a basis. When this transaction is later offset with a reverse transaction, selling previously bought cash grain and buying back futures contract, it is called a basis trading. So, the original buy basis is sold and the transaction is closed.

When grain is bought in cash for further storage and hedged with a short or sold futures position, it is called "Long the Basis", whereas not yet owned grain that is sold on a forward contract for later delivery and hedged with a long or bought futures position, it is called a "Short the Basis position". In this basis position there is no storage cost, since grain is not stored.

As was mentioned above basis is understood in two ways: buy basis and sell basis. Buy basis is established when grain is bought in cash and sold in futures. Sell basis is established when grain is sold in cash and bought in futures. When basis is traded, the focus is the basis itself, not a specific price. So, basis risk occurs when sell basis is lower than the original buy basis. When transactions are completed, the lower the buy basis is and the higher the sell basis is the better. However, although basis movement has a stochastic element, it is more predictable than a price movement. Predictable basis patterns occur in grain markets and can be explained by cash-futures price relationship. This relationship (basis) is less volatile because both cash and futures prices move in same directions, but not necessarily in same increments (Chicago Board of Trade, 1985).

Waiting for a basis improvement (arbitrage opportunity) and selling the grain when basis gets higher is a fundamental concept of basis trading. Difference between sell basis and buy basis less storage cost is a margin an elevator tries to lock in. This way, grain elevators not only manage price risk, but also can earn extra profit/margin.

Hedging style used by farmers is described more by Profit Margin Hedging, whereas Basis Trading is more pertinent to grain elevators and merchandisers. Profit Margin Hedging is a pre-harvest strategy used by farmers and exercised whenever harvest time futures at pre-harvest time are higher than farmer's production costs, thus that profitable opportunity is locked in by hedging. Zulauf and Irwin (1998) define it as a farmer's production response where it "involves placing a hedge in output and/or input futures whenever expected profit from production based on expected expenses and current futures prices exceeds some specified level. In essence, the market is signaling farmers to increase production. Hedging is a way to lock in this expected profit".

Marketing strategy timing and purpose to capture specific costs coverage make Profit Margin Hedging and Basis Trading with Pre-spreads similar. However, as a farmer and grain elevator are different, these strategies are different too. Further sections of this Introduction and examples provide more support to these concepts.

In sum, there is a slight difference in hedging styles of farmers and elevators. Since a farmer never has to buy a grain from any farmer, there is no cash purchase side of a hedging transaction as grain elevators have. So, a hedging transaction has three steps from farmer's side of trading, whereas there are four steps from grain elevator's side (Example 1).

Example 1: Farmer's transaction book. Profit Margin Hedging.

Early May, pre-harvest		October, harvest	
1) Sell May futures	$6.50	2) Buy May futures	$6.40
		3) Sell cash grain	$6.30

Total gross profit earned: *$6.40*

In the above example, we can see that using futures contract as a hedging tool, a farmer gained 10 more cents per bushel to the original cash sale. Here, a farmer has only a sell basis: cash sale price, $6.30, minus buy futures price, $6.40, -10 cents.

Note: all long the basis examples do not adjust for cost of storage and/or production.

Example 2: Grain elevator's transaction book. Long the Basis position.

Later May, post-harvest		October, harvest	
1) Buy May Futures	$6.35	3) Sell May futures	$6.40
2) Sell cash grain	$6.45	4) Buy cash grain	$6.30
Sell Basis	*$.10*	*Buy Basis*	*-$.10*
		Total gross margin earned:	*$0.20*

In the grain elevator's example there are paired reverse transactions for each cash transaction. As grain elevator has to store the grain, above example depicts margins from storage (long the basis position). So, using futures contracts the elevator earned extra 5 cents per bushel (p/b). For grain elevator trading, transaction should have both buy basis and sell basis, thus it is called a basis trading. Profit margin hedging creates a producer's fixed margin subject to harvest basis risk, whereas basis trading determines an elevator's profit while reducing price risk and allowing more returns from arbitrage opportunities.

In Short the Basis position an elevator does not need to own a grain to sell, as long as it can fulfill the delivery obligation when pre-agreed delivery time arrives (Example 3).

Example 3: Short the basis position:

Early February		Early April	
1) Sell cash grain (later delivery)	$6.65	3) Buy cash grain (to deliver)	$6.45
2) Buy May futures	$6.50	4) Sell May futures	$6.55
Sell basis	*$0.15*	*Buy Basis*	*-$0.10*

Gross margin: Sell basis-Buy basis = $0.25.

Spreading

Spread is the difference of prices between two consecutive futures contract months. Time wise, spreading typically occurs when hedges move from one futures month to the next one – and is also referred to as rolling contracts forward. It is usually applied to long periods of grain storage. For example, assume corn December futures is 610 cents per bushel and March futures is 615 cents per bushel, then the spread is at a +5 cents carry. If the difference is negative then the spread is called inverted. So, there is a definite relationship between basis and spread. Spread adjusts buy basis: positive spread lowers buy basis and raises margin, whereas negative spread does the opposite. Spreading allows elevators to tie together two profitable basis positions during storage of grain, and is an important part of the hedging/basis trading toolkit during the post-harvest period.

Example 4: Long the basis position with spreads.

Early October, harvest		Late November, post-harvest		Early February, post-harvest	
1)Buy cash grain	$6.30	3)Sell March futures	$6.50	5)Sell cash grain	$6.60
2)Sell December futures	$6.40	4)Buy December futures	$6.43	6)Buy March futures	$6.51
Buy basis	*-.10*	*Spread*	*.07*	*Sell basis*	*.09*

Gross margin: Sell basis-(buy basis - spread) = $0.26 per bushel.

Pre-spreading

Pre-spreading is a strategy whereby an elevator establishes a carry spread at pre-harvest time, before buying cash grain at harvest time. Since pre-spreading gives the opportunity to lock in a good carry spread ahead of time, it seems appealing and a safe way (less risky approach) to earn margins during post-harvest storage period. Time wise, pre-spreading occurs in this order: assume in early April an elevator plans to buy grain in cash at harvest time (early October) and store it until March, May or July. So, it sets a pre-spread by buying December futures and selling March futures simultaneously in April. When harvest arrives, cash grain is bought and December futures are sold, creating normal harvest time buy basis. Since the elevator already has a December/March pre-spread, the short December futures position transacted at harvest is automatically offset by long December futures part of the pre-spread position. In effect the pre-spread position adjusts harvest time buy basis and lowers it. At the end of storage period, in March, grain is sold in cash and March futures is bought back to offset the transaction. See Example 5 below. Theoretically, pre-spreading strategy increases returns to storage if pre-spreads at pre-harvest period are higher than harvest time spreads. Moreover, pre-spreads should cover cost of storage for the planned post-harvest period, e.g. March, May or July.

Example 5: Long the basis with pre-spreads.

Early April, pre-harvest		Early October, harvest		Early February, post-harvest	
1)Sell March futures	$6.55	3)Buy cash grain	$6.30	5)Sell cash grain	$6.60
2)Buy December futures	$6.35	4)Sell December futures	$6.40	6)Buy March futures	$6.51
Pre-spread	*$0.20*	*Buy basis*	*-$0.10*	*Sell basis*	*$0.09*

Net margin: Sell basis - (buy basis - pre-spread) = $0.39 per bushel.

An acceptable level for a pre-spread is explained in terms of its ability to cover cost of storage for the planned storage period. The decision pre-spread rule implemented in this thesis is to establish the spread whenever the first opportunity arises to cover expected cost of storage at various levels. This research considers cases when pre-spread is 100%, 125% and 150% of storage costs and, thus, has three different levels of pre-spreading strategy.

Grain storage without hedging

When grain is traded only in the cash market, without involving the futures market, then these transactions are said to be un-hedged. An elevator simply buys grain in cash at harvest time and stores it in hopes of price increase during post-harvest time. Whenever a profitable opportunity arises, then the grain is sold in cash, if not then it is stored longer or sold at even lower price to discontinue storage costs. So, there is no tool used to eliminate price risk. While it is impossible for grain elevators to use this strategy, most farmers may do so with their remaining harvest.

Research objectives

This thesis focuses on grain elevators, rather than farmers. Considering the risks, basis and storage costs, faced by grain elevators and the valuable service they offer we seek to determine which are the most profitable and/or least risky marketing/storage strategies available to elevators. Specifically, we statistically compare net returns across simple cash storage, basis trading, and basis trading with pre-spread strategies. So, this research has primary and secondary objectives. Primary objective comprises the following:

- to analyze and compare returns and risk to storage from each strategy: basis trading, basis trading with pre-spreads and un-hedged storage;
- to identify most optimal timeframe, in days, for storing corn and soybeans.

Secondary objectives are to:

- analyze returns and risk to storage in terms of different futures contract months and different levels of pre-spreading;
- gauge the likelihood of establishing different pre-spread levels in the pre-harvest period;
- compare corn and soybean markets based on their marketing strategies outcomes.

Three different post-harvest futures contracts we use in this thesis are March, May and July. Harvest time futures contracts are December for corn and November for soybeans. So, we have three different basis-trading strategies using these contracts and three different pre-spreading strategies at three different levels. Pre-harvest time (pre-spreading period) is considered as April 1 - September 30 and post-harvest time as October 1-June 30 calendar months.

We refer to days in pre-harvest and post-harvest periods as storage and trading days. Storage days mean all calendar days during these periods, including weekends and holidays as long as the grain is stored, whereas trading days include only business days when markets are active. Daily cumulative returns across trading days are adjusted for storage costs incurred for all storage days.

II. LITERATURE REVIEW

Much research has analyzed grain marketing strategies. This research covers everything related to successful grain marketing including risk management, efficient markets, optimal storage decision making and profitability. Most of this body of research is from a producer's/farmer's perspective with little research focused on grain elevators.

There is not much difference between a farmer and elevator grain storage, and those farmer related strategies can be used interchangeably by elevators as well. However, a higher risk is associated with the sheer volume of grain transactions that occur at elevators. Furthermore, elevators more actively use futures and options markets than farmers do.

Risk and Returns to Storage

Optimal storage period is associated with highest profits and least risk in a given time. Storing grain is risky and done so with the expectation of higher prices for farmers, speculators and grain elevators at a later period. However, according to Working's (1949) theory of storage, there should be no optimal point in grain storage, because, prices of futures contracts account for costs of storing grain through the contract expiration/delivery time. So, any positive price difference between futures contracts for different delivery periods (referred to as spreads in grain industry) is the price of storage. This price difference should not differ substantially from the physical cost of storing grain over the same period. The case of inverted futures price relations can be explained as another aspect of theory of storage, and implies that "negative prices for storage" can occur in grain markets during periods of current scarcity. In this case the nearby futures price reflects the relatively high current demand for grain relative to supply compared with deferred time periods. Another, later article of Working (1953) provides some clarifications on misapprehensions and misconceptions about futures markets and hedging. Working emphasizes that hedgers do not hedge merely to reduce risk; rather they hedge to benefit from cash-futures price arbitrage opportunities (p.325). Since there is a possibility of "negative prices for storage", in this research, we assume that optimal storage will occur when "prices for storage are positive".

Cunningham, Brorsen, & Anderson (2007) find that Oklahoma wheat producers who follow active cash marketing style strategies tend to store longer and receive lower prices because they store beyond the optimal storage time. They attribute this to the fact that farmers tend to be overconfident about their marketing timing skills and/or averse to myopic loss, e.g. after they have missed a sale at the highest price they consider selling at a price lower than that to be a loss, and thus, prefer storing than selling. Also, they find that net prices – adjusted for storage costs – tend to decrease over storage time. They note that their results may not be accurate as each producer's cost of carry can be different from others. Their results also support EMH as activeness variable on received prices in their model was insignificant. Active cash marketing style is defined by them as a strategy where farmers sell crop in different weeks of different harvest years in anticipation of better prices, whereas mechanical style farmers sell crop in the same week every year. So, for these cash marketing strategies they find no difference in their returns. Cunningham et al also cite Slusher's (1987) thesis research results regarding soybean optimal storage: storing soybeans beyond one month leads to negative returns, and strategies such as cash sales, storage, and basis contracts did not affect prices received by Indiana farmers.

Kastens & Dhuyvetter (1999) analyze post-harvest grain storage marketing strategies for Kansas corn, soybean, wheat and milo farmers. They simulated expected returns to storage over

13 years. They find that for 10 out of 13 locations a strategy of hedging and storing soybeans generated positive but not significant returns, whereas un-hedged storage generated significantly positive returns. During these years hedged storage reduced risk for corn and milo, but increased it for wheat and soybeans. As is the case with most of the literature on futures market efficiency, Kastens and Dhuyvetter results support grain futures market efficiency. They did not find advantageous profits to hedging across 32 model simulations. However, they found reduced risk for 20 simulations out of 32.

Peterson & Tomek (2007) compared four different groups of marketing strategies, from farmer's perspective, against base strategy-selling entire crop at harvest in cash. They use 40 year samples and run 10,000 simulations of corn futures prices. One group of the strategies they evaluate includes corn storage after harvest. One storage strategy routinely stores the crop without hedging and the second one hedges the storage in November using May futures, and sells at the May cash price, which is similar to our long the basis strategy.

Storage strategy with no hedging offered more variable returns, by 20.8%, and less mean returns by 1.4 cents than their base strategy of selling in cash at harvest. Post-harvest hedged storage strategy instead, reduced returns variability by 26.7% at the cost of even less mean returns. In general, all strategies involving hedging reduced lifetime variability of returns. However, no strategy was found to "beat the market", in the long run, with consistent higher returns, and superiority of some strategies were only time specific.

Zulauf and Irwin (1998) also analyze the case when a farmer needs to store his crop after harvest; data is for Ohio corn produced during 1964-96. Net returns to storage for corn, both hedged and un-hedged, were significantly positive for post-harvest storage periods beginning at the 50% harvest completion date (10% and 90% completion dates were not significant). Greatest returns occurred during storage periods of December 1-January 15 for un-hedged storage and of December 1-February 15 for hedged storage, where risk was substantially small.

Hauser et al (1990) find that returns variance of un-hedged soybean position increases more than returns variance of hedged position, confirming hedging effectiveness. They find that hedging opportunities to reduce risk vary depending on location and time of the marketing period. They compare 10 grain elevators on the Ohio, Mississippi and Illinois River.

Pre-harvest marketing strategies

Wisner, Blue, and Baldwin (1998) tested pre-harvest marketing strategies returns (simulated) versus returns from harvest cash sales for Ohio and Iowa corn and soybean farms. They also examined and analyzed seasonal price patterns and pricing premiums for marketing years 1975-1995. They find statistical significances between spring December futures prices and October prices for corn and soybean normal crop years, pre-harvest prices being higher than harvest time ones. So, they conclude that futures prices are not good indicators of harvest time prices, and as such can be exploited to form marketing strategies that can generate additional profits to simply selling in a cash market at harvest time. But, for short-crop years they find significance in prices in opposite direction: prices rise from pre-harvest time to harvest time (July-November). In years after short-crop years December corn and November soybean futures almost always were lower at harvest than in later winter before harvest. Following results from pre-harvest price patterns, they create pre-harvest marketing strategies and test their significance of returns. Since our pre-spreading strategy includes “locking in” good pre-harvest spreads, we can compare consistency of our results with their results.

Ten pre-harvest marketing strategies for soybeans and corn were generated; each includes futures, options or both, and were tested to see if they generate significantly different/higher net returns compared with naive cash marketing at harvest. For soybeans 5 out of 10 strategies for Ohio and 4 out 10 for Iowa yielded significantly higher returns. All of these strategies included options only. For corn 2 out of 10 strategies had significantly higher returns than cash marketing strategy and also included options. Thus, they also test for risk premiums for spring and summer periods of 1949-71 and 1975-96, and they find no risk premium for soybeans futures prices and mixture of results for corn that hint at the possibility of a risk premium in corn futures market – a violation of "Efficient Markets Hypothesis" (EMH). The strategies this research seeks to analyze are loosely based on the concept of farmer profit margin hedging. Under a profit margin hedging rule one first determines his/her actual production cost. Then futures prices are used to lock in profitable sale price opportunities (pre-harvest hedging) in terms of profit margins per unit of production, e.g. cents per bushel of corn, soybean and etc. In the elevator's case his profit margin should cover cost of storing grain per bushel. So futures transactions (pre-spreading) entered into before harvest time may be timed to cover a certain level of projected storage costs – referred to as cost-of-carry in grain industry.

A study by Kim, Brorsen, and Anderson (2010) compared returns to profit margin hedging for farmers versus other strategies such as "Always Hedging" and "Selling at Harvest in cash market". They simulate expected target utility functions for corn and soybean farmers over 31 years, and find that returns from profit margin hedging were not significantly different from always hedging, except for a soybean with yield risk scenario. However, returns from profit margin hedging were significantly higher than cash sale returns at harvest for both corn and soybeans.

Zulauf and Irwin (1998) do empirical research on different grain marketing strategies to test their ability to increase returns for farmers. The study heavily incorporates strategy expected outcomes with EMH by analyzing futures and options markets price behavior. Under EMH expected average change in current future price equals zero (Fama). This is because the current futures price incorporates all relevant market information, and as such its price dynamics can be best described as a random walk. One of the strategies they test is routine hedging; this is where farmers sell futures at a specific date to hedge part of their crop before harvest. Statistical results showed that there was no significant difference between pre-harvest and harvest time futures quotes for corn and soybean during 1952-97, and so routine hedging was not found to statistically increase returns. To test farm income sensitivity to these futures price quotes (different farms have different yields and prices), they apply this strategy to 21 farms operated by University of Illinois for only 1985-1995 period. Again, pre-harvest and harvest time returns did not differ significantly. Peterson and Tomek (2007) also studied the case where farmers pre-sell their expected entire corn harvest in May hedged with December futures contract, and found reduced risk and returns than harvest time sales.

Another pertinent strategy mentioned by Zulauf and Irwin is Farm Production Response Hedging, which is based on market-generated forecasts of production profits. Zulauf and Irwin define this strategy as a signal for a farmer whether to increase or decrease production. Farmers can lock in expected profits, as they can do so with returns to storage by hedging. However, the rationale behind this strategy seems to add odds with rational expectations theory and EMH and thus it should not produce abnormal profit opportunities.

Analyzing existing literature on profit margin hedging, Zulauf and Irwin find a need for research on this area using appropriate statistical techniques and samples, as the existing ones are not of high enough quality to make definitive conclusions. They see potential in this strategy in terms of income enhancement or risk reduction, because farmers no longer abide by government production plans. However, Zulauf and Irwin do not perform any empirical analysis regarding this strategy.

We hope that our research can enhance this limited research area as we evaluate a form of profit margin hedging, which we refer to as basis trading with pre-spreads strategy using appropriate statistical tools and 20 years of daily data. However, since this strategy is broadly used by grain elevators rather than by farmers, we analyze the issue from a grain elevator's perspective. At the same time, its conclusions can be applied to farmers as well, because the strategy pertains to optimal storage and returns, which relates to a farmer's decision "to sell at harvest or store, and for how long to store".

As elaborated in the Introduction, profit margin hedging is analogous to "basis trading with pre-spreads" as outlined in this thesis research. It is so routinely used by grain merchandisers, and margins are generated by buying and selling basis positions, as opposed to famer style hedging. The term "pre-spreading" is also used by grain merchandisers and is just abbreviated version of "basis trading with pre-spreads" strategy.

III. METHODOLOGY AND DATA

In this section we explain methodology of hedging, basis trading and storage concepts as stated in the Introduction section. Then, we discuss how some data were generated and applied in delivering the statistical results.

Basis trading

As mentioned in the Introduction section, there are two main ways to trade basis: long the basis and short the basis. However, these strategies may be further sub-divided into other versions of basis trading. For example, one version that is commonly used in the grain industry and that is analyzed in this thesis is long-the basis with pre-spreading. This thesis research analyses three returns to storage strategies – available to country grain elevators – with respect to two different commodities (corn and soybeans) at a specific geographic location. Thus, main objective of the research is to evaluate average returns to storage for a 20 year period over a number of post-harvest days in terms of higher margins, less risk and optimal storage period length.

To determine net margins per bushel from grain, after identifying basis for a specific day, we need to calculate cost of carry (COC) per day. Cost of carry is simply the cost of storing grain until a specific period. This research assumes storage period as post-harvest: beginning of October through end of June.

When COC is determined on a daily basis, we can easily adjust it for extended periods by just multiplying it by number of days we want to store the grain. So, the formula for cumulative COC is the following:

$$COC_t = (S_t).(r).(j/360) \quad (1)$$

where S_t is current spot/cash price observed at harvest time t, October 1st;

r is interest rate observed at that time plus 2% for miscellaneous expenses-insurance, grain shrinkage and etc. A 2% charge is standard practice in the industry to approximate opportunity costs (Lorton and White, 2006);

360 days represent the number of banking days in a year;

j represents number of storage days and ranges from 1 to 270, as 270 is the maximum number of days considered through our assumed storage period, including weekends.

The total number of days considered for the basis trading strategies (spread and no spread) differs across the futures contract used to initiate the hedge position: if March futures are used, then 150 days are analyzed; if May futures are used, then 210 days are analyzed; and if July futures are used, then 270 days are analyzed.

Now, we can calculate cumulative net returns (NR) over storage days from the basis trading strategy as:

$$NR_{t+j} = (S_{t+j} - F_{t+j}^{t+n}) - (S_t - F_t^{t+n}) - COC_{t+j} \quad (2)$$

where $t+n$ represents the delivery period for a futures contract maturing at time $t+n$;

$(S_{t+j} - F_{t+j}^{t+n})$ is basis at time $t+$ *j(post-harvest),* sell basis;

$(S_t - F_t^{t+n})$ is basis at time t *(harvest),* buy basis;

COC_{t+j} is cumulative cost of carry at time $t+j$.

It is assumed a grain elevator sets a buy basis on October 1st and potentially stores grain until the end of planned storage period. Cumulative net returns are calculated for each day over the storage period. So, for each day we record the cumulative returns generated from closing the hedged position by transacting a sell basis. In this way we can assess average returns to storage across time, strategies and commodities.

When setting basis-trading scenarios with different maturing futures contracts, we assume the elevator hedges directly in each of the different maturing futures contracts as opposed to initiating the hedge in the nearby contract and later “spreading” or “rolling over” between futures months to extend storage periods. So for example, in the basis trading case where we analyze storage from October through the following June, we suppose that the elevator, buys cash grain on October 1st and simultaneously sells July futures, and offsets the transaction close to end of June storage period. Thus, we do not calculate or consider spreads between futures months from December through July.

As mentioned earlier in the Introduction part, trading basis incorporates basis risk. Farmers may use basis signal (Working 1953) to avoid basis risk. Basis signal is positive if difference between current post-harvest futures quote and spot price at harvest time exceeds storage costs. Otherwise, the signal is negative and indicates not storing.

$$F_{t+j}^{t+n}\text{-}S_t > COC_t \qquad (3)$$

Under such circumstances, storing and hedging grain over time $t + j$ will result in higher margins than simply selling it at harvest time. Note that this research sees basis signal from farmer’s perspective only, and does not apply it to grain elevator business. Because, as the main job of grain elevator is storage, we assume that the elevator stores the grain irrespective of basis signal to supply grain end users all year round. While it seems risky for elevators to store grain with negative basis signal, in reality grain holders store and supply grain at zero returns, even at negative ones. Because, elevators and grain merchants have to keep adequate stocks to supply their customers, negative returns tend to be offset by convenience yields (Working, 1948). A convenience yield is explained as an extra return (can also be in non-monetary forms such as goodwill and value) for providing convenience to business operators when needed (Kaldor, 1939 and Bobenrieth et al, 2004), for example, supplying grain in scarcity periods. Moreover, most costs are fixed and joint in the short run, so they do not necessarily depend on bushels of grain stored (Working, 1948).

Some previous research found significantly positive net returns when basis signal was used in hedging and storage decisions. For example, Zulauf and Irwin (1998) analyze hedged storage strategy with 33 years of data following basis signal and found twice larger average net returns than not following the signal.

Kastens & Dhuyvetter (1999) find that different models of basis expectation (three year average basis and/or current basis) in determining basis signal and hedging decisions are very important, as returns and risk to storage varied significantly in different cases. However, Hauser, Garcia, & Tumblin (1990) found no significance in hedging effectiveness when various basis expectation models were analyzed (18 year period). Even so, the model which considers past year's new-crop bases performed better forecast of returns to storage for soybeans.

Basis-trading with pre spreads

In this research we consider pre-spreads between December (harvest time) and March, May and July (post-harvest) corn futures contracts and November (harvest time) and March, May, and July soybean futures contracts . For pre-spreading we consider pre-harvest period of April 1st through September 30th. As was stated in the Introduction, we try to capture pre-spreads when they cover 100%, 125% and 150% of expected storage cost till the time an elevator plans to store.

So, first we determine expected cost of storage as of April 1 through September 30:

$$E_{t-k}(COC_{t+n}) = E_{t-k}(S_t).(r).(t+n/360) \qquad (4)$$

where E_{t-k} is an expectations operator observed at time *t-k*, and *k* is days 1 to 180, the number of days between April 1 and September 30;

$E_{t-k}(S_t)$ is the harvest time expected cash price, based on basis proxies. This is consistent with the efficient markets hypothesis (EMH) as outlined in McKenzie and Holt (2002); McKenzie et al. (2002).

We derive expected harvest time cash price from last year's harvest time (December corn and November soybean) basis and current year's harvest time futures contracts (December and November) observed at pre-harvest time (April 1 – September 30) prices:

$$E_{t-k}(S_t) = F_{t-k}^{t} + (S_{t-360} - F_{t-360}^{t-360}) \qquad (5)$$

Again, the total storage period considered will vary depending on the futures contract month an elevator desires to use. If an elevator decides to pre-spread with March contract, then maximum number of storage days would be 150, and if it decides to use May contract, then the maximum storage period would be 210 days respectively. For July contract, the entire post-harvest storage period, is 270 days.

Net returns from pre-spreading are calculated as follows:

$$NR_{t+j} = (S_{t+j} - F_{t+j}^{t+n}) - (S_t - F_t^t) + (F_{t-k}^{t+n} - F_{t-k}^t) - COC_{t+j} \quad (6)$$

where $(S_{t+j} - F_{t+j}^{t+n})$ is sell basis at time $t + j$, post-harvest time;

$(S_t - F_t^t)$ is buy basis at time t, harvest time;

$(F_{t-k}^{t+n} - F_{t-k}^t)$ is pre-spread at time t-k, pre-harvest time.

With the pre-spread, the buy basis is adjusted: when pre-spread is a positive carry spread (an i.e. deferred post-harvest future contract is higher priced than the nearby harvest futures contract) it lowers the buy basis. COC_{t+j} time frame in pre-spreading will depend on the futures contract month an elevator is exercising, as mentioned above. Pre-spread level is identified by simply dividing a pre-spread by expected COC. So, for a 100% pre-spread coverage level strategy, the first trading day in the pre-harvest period when futures price differences cover expected COC at a level of 100% or higher the pre-spread is assumed to be set. Analogously, 125% and 150% pre-spreads are assumed to be transacted in the same manner – i.e. at the first opportunity.

If a pre-spread does not occur during the pre-harvest time, then we assume that an elevator will store the grain and simply do long the basis-trading. So, in our empirical analyses, we just simply replace pre-spreading margins with basis-trading margins for years when required pre-spread levels are not observed or attainable.

Grain storage without hedging

The cash-storage trading strategy, where no hedging of any kind takes place, generates the following net return:

$$NR_{t+j} = S_{t+j} - S_t - COC_{t+j} \qquad (7)$$

where S_{t+j} is a spot price at post-harvest time;

S_t is a spot price at harvest time;

COC_{t+j} is cost of carry up to post-harvest day j

Analytical approach

For our post-harvest storage basis-trading and basis-trading with pre-spreads strategies we use March, May and July futures contracts. Daily cumulative net margins are generated from 20 years of daily observations, based upon a total of 185 trading days from October 1 to June 30 each year. Since this research is interested in cumulative daily returns to storage, we use cumulative daily averages of net margins across the 20 years. All cumulative daily mean net returns from the various strategies are tested to see if they are significant at 5% level. This allows us to determine which of any strategies generate significantly positive net returns with respect to commodity type and length of storage period. Having calculated net returns (margins) per bushel from each strategy: basis-trading, basis-trading with pre-spread levels and un-hedged trading, we statistically analyze margins in three different ways.

The first type of approach we refer to as “Same contract, different levels” where we compare basis-trading margins with pre-spreading margins at different levels of the same futures contract month. Precisely, March basis-trading net returns are compared against March Pre-spreading net returns at 100%, 125% and 150% levels. Then, this procedure is repeated for May and July contract strategies net returns as well.

The second type of analysis is referred to as "Different contracts, same periods" where each of the three futures month strategies outcomes are compared against each other when more than one futures contract is available for a specific period. For example, in March futures contract period there also May, July and September contracts are available. After, one futures contract month ends, combination of alternative futures contracts reduce by one respectively. So, for March contract period we compare returns from March, May and July contracts simultaneously. Purpose of this analysis is to determine what futures contract generates the most profit for a specific period.

There are 150 storage days and 99 trading days in March contract period. Trading days are defined as storage days less weekends and holidays during the storage period. Then we compare net returns from May and July contracts, as they fall into May storage period: October 1st to end of April. There are 210 storage days and 142 trading days in May period. Since we didn't include September futures in this thesis, July contract closes the post-harvest period.

The last type of analysis assists with storage decision, and we refer to it as "Keep storing or stop". In this case we test returns over time to determine if there is a statistical difference between storing for longer versus shorter periods of time. Using this type of analysis, we can identify optimal or most profitable storage periods. In addition, this part of analysis allows us to evaluate risk of storing.

Statistical testing procedures

Microsoft Excel and Statistical Analysis Software (SAS 9.3) were interchangeably used to run statistical tests. First, we test for distribution normality of cumulative net margins derived from all strategies. For that purpose, Shapiro-Wilk test was used in SAS.

Then, we conduct an F-test for equal variances, pairing strategy daily margins within and across months. Using this test we want to identify most and least risky strategies. Also, variances of same strategies are compared across time, for example, variance on storage day 21 versus day 99 in March trading period. Hence, we can see how variance changes through the storage period.

We find paired t-test the most suitable for our case because margins from all strategies are highly correlated with each other. Reasons for correlation are: cash prices are the same in all strategies; all three futures contract prices are highly correlated – which is consistent with theory of storage model; most importantly, when pre-spread at a specific level is not observed, in that trading period simple basis-trading is implemented, so both basis-trading and basis-trading with pre-spreads will have same margins.

Theory of storage and inter-temporal prices introduced by Working (1949) explains that futures prices of different contract months change/move together at a same rate or percent. Because, expectations of coming harvest affect futures prices of pre-harvest contracts as well as harvest time contracts, thus inter-temporal price relations are not independent.

Another vital reason for applying paired t-test for same contract month different strategies is that basis-trading and its respective pre-spread levels are highly correlated, up to 99%. This kind of high correlation comes from arithmetic of calculating pre-spread levels. The only difference in margins is due to adjusted buy basis (buy basis minus the pre-spread) on

October 1st, but rest of the sell basis stays the same as in simple Basis-trading, because pre-spreading does not affect sell basis. So, when a pre-spread level is set, margins for that trading period will only differ by a constant number between its original buy basis (basis-trading with no pre-spread) and adjusted basis (Dec buy basis minus pre-spread). For example, when setting a buy basis and pre-spread level for May contract, buy basis for basis-trading would be cash price minus May futures price on October 1st, let's say -15.2 cents per bushel. And, for pre-spreading, adjusted buy basis would be cash price minus December futures price on October 1st minus a December – May futures spread captured earlier at pre-harvest time: let Dec basis be -6.25 and Dec/May pre-spread 7.75 cents per bushel. So, only changed variable is the initial buy basis on October 1st (day 1) and resulting cumulative daily margins differ by this initial constant difference, in this case 1.20 (Example 8). Thus, difference between basis-trading and pre-spreading margins is a constant number within a trading period, but not constant across different trading periods, as new trading period starts with a new pre-spread value each trading year. Therefore, it is sufficient for us to test only one day during the whole trading period, and extend its conclusion for all days. By using a paired t-test we are able to test the differences between each observation of two strategies (daily margins), and see whether mean of differences is significant or not.

Example 8

Basis trading					Pre-spreading150				
Days	May Basis	COC	Margin		Days	Adj Basis	COC	Margin	Difference
1	-15.2	6.78			1	-14	6.78		1.20
2	-16.85	0.32	-1.97		2	-16.85	0.32	-3.17	1.20
3	-20.05	0.65	-5.50		3	-20.05	0.65	-6.70	1.20
4	-23.55	0.97	-9.32		4	-23.55	0.97	-10.52	1.20
5	-27.3	1.29	-13.39		5	-27.3	1.29	-14.59	1.20
6	-22	1.61	-8.41		6	-22	1.61	-9.61	1.20
7	-19.4	1.94	-6.14		7	-19.4	1.94	-7.34	1.20

Relevant formulas for a paired t-test:

$$t = \frac{\bar{D}}{S_{\bar{D}}} = \frac{\bar{D}}{\frac{S_D}{\sqrt{n}}} = \frac{\bar{D}}{\sqrt{\frac{SS_D}{n(n-1)}}} \qquad (8)$$

where $\bar{D}$ is mean of paired differences;

$S_{\bar{D}}$ is standard deviation of that mean;

SS_D is $\sum_{i=1}^{n} D_i^2 - {(\sum_{i=1}^{n} D_i)^2}/{n}$;

n is number of pairs (sample).

Data

Secondary data, for years 1991[1] -2012, collected were daily average cash bid prices, settle futures prices and prime interest rates. Cash bid prices were taken from Agricultural Marketing Service of USDA for North Central Illinois location; Chicago Board of Trade futures contracts from Bridge CRB; and prime interest rates from Federal Reserves Bank of St. Louis.

When missing cash prices were observed, data was built using regressions with related cash prices. Data used to predict our missing values were gathered from USDA Agricultural Marketing Service as well, but for different – but correlated – locations. A few observations were not available for any location, especially on holidays, so we replaced those cash prices with previous day's value. There were 29 days with missing cash price values for corn and 36 days for soybean throughout 20 years.

[1] 1991Z (December) futures contract was only used to determine lagged basis for calculating expected COC in 1992. Our analysis of net returns and risk begins from year 1992 to 2011.

Although interest rates changed more than once during some calendar years, our daily interest rates are held constant from each October 1 through June 30, end of post-harvest storage period. Rationale behind that is once a loan is contracted with a bank, we assume interest rate stays unchanged throughout the agreement period. However, we do not hold pre-harvest time interest rates constant in estimating expected COC. Because, those interest rates are estimates/indicators of harvest time interest rates as well.

Pre-spread level determination

We assume pre-spread period from April to end of September. So, an elevator can set first available pre-spread at pre-harvest time and adjust it with Dec basis in October, harvest-time. All spreads between futures months Dec-March, Dec-May and Dec-July for corn and Nov-March, Nov-May and Nov-July for soybeans are divided by expected COC with their respective number of days March-99, May-142 and July-185. Then a spread is selected where it covers expected COC at 100%, 125% and 150% and above, and these positions form our pre-spreading strategy and generate our pre-spreading strategy net returns.

During Dec-March pre-spread period we observed pre-spreads at 100%-125% for 17 years out of our total 20 years of observations. Spreads at 125%-150% occurred 15 times (excluding years 1993, 1995-1997 and 2011). Spreads at 150% and above happened 11 times out of 20, and excluded years 1992-1997, 2007, 2008 and 2011.

During Dec-May pre-spread period spread at 100%-125% covering expected COC occurred 17 times at 20 year period. Spreads at 125%-150% level were observed 17 times (excluding years 1995-1997). Spreads at 150% and above occurred 14 times out of 20, and excluded years 1993, 1995-1997, 2007 and 2011.

During Dec-July pre-spread period there were 17 years where pre-spread was observed at 100%-125%. Spreads at 125%-150% happened 17 times (excluding years 1995-1997) during 20 year observation. COC coverage by spreads at 150% and above was observed 15 times when July futures contract is used. Years when this case did not happen were 1993, 1995-1997, and 2011.

In soybeans market spread at 150% and 125%[2] of COC cover were not observed at all. Only 100% cover by spreads occurred in 7 years for March and July futures contracts, and 8 years for May contract during our 20 years of observation. These years include 1998, 1999, 2000, 2001, 2004, 2006 and 2008, and plus 1992 respectively.

[2] Actually, pre-spread at 125% level was observed once during this pre-harvest period, but we exclude it from analysis due to potential statistical inaccuracy.

IV. RESULTS

Corn

Before running any statistical analysis, we first test sample data for normality using Shapiro-Wilk test at 1% level of significance in SAS. Null hypothesis is that sample data is normally distributed. This test for all March and May strategies cumulative net returns did not reject the null hypothesis, except for 2 days in May pre-spreading125 strategy.

However, several daily cumulative net returns were not normally distributed when July strategies were employed. In July basis-trading 1 day (46), July pre-spreading150 7 days (42-50), July pre-spreading125 10 days (45-52 and 153, 176) July pre-spreading100 7 days (150-153 and 176-179) rejected this normality hypothesis. There are 185 trading days in July contract strategy period. Thus, we are able to apply parametric statistical analysis. Cumulative net returns from un-hedged corn storage strategy rejected normality at 1% level for 71 days out of 185.

Daily F-test of equal variances for paired strategies was conducted as well. At 19 degrees of freedom F lower and higher critical values are 0.4612 and 2.1682, where F-statistics between these values indicate variances equality.

Prior to comparing and contrasting any given pre-spreading strategy across different COC coverage levels, we present one sample two tailed t-test results for each basis-trading strategy with respect to each of the different futures contract to determine if their respective mean cumulative net returns are statistically different from zero at 5% level. Results are graphically represented below in Figures 1, 2 and 3(Appendix 1).

Figure 1. Daily cumulative net returns from March contract corn basis trading.

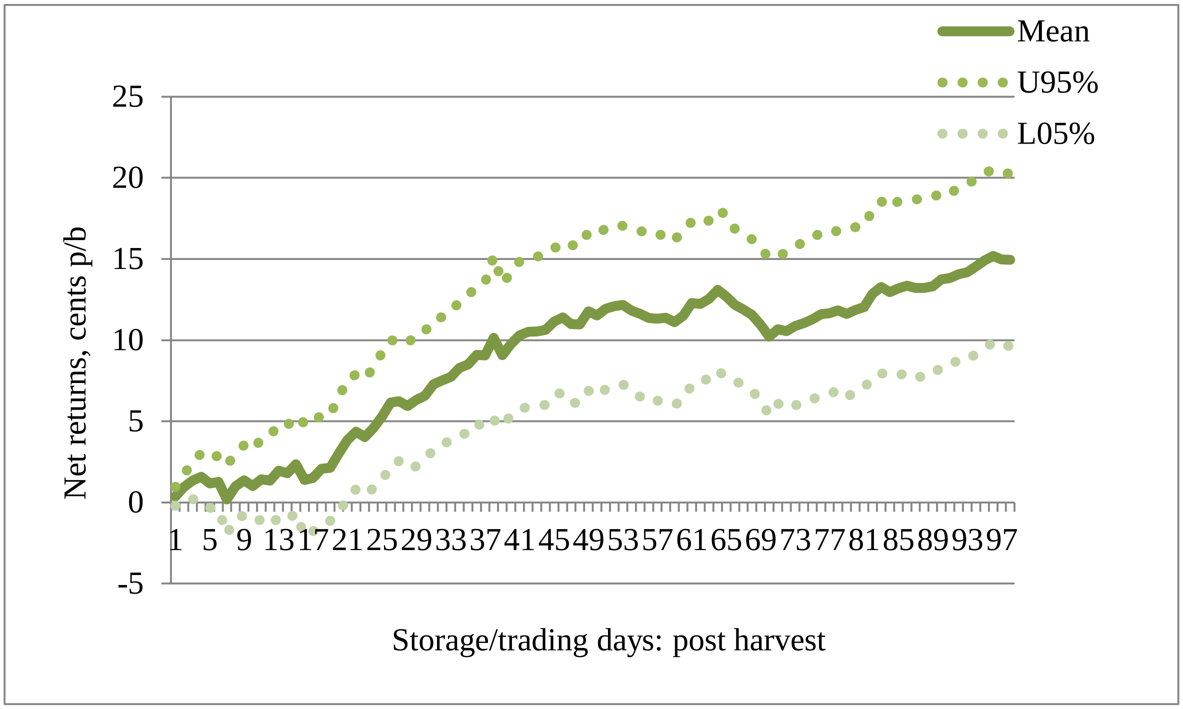


Figure 2. Daily cumulative net returns from May contract corn basis trading.

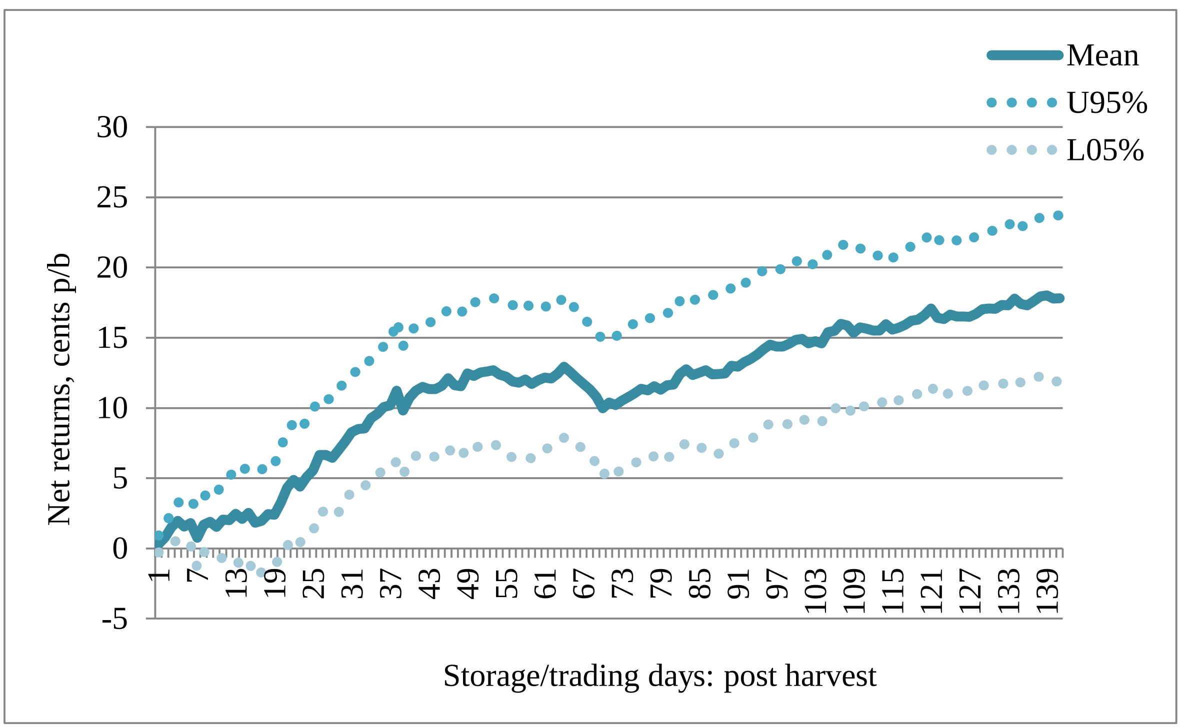
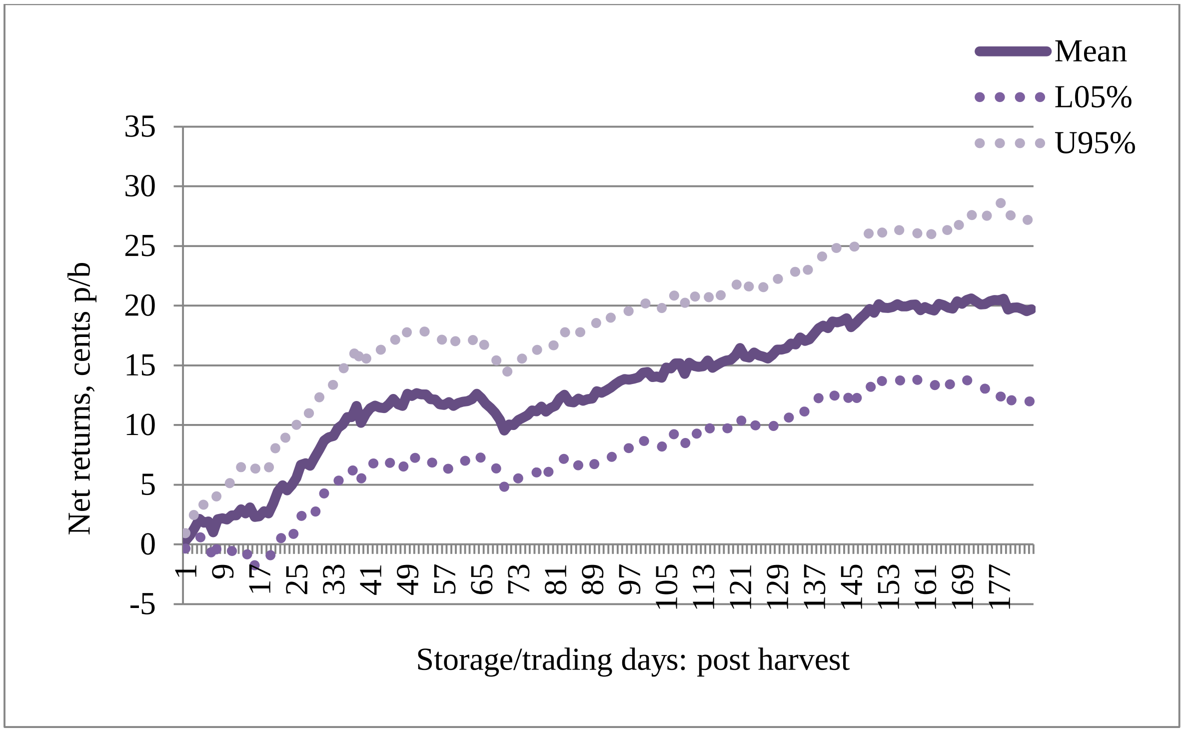


Figure 3. Daily cumulative net returns from July contract corn basis trading.



So, from all three graphs we can see that cumulative mean net returns from basis trading strategies are significantly positive starting from trading day 20, and tend to increase over the storage period. Thus, in further differences analysis we exclude those days with insignificant net returns. Apparently, those 20 trading days are still harvest time period, where trade of grain is still active in the cash market, thus sell basis is lower than a buy basis. So, it does not make sense for an elevator to offset long-the-basis positions at this time. Rather, it shows that it is better keep buying during that period and store beyond 20 trading days, and then offset long-the-basis positions during periods when it is possible to obtain a higher sell basis. Now, we can proceed to inter-strategy comparisons. Let's see how mean net returns from each strategy – basis trading and pre-spreading levels – are related with one another.

"Same contract, different levels" analysis

Figure 4. Daily cumulative mean net returns from March contract strategies

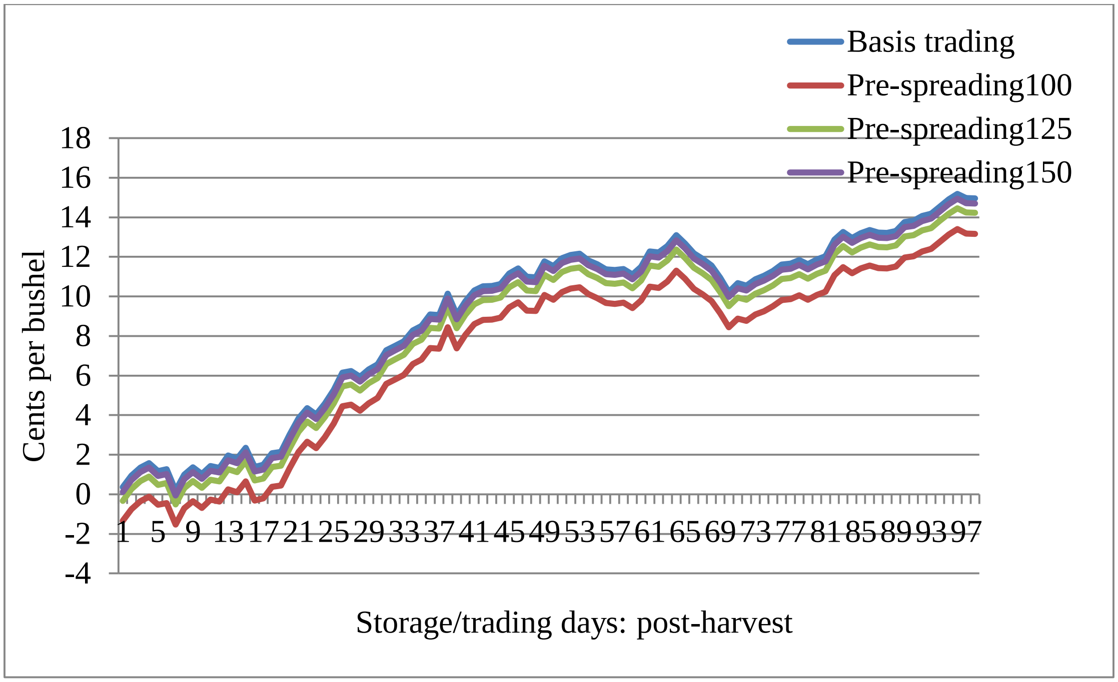


Figure 5. Daily cumulative mean net returns from May contract strategies

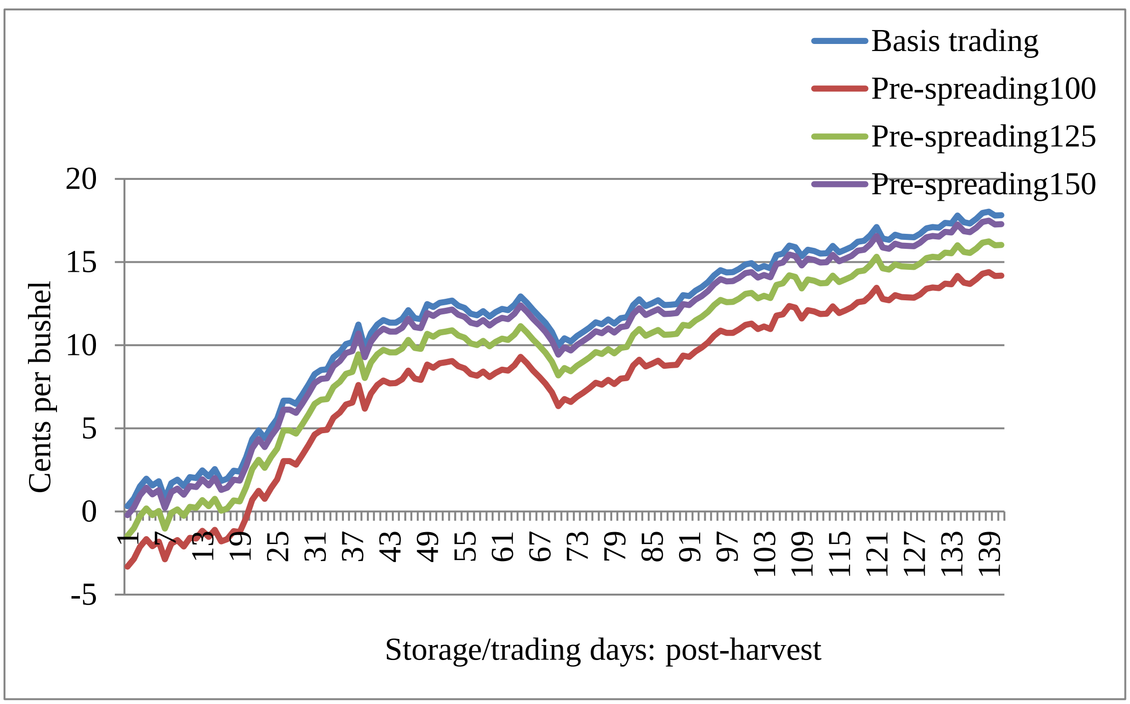
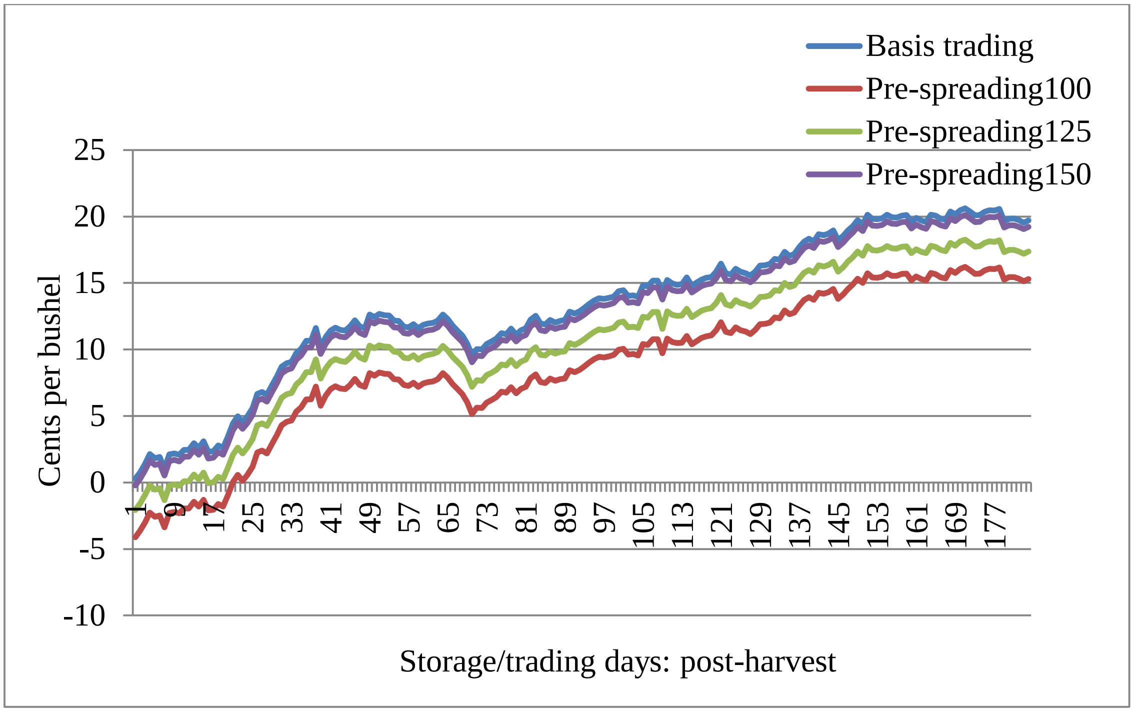


Figure 6. Daily cumulative mean net returns from July contract strategies



From all three different futures month contract trading strategies (Figures 4, 5 and 6) we see that basis trading and pre-spreading at 150% level of storage cost coverage generate similar returns, whereas pre-spreading at 100% generates the least net returns. Now, following our "Same contract, different levels" analysis, we statistically test these differences for significance. We use one tailed paired t-test and conclusions are based on 5% level of significance for cumulative net returns measured on any day of our sample. Table 1 below summarizes statistical results, with corresponding p-values and mean of differences between basis trading and its pre-spreading level net returns. Null hypothesis is that mean of differences of cumulative net returns is zero.

Table 1. Basis-trading and pre-spreading levels-Corn

	March Basis-trading		May Basis-trading		July Basis-trading	
	P-value	Difference	P-value	Difference	P-value	Difference
Pre-spreading150	0.136	0.24	0.040*	0.80	0.101	0.97
Pre-spreading125	0.015*	0.70	0.000*	2.28	0.010*	2.73
Pre-spreading100	0.000*	1.70	0.000*	3.95	0.000*	4.98

March strategies cumulative mean net returns, 99 day period

Net returns from basis trading and pre-spreading150 are compared with their daily difference means, for 99 days post-harvest based upon all days. We cannot reject the null hypothesis of no mean difference at α=5% level. We conclude that although March basis-trading strategy on average numerically generates 0.24 cents per bushel more than pre-spreading150 strategy, this difference is not statistically different.

However, for March basis-trading and pre-spreading125 level returns we reject the null hypothesis, and conclude that their daily cumulative mean net returns are significantly different. March basis-trading cumulative mean net returns are higher than the pre-spreading125 returns by 0.7 cents per bushel. Statistically and intuitively we reach the same conclusion for pre-spreading100 level comparison: with basis-trading margins being statistically higher by 1.7 cents per bushel.

* significance at 5% level, one tail paired t-test

May strategies cumulative mean net returns, 142 day period

Daily cumulative net returns from May strategies are analyzed over 142 days from harvest to contract month expiration. May mean net returns from basis-trading and pre-spreading150 are significantly different from each other: with rejecting p–value of 4% and daily mean difference of 0.80 cents per bushel. Both pre-spreading125 and pre-spreading100 daily mean margins are significantly different from basis-trading margins, with lower 2.28 and 3.95 cents per bushel margins respectively.

July strategies cumulative mean net returns, 185 day period

July contract strategies are compared daily over 185 days. Similar to March and May contract strategies, daily cumulative mean net returns for July basis-trading and pre-spreading150 strategies are not statistically different at 10% p-value. Again, we reach the same conclusions for pre-spreading125 and pre-spreading100 strategies as in March and May. Their cumulative daily mean net return are significantly different from basis-trading strategy returns, and lower by 2.73 and 4.98 cents per bushel respectively.

So, we can see that pre-spreading does not generate, on average, additional net returns when compared with simple long the basis trading strategy, and in fact 125% and 100% pre-spreading strategies result in statistically lower cumulative mean net returns . May contract offers pre-spreading150 mean net returns that are significantly less than May basis trading strategy, unlike two other contracts. In addition, we observe that the more deferred the pre-spread contract months generates on average lower net returns in comparison to simple basis-trading strategies for these same months. In sum, pre-spreading does not appear to provide better/higher net returns opportunities than basis-trading strategy.

Now, we test daily variances of cumulative net returns from basis trading and pre-spreading strategies. Since we have found that pre-spreading100 strategy generated significantly the least mean net returns for all of the three contract strategies, we test variances of net returns from basis trading and pre-spreading100 to determine whether their variances are significantly different or not. Summary of results are summarized below and detail results are attached in the Appendix 2A:

March contract strategies. Basis-trading and pre-spreading100 strategies were found to have daily equal variances. So, we can be certain that variances of net returns from basis trading and other pre-spreading strategies are equal as well, due to their net returns mean equality;

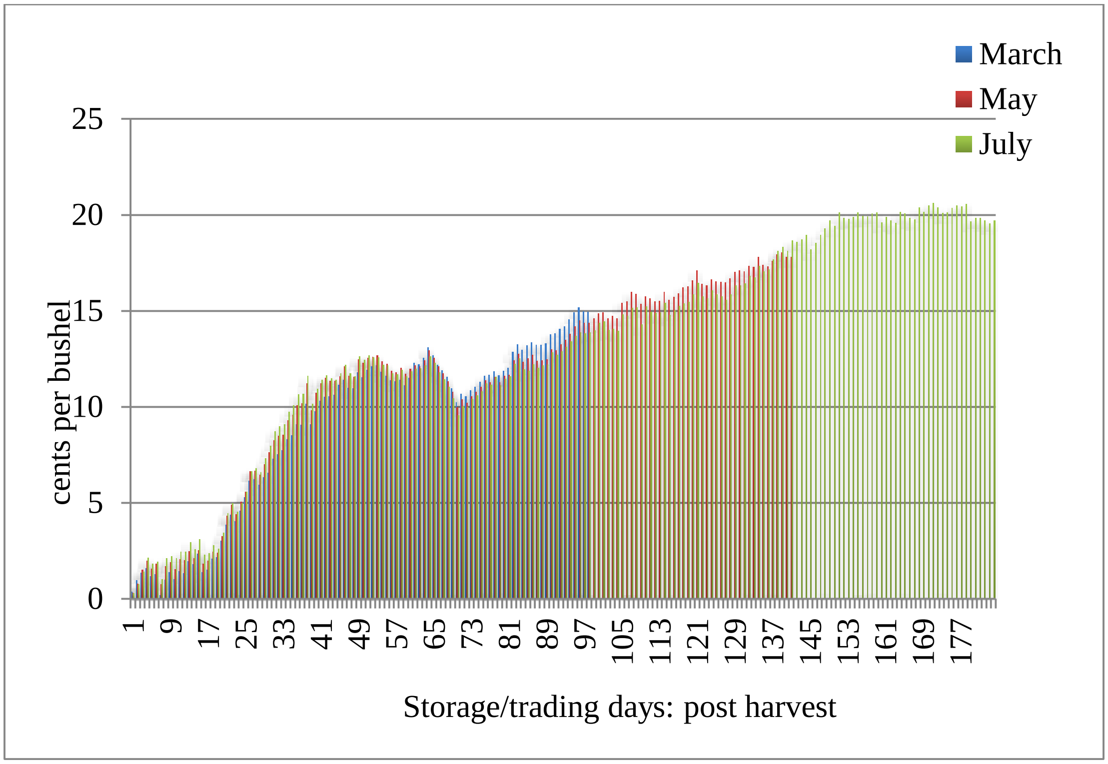
May contract strategies. Basis-trading and pre-spreading100 strategies were found to have daily equal variances except for 4 days in the beginning. This conclusion can be generalized for other levels of pre-spreading net returns variances;

July contract strategies. Basis-trading and pre-spreading100 strategy variances are statistically equal for 179 days, where first 6 day variances are not equal. Similar conclusion can be drawn for basis trading and other levels of pre-spreading net returns variances, because basis trading and pre-spreading150 mean net returns are statistically equal.

"Different contracts, same period" analysis

Since our results indicate that basis-trading and pre-spreading150 strategies mean net returns are statistically equal for March and July contracts, and basis trading mean net returns were significantly higher than May pre-spreading150, we only analyze basis-trading strategy daily cumulative mean net returns as a base strategy when comparing returns from different contract months: March, May and July. Figure 7 below shows daily cumulative net returns for three different contract months basis-trading strategies with respect to three different post-harvest periods. We can see that mean net returns from different contracts look similar during each period- March and May. However, we need to statistically test this hypothesis.

Figure 7. Daily cumulative mean net returns over storage periods. Corn basis trading.



So, first we compare and evaluate three different futures contract month strategies outcomes for March period, which is 99 post-harvest trading days. Then we apply same analysis for May and July contract month strategies for May storage/trading period, 142 days. Finally, results for July contract month strategy for the July period, which extends up to 185 post-harvest trading days, are evaluated. Note that our analysis excludes the initial 20 days, which as noted earlier, were not significantly different from zero.

March, May and July cumulative net returns, 99 day period (Appendix 3)

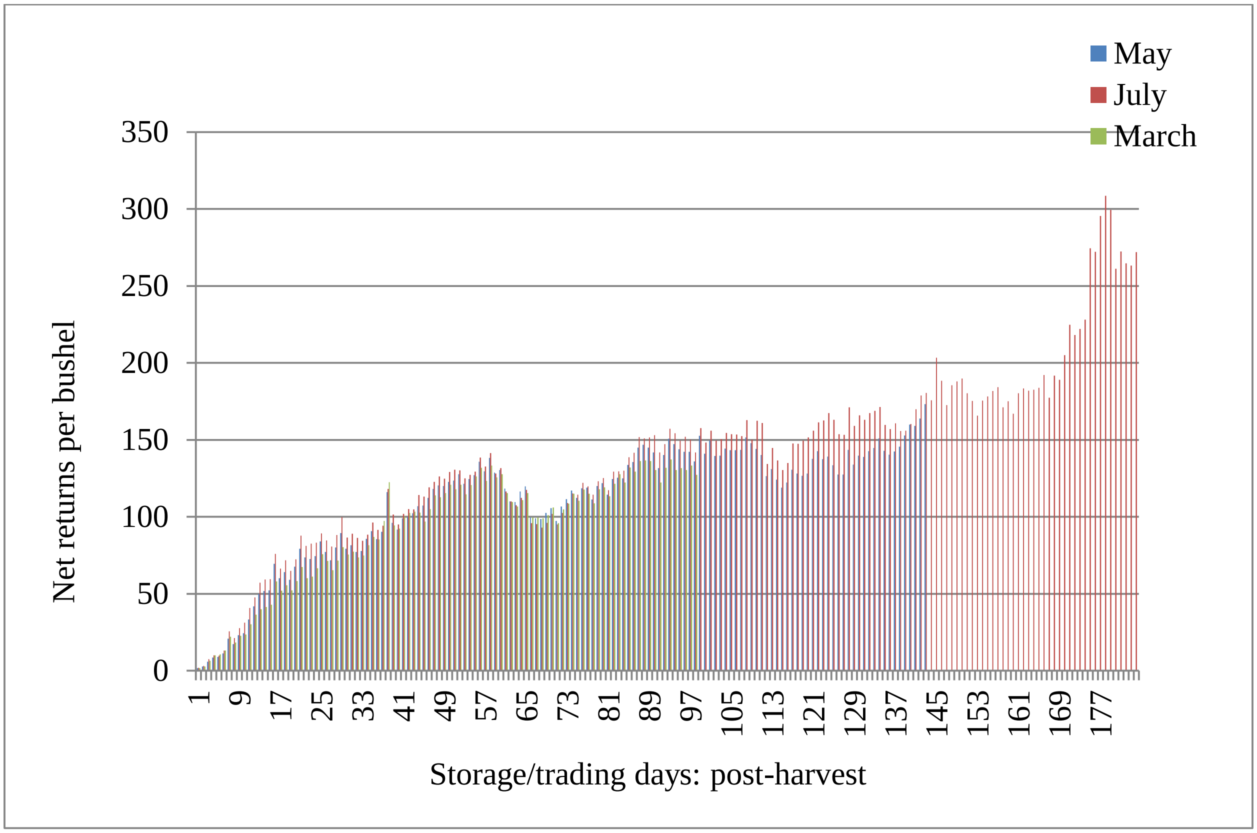
When comparing March and May basis trading strategies cumulative net returns across this period we found no statistical evidence to reject the null hypothesis of zero mean differences. For all 79 significantly positive days (less 20 insignificant mean net returns described earlier) means of daily returns differences were not significantly different. Paired t-test results of March and July basis trading cumulative mean net returns show that for this period mean returns are not statistically different from each other. For March period March, May and July basis-trading strategies cumulative mean net returns are statistically equivalent. Consequently, we can conclude that pre-spread levels at 125% and 100% from May and July contracts generate significantly lower mean net returns over the March storage period than basis-trading with March contract.

May and July cumulative net returns, 142 day period (Appendix 4)

Paired difference tests of May and July basis trading cumulative mean net returns for each day through 142 day period (122 days with significant mean net returns discussed earlier) indicate mean net returns are not significantly different, except for one day, which occurred on the 110^{th} trading day. From this we can also draw a conclusion that July pre-spreading150 strategy generates statistically equal mean returns as May basis trading, and other two levels of July pre-spreading yield significantly lower returns than May basis trading.

Earlier in this section it was stated that daily variances of all basis trading and pre-spreading strategies were statistically equal within their respective contract months. Since all three futures contracts generated statistically similar net returns with basis trading and pre-spreading150 strategies, we want to test their variance equality as well, for the same periods but across different futures contracts. Thus, this type variance equality test will evaluate only basis trading strategy mean net returns variances and its results can be generalized to all pre-spreading levels as well. From Figure 8 we can see that variances of daily cumulative net returns from basis trading strategies increase over time, just as their daily cumulative mean net returns did.

Figure 8. Variances of daily cumulative net returns from basis trading - Corn.



March, May and July cumulative net returns variances equality (Appendix 2B)

F-test statistics indicate that variances of net returns of all three futures contract basis trading strategies are statistically equal over the March storage/trading period. May and July contracts basis-trading strategies over the May storage period (142 days) were found to have daily equal variances. We conclude that daily net returns variances are statistically equal within and across different month strategies and across their different pre-spread levels. For instance, March basis trading daily variances equal July pre-spreading100 daily variances in March contract period.

"Keep storing or stop" analysis

This type of analysis is conducted to test whether storing grain beyond a specific period is profitable or not. First, we divide post-harvest storage period into 5 sub-periods and then compare net returns across these sub-periods. These sub-periods comprise the following days: 21, 60, 99, 142 and 185. From Figure 7 we see that average cumulative net returns from day 21 through day 185 follow a general upward trend, so we seek to test whether cumulative returns are significantly different as the post-harvest period extends. For the reasons mentioned in the Methodology, we use one tailed paired t-test as well for this analysis.

The March contract storage period covers sub-period days 21, 60 and 99. Then, we proceed from day 99 to day 142 (end of May contract storage period), from day 142 to 185 (end of July contract storage period). Each sub-period includes approximately 40 trading days. Given our earlier results that indicated that all basis trading strategies resulted in the highest level of cumulative net returns and that there was no statistical difference between the simple basis trading strategies established using different futures contract months over the same storage period, we proceed by measuring only March basis-trading strategy net returns over the first 2 sub-periods, and by measuring only May basis-trading strategy net returns over the next sub-period, and by measuring only July basis-trading strategy net returns over the last sub-period. Then we compare these cumulative mean net returns measures across different paired sub-periods. Paired sub-periods are organized both diagonally and horizontally. Diagonal pairs represent storage transfers from one sub-period to the next. Paired t-test results comparing mean net returns differences, in cents, across various sub-periods are summarized in Table 2 below, with corresponding p-values and significance test at 5% level.

Table 2. Returns to storage – Mean Equality – Corn basis trading.

	60		99		142		185	
Days	p-value	differen	p-value	differen	p-value	differen	p-value	differen
21	0.000*	8.46	0.000	11.86	0.000	14.72	0.000	16.62
60			0.016*	3.36	0.000	6.22	0.004	8.12
99					0.004*	2.86	0.023	4.76
142							0.197	1.90

Paired t-test results above suggest that mean of net returns differences for each sub-period: 21-60, 60-99, and 99-142 (diagonally) are significantly different from each other, meaning that returns per bushel tend to significantly increase as storage period increases. Only the last sub-period 142-185 show mean net returns differences to be insignificantly different from zero, suggesting that margins do not increase, statistically, after day 142, rather they stay unchanged. From day 21 until the end of storage period cumulative mean net returns double in numerical terms.

In conclusion, basis-trading strategies formed with March, May and July contracts can be equally used through the post-harvest storage period to earn increased returns over their respective periods: March period-99 days-March, May and July contracts; May period-142 days-May and Jul contracts. We also generalize these results for March and July pre-spreading150 levels, as we have found them to be statistically equivalent to March and July basis trading strategies. In addition, our results show that increasing net returns to storage can be earned at least up to day 142 over the post-harvest storage period. These findings are consistent with Peterson and Tomek (2007) where they simulate monthly both futures and cash prices from November through May to determine seasonal price index for Central Illinois corn over 16 years. They find that both prices increase from November through May, indicating a "price of storage".

We presented results earlier to show that all strategies – simple basis trading and pre-spreading across all levels – have daily equal variances. Now, we are interested to test variance changes over the storage period (Figure 9). Again, we use the same sub-periods approach for this F-test at 5% significance level and 19 degrees of freedom[3]. We use only March basis trading strategy net returns variances for March contract period (days 21-99) and May basis trading net returns variances for May contract period (day 142) and July contract period (day 185) as their same period net return daily variances were equal. Table 3 below summarizes F-statistics.

[3] F critical upper value at 5% level is 2.1682

Table 3. Returns to storage-Variance Equality- Corn.

Days	21	60	99	142	185
21	1	2.079	2.083	2.601*	4.447*
60		1	1.002	1.251	2.139
99			1	1.249	2.135
142				1	1.710
185					1

Even though basis-trading strategy variances are equivalent for any one day or sub-period, we can see from the Table 3, variances for a strategy actually increase over time. The net return variance to basis-trading is significantly higher for days 142 and 185 compared with day 21, indicating that risk of storing corn gets more for these longer storage periods.

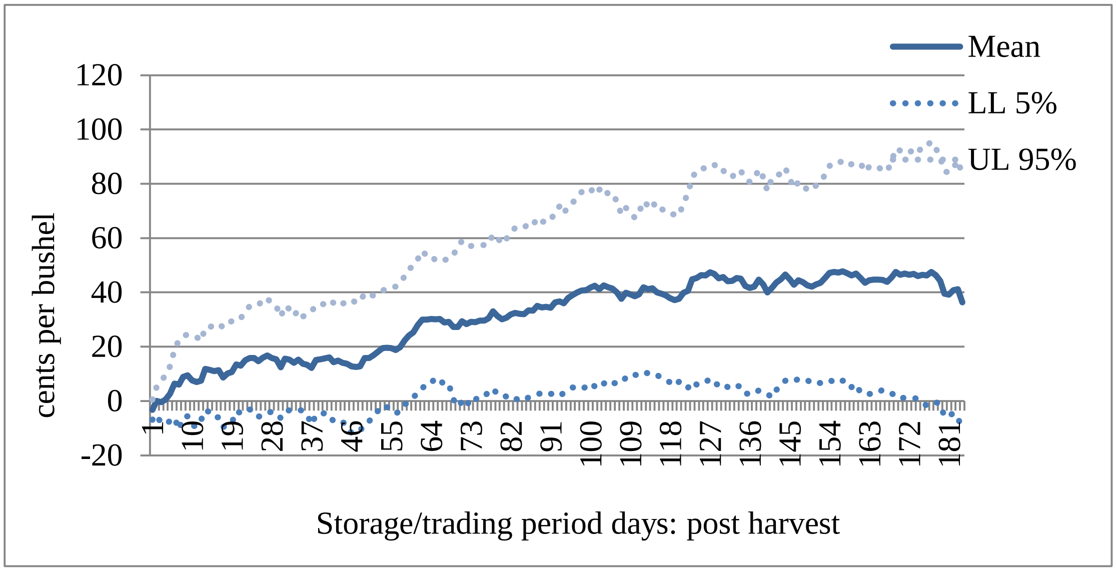
We can see (Table 2) that storing corn from day 21 till day 185 (four sub-periods) generates increased returns, but risk starts increasing from day 142 only. For days 142 and 185 both variance and mean of net returns are statistically equal. However, increased margins can be earned until day 142 at no extra risk. We can also generalize these results for Pre-spreading150 level variances for all three contract month contracts.

Corn storage without hedging

We do not conduct any paired or compared analysis for corn storage without hedging against basis trading. Plenty of previous literature has shown storing corn un-hedged returns insignificant margins or higher variability than hedged storage (Peterson and Tomek, 2007; Hauser et al, 1990; Working 1953; Kastens and Dhuyvetter, 1999). We believe that testing means of net returns for significance from un-hedged storage is self-sufficient and selfexplanatory without detailed comparisons. Figure 9 below summarizes one sample 2-tail t-test results at the 5% level of significance (Appendix 8).

Using only cash market and storing corn un-hedged generates on average numerically higher net returns than any of basis trading strategies; however, at the same time insignificant returns occur over half of the storage period and even periods of significant mean net returns are very close to zero. Positive cumulative mean net returns are generated between days 60 through 174, totaling 111 days during the 185 post-harvest storage/trading days. So, it is possible to earn significant and higher returns 60% of the post-harvest period without hedging the corn. But it is highly risky for elevators to do so, due to their large volumes of grains. Positive mean net returns are assured 89% of the post-harvest period with basis trading. It is apparent that at the 1% significance level mean net returns for un-hedged storage would be insignificant over the whole storage period. Also, confidence interval of un-hedged storage mean net returns widens significantly towards the end of storage period, whereas basis trading mean net returns confidence intervals are relatively constant across the storage period.

Figure 9. Daily cumulative mean net returns from un-hedged corn storage.



Pre-spreads cover cost of storage

Earlier we have stated how many times during our 20 years observation pre-spread at different levels were attained. Pre-spread application period is pre-harvest time starting April 1 through September 30, approximately 125 trading days. Now, we average all pre-spread levels for these 125 days, and derive 95% confidence interval to illustrate how easily the cost of carry can be covered with these pre-spreads. The analysis is separated and evaluated across respective futures contracts. Figure 10 depicts results for March, Figure 11 May and Figure 12 July futures contract pre-spreads.

Figure 10. COC covered by pre-spreads. Dec/March contract spreads.

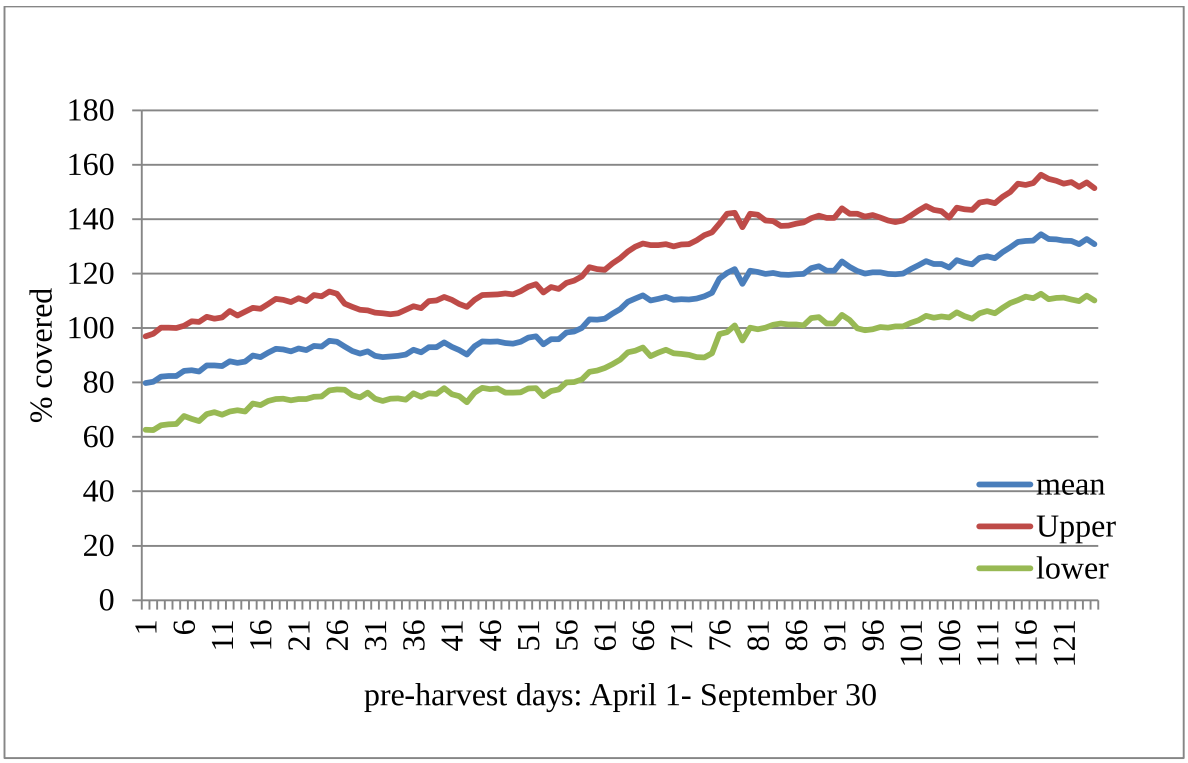


Figure 11. COC covered by pre-spreads. Dec/May contract spreads.

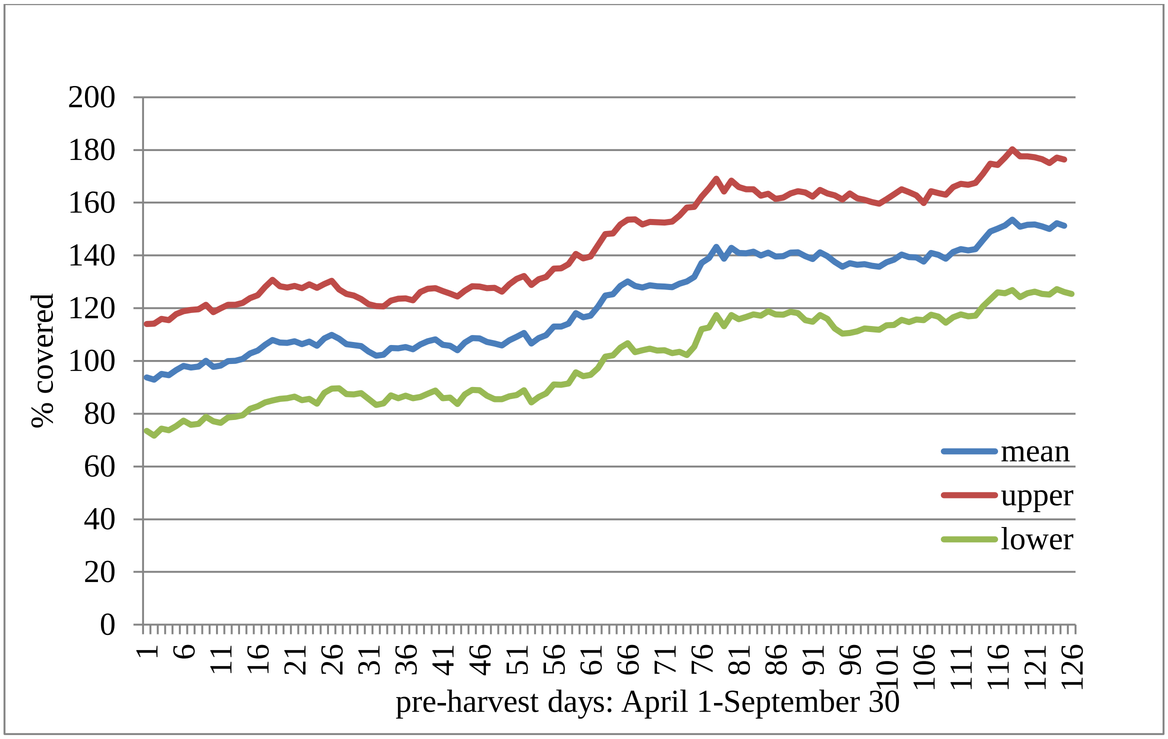
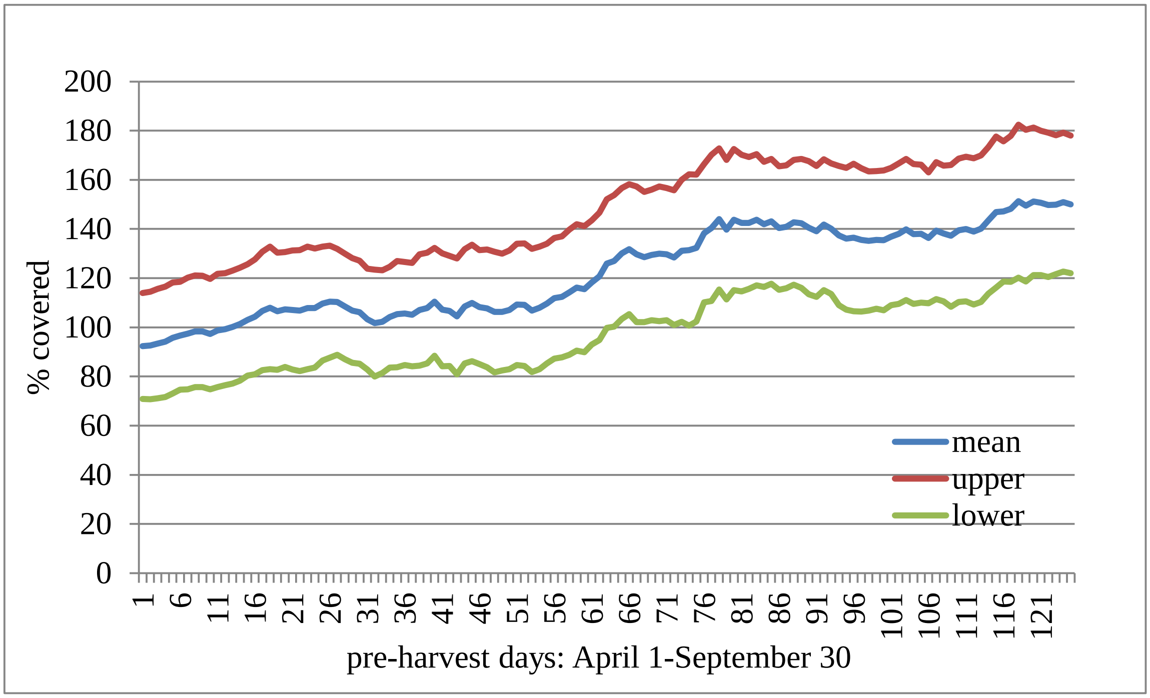


Figure 12. COC covered by pre-spreads. Dec/July contract spreads.



Figures above show that when March futures contract for a pre-spreading strategy is used it starts fully covering cost of carry on average 65 days before harvest and May and July contracts on average cover cost of carry 45 days earlier than that. From previous results we know that March and July contracts for same periods performed equally with basis trading and pre-spreading150 strategies. Now, we can conclude that using May and July contracts to pre-spread is better, as they assure more percentage of coverage (up to 180% with 95% confidence) and in earlier days before harvest. Also, from Methodology we remember that pre-spreads at 150% and above occurred more in May and July futures contracts as compared to March.

Figures above which illustrate COC cover and pre-spreads relationship explains that futures price spreads appear on average to rise/widen closer to harvest period relative to storage costs. Although, on average, pre-spreads cover COC at 100-140% most of the time, we have seen from prior results those levels of pre-spreading does not perform better than harvest time simple basis trading. In other words, this pre-harvest time frame does not provide spreads which are above harvest time basis spreads, thus, even the highest level 150% pre-spreading cannot on average outperform simple harvest time basis trading. These results have important implications for futures market efficiency and theory of storage.

First, with respect to future market efficiency the fact that pre-spreading does not result on average in statistically higher mean net returns compared with simple harvest-time basis trading strategy is consistent with “Efficient Market Hypothesis” (EMH). In other words if futures prices efficiently reflect current market information then there should be no systematic trading advantage in forming different futures based marketing strategies.

Second, with respect to the theory of storage, spreads are “price of storage” between deferred futures months, we found that pre-spreading at 150% level covered cost of storage and its net returns were statistically equal to basis trading. Thus, we can conclude that corn futures market offers price premiums more than the “price of storage”, at least 50% more than a physical storage cost. According to Figures 10, 11 and 12 such opportunities arise 60 days before harvest, with 95% confidence.

Soybeans

The same statistical procedures were followed to evaluate soybean trading strategies outcomes. First, Shapiro-Wilk test for net returns distribution normality was conducted at 1% significance level. Null hypothesis is that daily net returns are normally distributed over 20 year sample.

Results show that net returns from March basis trading are not normally distributed for 14 days. These days fall between 7-22 and 42-46. March pre-spreading100 strategy net returns were not normally distributed for 11 days: 8-22 and 42-45. There are 99 trading days in March storage contract period. In May basis-trading strategy there were 31 days with non-normally distributed margins: 8-47 and 61. May Pre-spreading100 have 21 days with non-normally distributed net returns: days 8-20, days 29-33 and days 42-45 and 61. There are 142 trading days in May contract storage period. July basis-trading strategy net returns rejected the normality hypothesis for 46 trading days: 8-21, 27-49, 61, 105-109 and 169-174. July Pre-spreading100 strategy net returns were with 22 non-normally distributed days: 9-21, 28-33 and 42-47. There are 185 trading days in July contract storage period. Normality of cumulative mean net returns from un-hedged soybean storage strategy was rejected for 41 days out of a total of 185 days. Non normal samples include days 4, 5, 66-97, 106, 122, 135-144 and 180.

Now, we graphically present the results of cumulative mean net returns from soybean hedged storage (Appendix 5). Mean net returns are tested for significance at 5% level with one sample two tailed t-test. Figures 13, 14 and 15 summarize the results for March, May and July basis trading strategies with their respective pre-spread at 100% level.

Figure 13. Daily cumulative net mean returns from hedged soybean storage. March contract.

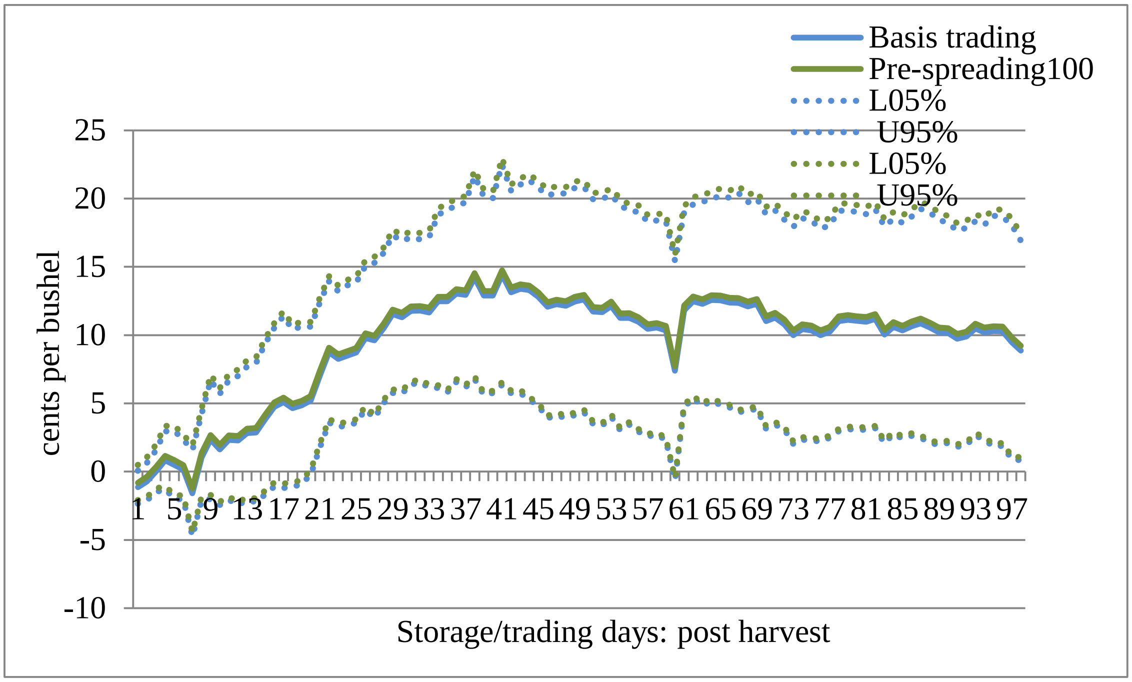


Figure 14. Daily cumulative net mean returns from hedged soybean storage. May contract.

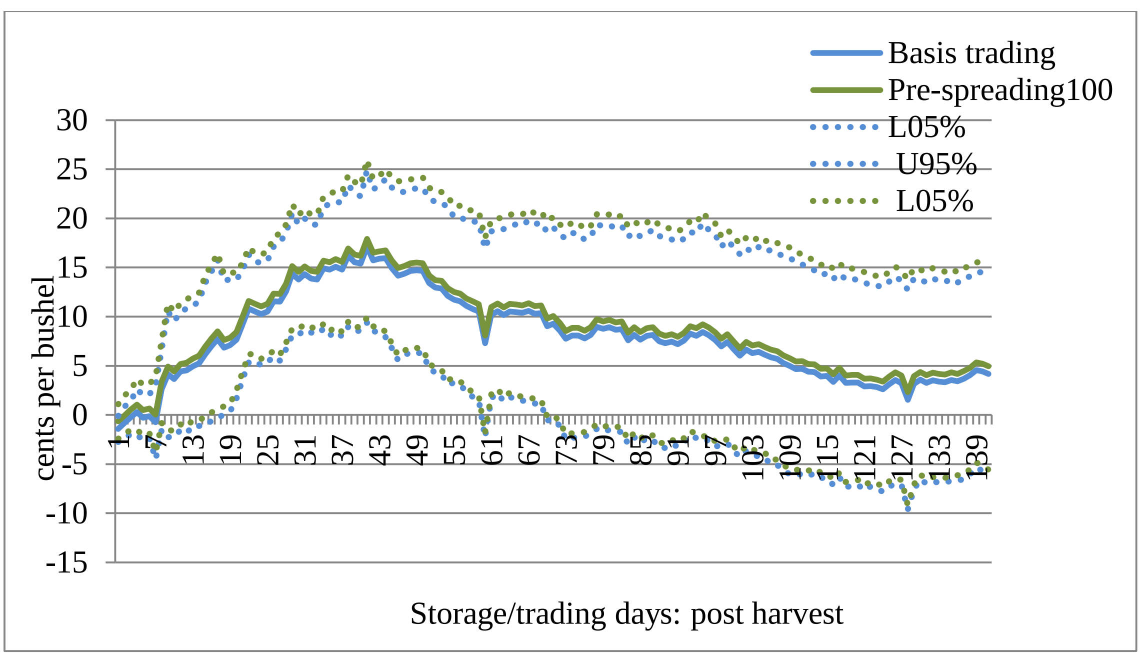
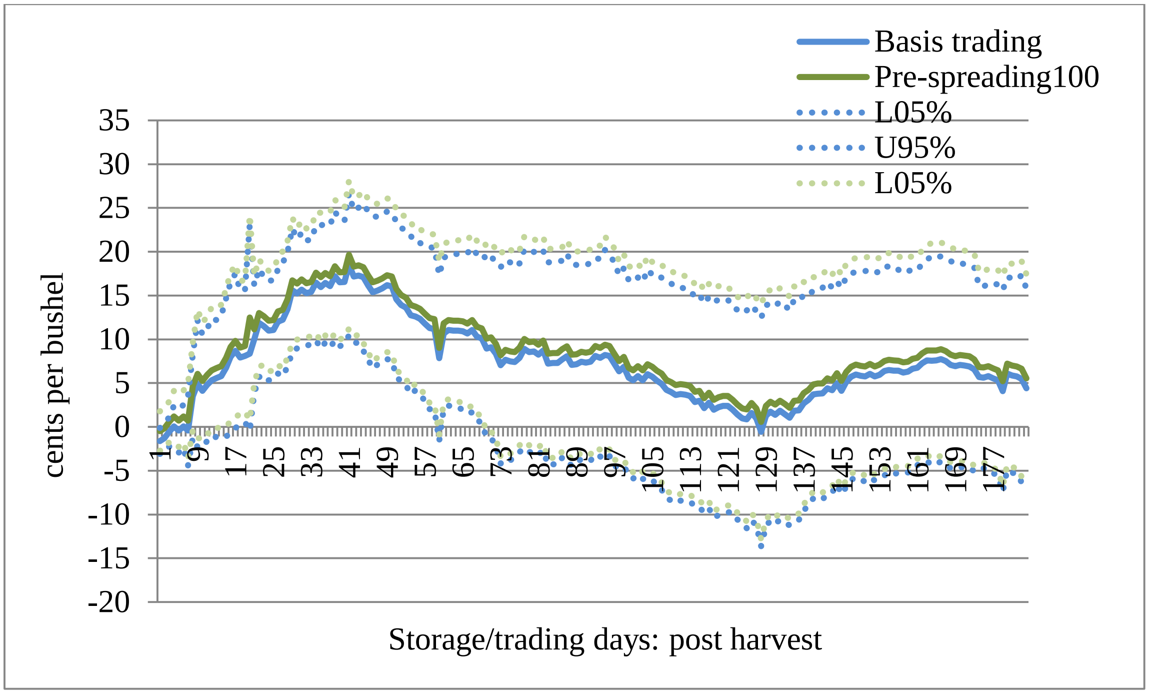


Figure 15. Daily cumulative mean net returns from hedged soybean storage. July contract.



From figures above we see that cumulative mean net returns become significantly positive after day 20, increase for 40 more days and then drop to negative values towards the end of storage period, especially when deferred futures contracts are used. Analogous to corn results, the first 20 days show insignificant mean net returns and probably reflect basis patterns peculiar to soybeans harvest time, where sell basis is lower than buy basis. So, again it could be argued that it is favorable either to keep buying during that period or start storing for more than 20 days. The kink on day 60 is not systematic, rather can be explained by the sudden rise of futures prices on that day in year 2003, when the spot price stayed unchanged dropping the average sell basis value. Also, contrary to corn results, soybean net returns from pre-spreading100 are little higher than the ones from basis trading. So, it is of interest to test if their mean net returns are significantly different.

Again, we test paired strategies within same months, and different levels with same length of storage periods. Based upon figures above, we only evaluate trading days with significantly positive cumulative mean net returns. So, in March contract period we can compare all 99 days, as they are significant towards the end. However, for May and July contracts periods up to 60 days only, as beyond that day mean net returns reach negative values. Table 5 below summarizes paired t-test results for basis trading and pre-spreading100 strategies mean net returns for each contract month. Null hypothesis is that mean of differences of net returns is zero at 5% significant level.

Note that pre-spread level at 150% was not observed at all during soybean pre-harvest period, whereas the level at 125% was observed only once, and because of this lack of observations, it was deemed to be not sufficient to conduct separate statistical tests at this level.

"Same contract, different levels" analysis

Table 5. Basis-trading and Pre-spreading levels-Soybean.

	March Basis-trading		May Basis-trading		July Basis-trading	
	p-value	difference	p-value	difference	p-value	difference
Pre-spreading100	0.09	-0.30	0.045*	-1	0.07	-1.10

Paired t-test analysis of soybean March basis-trading and pre-spreading100 level suggest that pre-spreading100 generate statistically similar mean net returns as basis-trading. Null hypothesis of zero mean of differences is not rejected at p-value of 0.09, and so 0.30 cents per bushel difference is not significant; May basis-trading and pre-spreading100 strategies reject the null hypothesis of zero mean of differences at 0.045 p-value. The daily mean difference of lower

1 cent per bushel for basis-trading strategy is statistically significant at the 5% level; July basis-trading and pre-spreading100 mean returns differences do not provide sufficient evidence to reject the null hypothesis of zero mean differences, and we conclude that mean net returns are not different at p-value of 0.07. The daily difference of lower 1.1 cents from basis-trading is not significant.

In sum, March and July basis trading strategies performed equivalently as their respective pre-spreading100 levels. However, pre-spreading100 using May futures contract generated significantly higher mean net returns than its fellow basis trading strategy. So, either basis trading at harvest or pre-spreading100 at pre-harvest period can be applied with these three contracts to earn statistically similar net returns over a 60 day period.

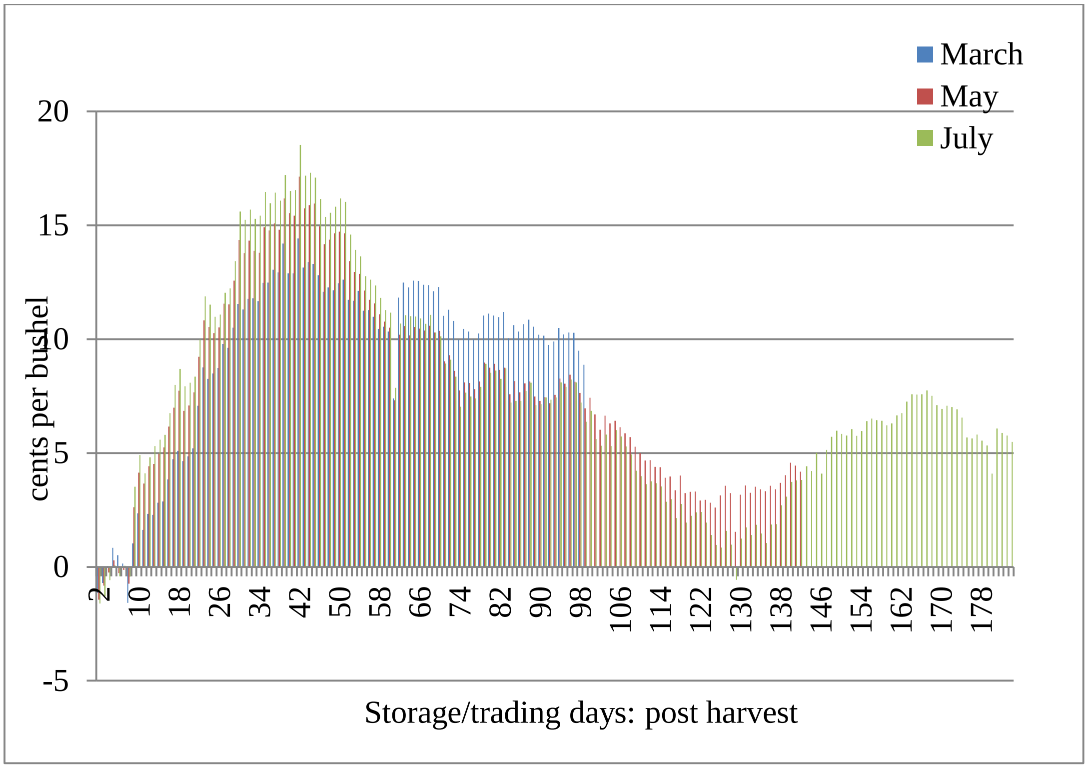
Now, we should test the variances equality of these net returns, from basis trading and pre-spreading100, to determine whether it would be more or less risky using pre-spreading100 rather than a basis trading. Detail daily comparison results are attached in Appendix 6A and the summary is following: all daily F-statistics over 60 trading periods indicate equal variances of net returns for March basis trading and pre-spreading100 strategies; May basis trading and pre-spreading100 strategies also have daily equal variances; July basis trading and pre-spreading100 strategies have daily equal variances, except for one day.

"Different contracts, same periods" analysis

We move on to "Different contracts, same periods" analysis, where we compare March basis trading strategy against basis trading and pre-spreading100 strategies with May and July contracts. The reason for including pre-spreading100 into this analysis that from previous net returns mean differences analysis we know that pre-spreading100 returns were numerically higher than basis trading strategy net returns. So, there is a hypothesis that May and July contracts pre-spreading100 mean returns might be significantly greater than March basis trading returns for some days. Since 60 days are the minimum number of days with significant mean net returns for all three contracts, same period length will be 60 days as well.

Figure 16 below shows the relationship between mean returns from three different contracts soybean basis trading, and how three contract periods are overlapped during each storage period. March, May and July contracts are available to hedge the storage until March and can be used alternatively. This analysis will determine the contract which yields the highest returns over the March storage period.

Figure 16. Daily cumulative mean net returns from soybean basis trading.



March, May and July cumulative net returns, 60 day period (Appendix 7)

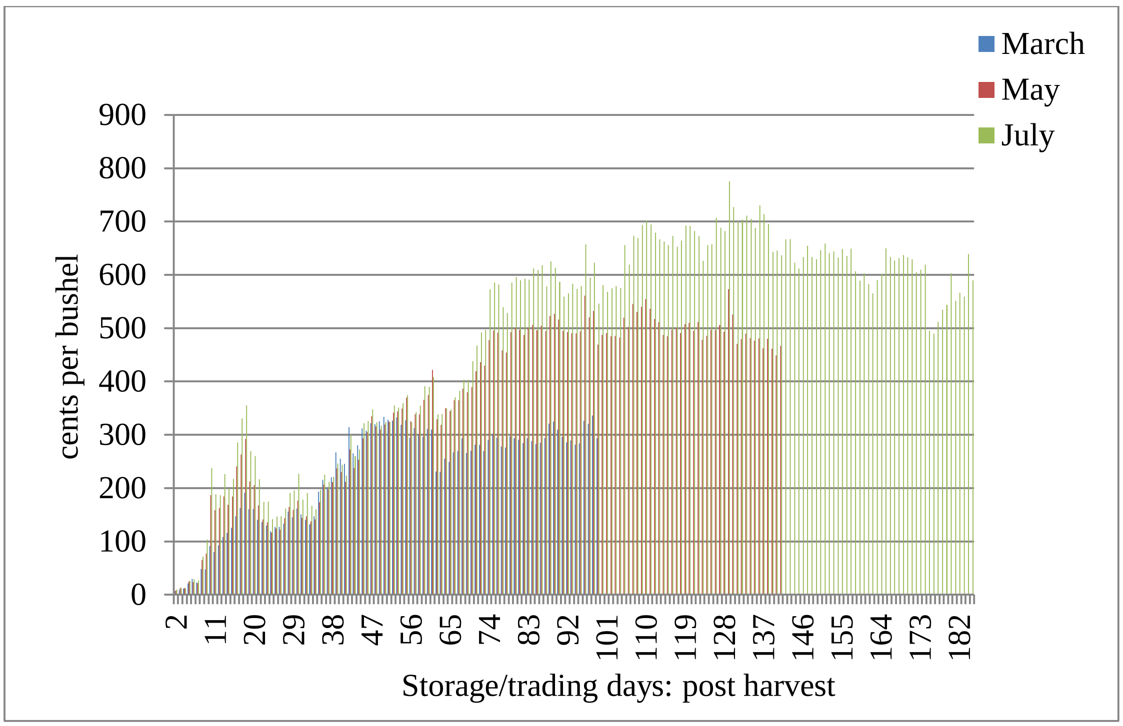
Daily paired t-test results at 5% significance level indicate that March basis-trading and May basis trading strategies cumulative mean net returns are not different from each other over 60 trading day post-harvest period, except for couple days before day 20. We have seen earlier that May pre-spreading100 mean net returns are significantly higher than the May basis trading returns. So, we compare March basis trading daily mean net returns with them. Results indicate that May pre-spreading100 net returns are higher for 20 days, which include 21-41 which is half of 60 days when first 20 days are excluded.

When comparing March and July basis-trading cumulative mean net returns we find only 5 days of significant mean differences between these days 31-37 where July net returns are higher. For other days we find no significant difference in cumulative mean net returns. March basis trading and July pre-spreading100 strategies mean net returns are tested, and we find that July pre-spreading100 strategy generated higher mean returns than March basis trading returns for 28 days, which include 21-51, which is more than half of this period's total storage/trading days (60 days less first 20 days with insignificant mean returns: Figure 13). We conclude that it seems better to use July pre-spreading100 strategy for March storage period, as it returned significantly higher margins than March and May contracts strategies for most of the days.

We cannot evaluate May contract period cumulative mean net returns with July contract cumulative mean net returns, because trading days with significant cumulative mean net returns do not go beyond 60 days, as was mentioned earlier. To compare May contract period we need more than 99 trading days, because prior to that day a period is considered as March contract period.

Now, we need to test if using the July pre-spreading100 strategy is indeed better than using the March basis trading in terms of risk. From previous analysis we remember that daily variances of net returns from July basis trading and July pre-spreading100 are statistically equal, so in this current analysis we use daily variances of July basis trading as a base. Figure 17 below shows us the whole picture of net returns variances for all three futures contracts basis trading, but we only test 60 days. It is interesting that towards then end of the storage period variances of net returns tend to increase, whereas the means tend to decrease.

Figure 17. Daily variances of cumulative net returns from soybean basis trading.



March, May and July cumulative net returns variances, 60 day period (Appendix 6B)

F-test results for equal variances suggest that March and May basis trading cumulative net returns variances are equal over all 60 trading days. Also, March and July basis trading daily variances of cumulative net returns are equal too, except for two days: 11 and12. So, using July contract, more precisely – July pre-sprading100 strategy, over the 60 day period is not more risky than using a March contract.

"Keep storing or stop" analysis

From previous results (Figures 14 and 15) we know that storing soybeans beyond 60 days does not provide significantly positive mean returns, especially when May and July contracts are used. Also, we know that March basis trading daily mean returns are not different from May and July basis trading returns with exception of few days. Additionally, March basis trading strategy yielded significantly less mean returns for 20-28 days than May and July pre-spreading100 strategies. However, for this current analysis we do not measure how May or July pre-spreading100 strategies mean returns changed over time, instead, we use March basis trading mean returns as a base strategy, and can imply that May and July pre-spreading100 mean returns have changed in a same pattern but in larger increments (cents per bushel). Even though we visually see (Figure 13) that cumulative mean net returns at the end of March contract period (day 99) is less than cumulative mean net returns in mid period storage days, for the sake of assurance we include day 99 in this analysis.

Sub-periods in March contract storage period are days 20, 40, 60 and 99. Null hypothesis for paired sub-periods is that mean differences of cumulative net returns is zero at 5% level of significance. Table 6 summarizes the results of differences between mean returns per bushel with corresponding p-values. Paired sub-periods are organized both diagonally and horizontally. Diagonal pairs represent storage transfers from one sub-period to the next.

Table 6. Returns to storage from March basis trading - Mean Equality. Soybean.

	40		60		99	
Days	p-value	difference	p-value	difference	p-value	difference
20	0.00*	9.05	0.02	6.35	0.15	3.28
40			0.00*	-2.70	0.00	-5.76
60					0.03*	-3.06

From Table 6 above we can see that from day 20 through day 40 mean of cumulative net returns differences is not zero, but in fact are increasing with significant difference of 9.05 cents per bushel. However, cumulative mean net returns tend to significantly decrease after that sub-period by 2.7 and 3.06 (diagonals) cents per bushel. Eventually, by the end of storage period, cumulative mean net returns drop to their beginning period levels, because their difference of 3.28 cents is insignificant (days 20 and 99). We can conclude that using March, May or July contracts one can earn significantly higher mean returns until 40 trading/storage days, beyond that period cumulative mean net returns are still positive but significantly lower. Moreover, storing soybeans through the end of the March contract period is certainly not better than storing for shorter periods, as cumulative mean net return difference between sub-periods 40 and 99 is significantly less by 5.76 cents per bushel. So, optimal storage day for soybeans is approximately 40 days (Figures 13, 14 and 15), and we can imply that when July pre-spreading100 strategy is used mean returns would be even greater around that day.

These results indicate that futures market is signaling “not to store soybeans” after November. This signal can be explained by Brazilian soybean supply which comes to world markets from March following November. Frechette (1997) analyzed the effects of Brazilian soybean supply on the U.S. supply and consumption. He finds that if Brazilian supply surpasses the U.S. supply then that effect flattens the soybeans futures profile (prices) and expectations of one more harvest in the spring eliminates the need for the U.S. post-harvest soybean storage.

Now, having analyzed the cumulative mean net returns to storage, it is time to test how variances of cumulative net returns change over these sub-periods. We have found earlier that all daily cumulative net returns variances are equal across all three contracts up to 60 trading/storage days. We further analyze daily cumulative mean net returns variances for March basis trading strategy over these 60 days, and generalize its results for other futures contract strategies. However, the variance change on day 99 pertains to March contract strategy only. Null hypothesis for this F-test is that variances of net returns between paired sub-periods are equal. F-critical value with 19 degrees of freedom is 2.168 at 5% significance level, and results are presented in Table 7 below.

Table 7. Returns to storage from March basis trading - Variance Equality. Soybean.

Days	20	40	60	99
20	1	1.34	1.78	1.91
40		1	1.34	1.43
60			1	1.07
99				1

F-statistics suggest equal variances of cumulative net returns between each sub-period and between beginning and ending periods. Irrespective of whether cumulative mean net returns are equal or not, variances of cumulative net returns are always equal during this period. So, we conclude that it is better to store soybeans only up to 40 trading days starting from October 1, and earn significantly higher cumulative mean net returns with the same level of risk. This result is similar to Slusher's findings, where he finds that storing soybeans for more than one month leads to negative returns (Cunningham et al, 2007).

So far we have found that pre-spreading100 strategy with July contract yields the most returns (higher returns for longer days) over a 60 day storage period. It implies that soybean futures market behaves in line with theory of storage, since it does not offer price spreads which are more than 100% of cost of storage. In addition, the market does not seem to be consistent with EMH as pre-harvest spreading100 strategy with July contract offered statistically greater returns over a harvest time basis trading strategy with March contract. We also conclude that pre-spreading in soybeans market is better than basis trading, as we have found that pre-spreading with May and July contracts generated significantly higher returns for longer days (20-28 days) than basis trading with March contract over the March storage period.

Although we do not test the variances beyond trading day 99 for May and July contracts, it is apparent that variance of cumulative net returns changes significantly (Figure 17) and cumulative mean net returns significantly fall (Figure16) by the end of post-harvest storage period. Our findings can be supported with the findings of Kastens and Dhuyvetter (1999), where they conclude that hedged soybean storage generates insignificantly positive returns and increase risk by 34% compared to un-hedged storage for Kansas farmers. Frechette (1997) also finds that storing soybeans is more risky than storing corn, as soybeans market offered higher risk premium for soybean storers.

Soybean storage without hedging

Figure 18. Returns to un-hedged soybean storage.

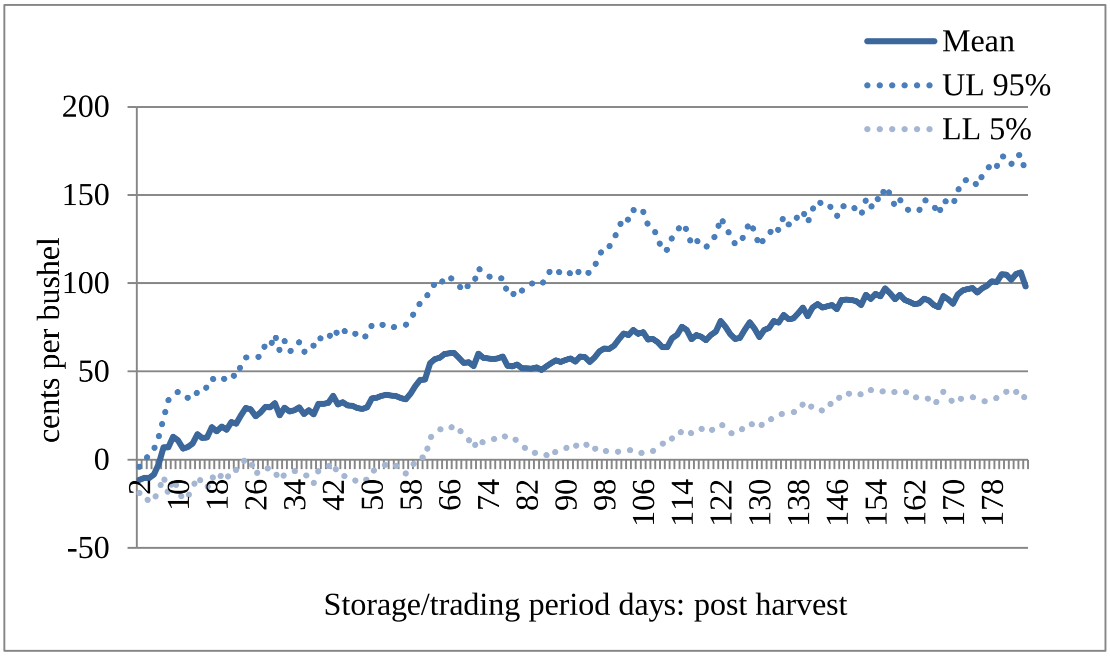


Figure 18 above illustrates the results from one sample t-test at 5% significance level and raw results are attached in Appendix 8. Again, consistent with Kastens and Dhuyvetter's findings, our un-hedged storage model generates significantly positive and increasing cumulative mean net returns than the hedged storage returns. Kastens and Dhuyvetter (1999) suggest not hedging soybeans, but rather using futures based cash price expectations to estimate returns to storage for Kansas farmers. So, when an elevator stores soybeans un-hedged it can earn higher returns, around 170 cents per bushel, with less risk towards the end of storage period- in the sense that net returns for any given storage year less likely to be negative, whereas the elevator hedges (either basis trading at harvest or pre-spreading prior to harvest) for soybean storage only earn up to 25 cents per bushel by trading day 40. Significant cumulative mean net returns can be obtained from un-hedged storage beyond day 60 and during 125 storage days out of a total of 185 days.

Cumulative mean net returns trends of hedged and un-hedged storage move in opposite directions (Figures 18 and 15). If an elevator needs to sell soybeans around 40 trading days after harvest, it can use basis trading at harvest, as cumulative mean net returns from un-hedged soybeans are not significant during the first 60 trading days of the storage period. However, basis trading soybeans beyond 60 days does not appear to be a profitable strategy.

In contrast to the storage theory, soybean futures market does not seem to consistently pay a “price of storage” for longer periods, as sell basis gets consistently lower than the original buy basis (adjusted for storage costs), whereas cash market prices on average increase enough to more than cover storage costs. These differences can also be explained by Frechette (1997) study when futures market is paying “negative price” for storage because of another spring harvest expectations, and we assume/hypothesize that processors are “consuming up” a recent spot harvest increasing an immediate demand and price (Figure 18) for local soybeans.

Pre-spreads cover cost of storage

We can also see from Figures 19, 20 and 21 below that soybean pre-harvest futures prices do not fully cover expected cost of storage at 95% confidence, and we observed 100% coverage in only 8 years out of 20. These results indicate how significantly rare the opportunity to obtain pre-spreads in the soybeans futures market is.

Figure 19. COC covered by pre-spreads. Soybean November/March contracts.

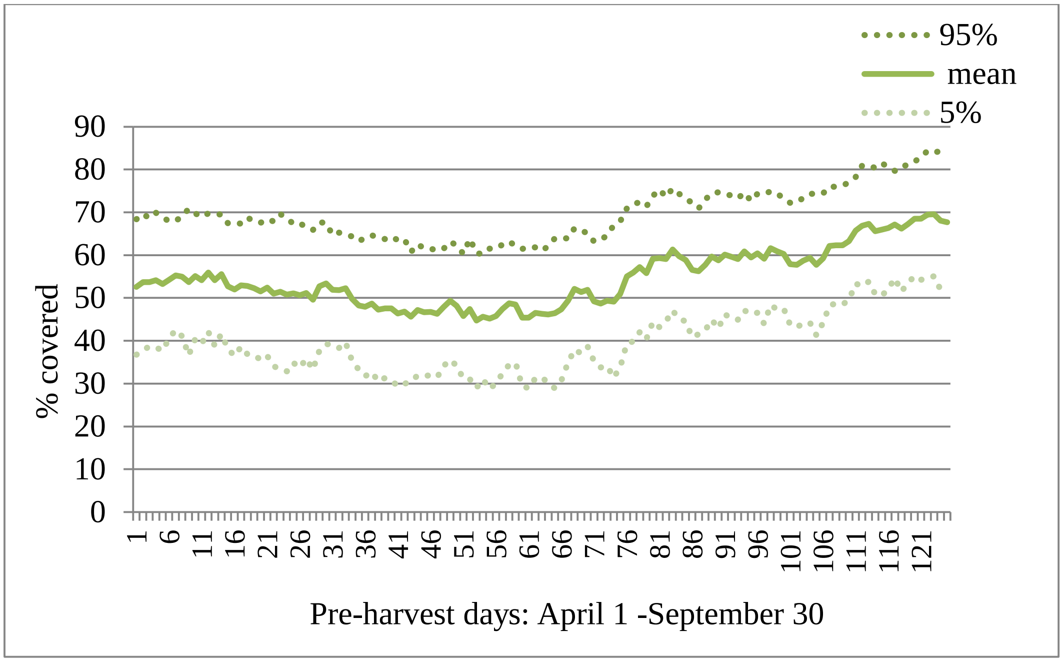


Figure 20. COC covered by pre-spreads. Soybean November/May contracts.

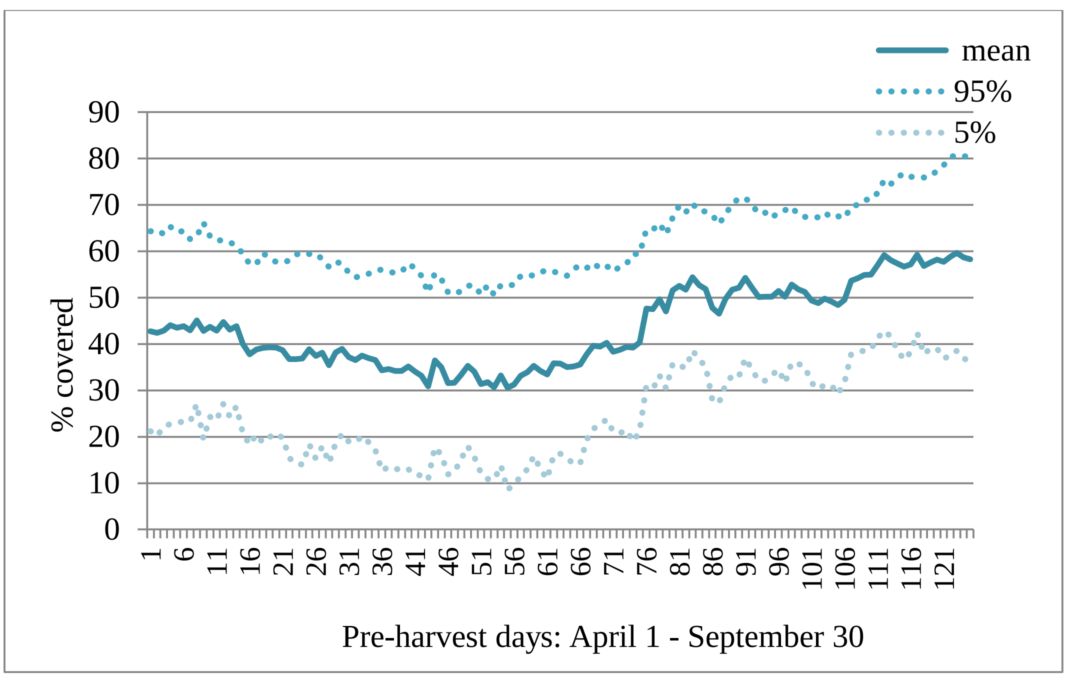
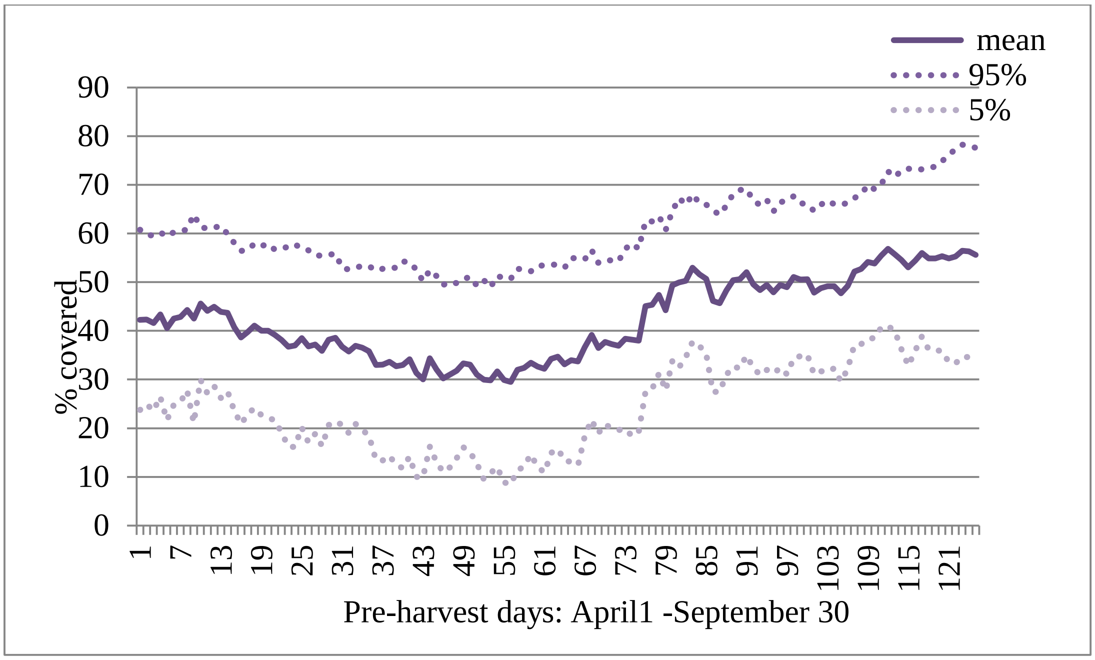


Figure 21. COC covered by pre-spreads. Soybean November/July contracts.



V. CONCLUSIONS

This thesis research evaluated several soybean and corn trading strategies from grain elevators perspective. Evaluation results are based on returns and risk to storage for post-harvest period of October 1-June 30. Data analyzed was for North Central Illinois location for years 1992-2012.

Corn

Paired t-test results for corn basis trading and pre-spreading strategies for all three futures contracts generated similar results, where all three basis trading and pre-spreading at 150% level strategies daily mean net returns were not significantly different from each other. Other levels of pre-spreading such as 125% and 100% returned significantly lower margins than basis trading within their respective futures contracts. Also, it was found that alternative use of March, May and July contracts to basis trade corn does not yield significantly different returns over a same storage period.

Although daily variances of net returns from all strategies were equal, variance changes were found to be not equal over different days of storage period: risk increased when corn was stored for more than 2-3 consecutive sub-periods regardless of any futures contract. Results suggested that it is better to simply basis trade at harvest time or to pre-spread at 150% just 60 days before harvest using either May or July contract. Because, these contracts provided with pre-spreads which are higher and earlier than March contract did.

Returns to un-hedged corn storage also indicated increasing net returns towards the end of storage period. However, at 5% significance level positive returns could be earned for only 60% of the storage period with wide confidence intervals very close to zero.

Soybeans

Results for soybean hedged and un-hedged storage strategies are dramatically different from corn results. Pre-spread levels at 150% were not observed at all, whereas pre-spreading at 100% resulted in cumulative mean net returns of a similar magnitude to basis trading within two futures contracts, and significantly different magnitude within May contract. However, pre-spreading100 with July contract generated the highest returns over the 60 day March storage period, implying that there is an advantage of using alternative futures contracts and pre-spreading strategy over a storage period. Both hedging strategies (basis trading and pre-spreading) generated significantly decreasing cumulative mean net returns after storage/trading day 40 with all contracts. So, for hedged soybean storage trading day 40 after October 1 was the optimal point of storage with highest returns and similar risk.

Soybean futures market does not consistently pay a “price for storage” as mean net returns from basis trading and pre-spreading became insignificant after day 60 with deferred futures contracts such as May and July. During this 60 day period, risk to hedged storage did not significantly increase and risk of using alternative contracts and strategies were equivalent.

Cumulative mean net returns from un-hedged soybean storage were significantly positive and increasing towards the end of the whole storage period, suggesting that cash market, on average, indeed paid the “price for storage”. Significantly positive and increasing cumulative mean net returns could be obtained over 67% of the storage period for soybeans, which compares with only 60% of the storage period for un-hedged corn (and even over these days corn returns are only marginally significant). Positive cumulative mean net returns were observed for 22% of the storage period for soybeans, and for 89% of the storage period for corn when futures market was used to hedge. We assume that first 20 trading days (11%) following October 1 are still harvest time period, where spot prices are low due to sufficient supply, thus not allowing a sell basis to increase.

In sum, we find that storing corn for long periods (up to 185 days) with basis trading strategy is more appropriate, whereas soybeans pre-spreading for only short periods (under 60 days) or storing without any hedging at least beyond 110 days is more appropriate storage strategy for North Central Illinois grain elevators. These differences in corn and soybean hedged storage strategies were explained by Brazilian soybean supply, where this spring harvest expectations affected (flattened) the U.S. soybean futures prices. For this reason, soybean futures market signals “not to store”, resulting in insignificant returns if stored longer using the futures market.

Limitations and future research

Some pieces of work were omitted when generating net returns from these strategies. However, they are negligent, thus should not affect main results and conclusions. For example, for cost of carry calculations we do not include hedging transaction and brokerage fees, which could be around $50 per round futures transaction for corn and soybean 5000 bushel contracts (Peterson and Tomek, 2007). So, it would be a 1cent per bushel fixed cost for all hedging strategies and not change their paired differences outcomes. Another argument might be the use of basis signal when employing harvest time basis trading strategy. However, as stated in Introduction and Methodology, grain elevators have to store grain regardless of basis signal due to their essential business function, whereas farmers could benefit from basis signal when deciding to store or not.

This thesis research modeled basis trading strategies with no “rolling over” option between futures contracts. For example, setting a pre-spread by buying December and selling July futures contracts, and offsetting with reverse transaction is the case where we assume that the elevator does not exchange any more futures contracts in between those two. However, in practice it is possible that grain elevators re-use the existing pre-spread or create spreads when moving from one contract period to the next, by buying and selling other contracts, and benefitting from their spreads too. So, it would be interesting to see if any spreads over the storage period, October 1-June30, could significantly change the basis trading and pre-spreading strategies results found in this research. Also, we could further this analysis to determine the extent of 2008-2009 corn and soybean price spikes influences on our net returns results. In addition, based on soybean decreasing mean net returns results (where sell basis is lower than the buy basis), a potential future research might analyze short the basis type strategies, where an elevator sells not yet owned grain for later delivery. Since wheat and rice are also commodities that grain elevators possess at their storage, future research might evaluate performance of the strategies analyzed in this research for those grains.

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Appendix 1. One sample t-test[i] for mean significance: corn basis trading and pre-spreading150 cumulative daily mean net returns.

Trade day	March	p-value	May	p-value	July	p-value	March150	p-value	May150	p-value	July150	p-value
2	0.365	0.205	0.310	0.290	0.284	0.371	0.127	0.693	-0.490	0.355	-0.691	0.431
3	0.951	0.016	0.775	0.047	0.774	0.068	0.713	0.098	-0.025	0.965	-0.201	0.825
4	1.354	0.025	1.510	0.012	1.397	0.034	1.116	0.080	0.710	0.334	0.422	0.684
5	1.583	0.033	1.964	0.007	2.138	0.007	1.345	0.078	1.164	0.181	1.163	0.319
6	1.169	0.118	1.553	0.032	1.815	0.018	0.930	0.205	0.753	0.321	0.840	0.386
7	1.261	0.126	1.812	0.026	1.912	0.029	1.023	0.227	1.012	0.263	0.937	0.410
8	0.180	0.863	0.753	0.469	1.015	0.382	-0.058	0.956	-0.047	0.963	0.040	0.974
9	0.999	0.299	1.701	0.083	2.100	0.056	0.761	0.422	0.901	0.349	1.125	0.328
10	1.360	0.206	1.904	0.093	2.192	0.078	1.122	0.295	1.104	0.339	1.217	0.377
11	1.018	0.348	1.532	0.182	2.094	0.110	0.780	0.473	0.732	0.534	1.119	0.434
12	1.431	0.246	2.054	0.128	2.441	0.104	1.193	0.342	1.254	0.371	1.466	0.377

13	1.339	0.322	2.007	0.181	2.444	0.130	1.101	0.424	1.207	0.439	1.469	0.416
14	1.956	0.171	2.467	0.135	2.954	0.097	1.718	0.236	1.667	0.328	1.979	0.314
15	1.805	0.214	2.096	0.208	2.583	0.150	1.567	0.290	1.296	0.466	1.608	0.436
16	2.355	0.115	2.536	0.133	3.097	0.088	2.117	0.163	1.736	0.327	2.122	0.301
17	1.388	0.413	1.833	0.338	2.295	0.253	1.150	0.507	1.033	0.610	1.320	0.563
18	1.497	0.353	1.961	0.272	2.360	0.211	1.259	0.443	1.161	0.542	1.385	0.523
19	2.079	0.216	2.446	0.188	2.783	0.158	1.841	0.283	1.646	0.401	1.808	0.417
20	2.142	0.190	2.388	0.181	2.600	0.165	1.904	0.251	1.588	0.401	1.625	0.451
21	3.014	0.085	3.253	0.093	3.440	0.086	2.776	0.117	2.453	0.221	2.465	0.272
22	3.844	0.044	4.325	0.043	4.449	0.047	3.606	0.062	3.525	0.108	3.474	0.155
23	4.359	0.018	4.878	0.020	4.965	0.023	4.121	0.027	4.078	0.057	3.990	0.095
24	4.035	0.028	4.401	0.032	4.526	0.038	3.797	0.042	3.601	0.091	3.551	0.139
25	4.587	0.018	5.055	0.017	4.979	0.025	4.349	0.028	4.255	0.052	4.004	0.101
26	5.280	0.012	5.557	0.014	5.581	0.016	5.042	0.018	4.757	0.041	4.606	0.068
27	6.147	0.003	6.655	0.003	6.655	0.004	5.909	0.005	5.855	0.010	5.680	0.022

28	6.233	0.002	6.657	0.002	6.795	0.003	5.995	0.003	5.857	0.008	5.820	0.016
29	5.933	0.004	6.456	0.004	6.593	0.005	5.695	0.007	5.656	0.014	5.618	0.025
30	6.306	0.004	7.010	0.004	7.310	0.004	6.068	0.006	6.210	0.010	6.335	0.016
31	6.572	0.002	7.614	0.001	7.963	0.001	6.334	0.003	6.814	0.003	6.988	0.006
32	7.283	0.001	8.261	0.001	8.711	0.001	7.045	0.002	7.461	0.002	7.736	0.004
33	7.513	0.001	8.502	0.000	8.975	0.000	7.275	0.001	7.702	0.001	8.000	0.002
34	7.737	0.001	8.538	0.000	9.074	0.000	7.499	0.001	7.738	0.001	8.099	0.002
35	8.289	0.000	9.279	0.000	9.741	0.000	8.051	0.001	8.479	0.001	8.766	0.001
36	8.506	0.000	9.581	0.000	10.056	0.000	8.268	0.001	8.781	0.001	9.081	0.001
37	9.098	0.000	10.067	0.000	10.653	0.000	8.859	0.000	9.267	0.000	9.678	0.000
38	9.065	0.000	10.181	0.000	10.655	0.000	8.827	0.001	9.381	0.000	9.680	0.000
39	10.138	0.000	11.234	0.000	11.609	0.000	9.900	0.000	10.434	0.000	10.634	0.000
40	9.078	0.000	9.808	0.000	10.170	0.000	8.840	0.000	9.008	0.001	9.195	0.001
41	9.759	0.000	10.723	0.000	10.934	0.000	9.521	0.000	9.923	0.000	9.959	0.000
42	10.302	0.000	11.231	0.000	11.418	0.000	10.064	0.000	10.431	0.000	10.443	0.000

43	10.509	0.000	11.511	0.000	11.634	0.000	10.271	0.000	10.711	0.000	10.659	0.000
44	10.526	0.000	11.340	0.000	11.478	0.000	10.288	0.000	10.540	0.000	10.503	0.000
45	10.631	0.000	11.351	0.000	11.413	0.000	10.393	0.000	10.551	0.000	10.438	0.001
46	11.154	0.000	11.575	0.000	11.737	0.000	10.916	0.000	10.775	0.000	10.762	0.000
47	11.411	0.000	12.107	0.000	12.182	0.000	11.173	0.000	11.307	0.000	11.207	0.000
48	10.993	0.000	11.619	0.000	11.743	0.000	10.755	0.000	10.819	0.000	10.768	0.001
49	10.966	0.000	11.552	0.000	11.589	0.000	10.728	0.000	10.752	0.000	10.614	0.001
50	11.779	0.000	12.469	0.000	12.631	0.000	11.541	0.000	11.669	0.000	11.656	0.000
51	11.528	0.000	12.281	0.000	12.442	0.000	11.290	0.000	11.481	0.000	11.467	0.000
52	11.929	0.000	12.538	0.000	12.675	0.000	11.691	0.000	11.738	0.000	11.700	0.000
53	12.094	0.000	12.599	0.000	12.573	0.000	11.856	0.000	11.799	0.000	11.598	0.000
54	12.161	0.000	12.682	0.000	12.557	0.000	11.923	0.000	11.882	0.000	11.582	0.000
55	11.821	0.000	12.362	0.000	12.174	0.000	11.583	0.000	11.562	0.000	11.199	0.000
56	11.620	0.000	12.240	0.000	12.138	0.000	11.382	0.000	11.440	0.000	11.163	0.000
57	11.365	0.000	11.885	0.000	11.722	0.000	11.127	0.000	11.085	0.000	10.747	0.001

58	11.329	0.000	11.797	0.000	11.671	0.000	11.091	0.000	10.997	0.000	10.696	0.001
59	11.390	0.000	12.035	0.000	11.909	0.000	11.152	0.000	11.235	0.000	10.934	0.001
60	11.110	0.000	11.717	0.000	11.591	0.000	10.872	0.000	10.917	0.000	10.616	0.001
61	11.498	0.000	11.973	0.000	11.847	0.000	11.260	0.000	11.173	0.000	10.872	0.001
62	12.281	0.000	12.169	0.000	11.956	0.000	12.031	0.000	11.369	0.000	10.981	0.000
63	12.220	0.000	12.096	0.000	12.007	0.000	11.970	0.000	11.296	0.000	11.032	0.000
64	12.543	0.000	12.431	0.000	12.169	0.000	12.293	0.000	11.631	0.000	11.194	0.000
65	13.090	0.000	12.929	0.000	12.628	0.000	12.840	0.000	12.129	0.000	11.653	0.000
66	12.682	0.000	12.546	0.000	12.282	0.000	12.432	0.000	11.746	0.000	11.307	0.000
67	12.173	0.000	12.110	0.000	11.797	0.000	11.923	0.000	11.310	0.000	10.822	0.000
68	11.897	0.000	11.723	0.000	11.434	0.000	11.647	0.000	10.923	0.000	10.459	0.000
69	11.558	0.000	11.322	0.000	11.046	0.000	11.308	0.000	10.522	0.000	10.071	0.000
70	10.948	0.000	10.787	0.000	10.436	0.000	10.698	0.000	9.987	0.000	9.461	0.000
71	10.228	0.000	9.966	0.000	9.541	0.000	9.978	0.000	9.166	0.001	8.566	0.001
72	10.673	0.000	10.398	0.000	10.035	0.000	10.423	0.000	9.598	0.000	9.060	0.001

73	10.551	0.000	10.215	0.000	10.001	0.000	10.301	0.000	9.415	0.000	9.026	0.001
74	10.870	0.000	10.533	0.000	10.420	0.000	10.620	0.000	9.733	0.000	9.445	0.001
75	11.045	0.000	10.784	0.000	10.596	0.000	10.795	0.000	9.984	0.000	9.621	0.001
76	11.292	0.000	11.042	0.000	10.816	0.000	11.042	0.000	10.242	0.000	9.841	0.001
77	11.606	0.000	11.369	0.000	11.231	0.000	11.356	0.000	10.569	0.000	10.256	0.001
78	11.658	0.000	11.259	0.000	11.146	0.000	11.408	0.000	10.459	0.000	10.171	0.001
79	11.843	0.000	11.545	0.000	11.556	0.000	11.593	0.000	10.745	0.000	10.581	0.000
80	11.623	0.000	11.287	0.000	11.112	0.000	11.373	0.000	10.487	0.000	10.137	0.001
81	11.863	0.000	11.614	0.000	11.451	0.000	11.613	0.000	10.814	0.000	10.476	0.001
82	12.030	0.000	11.668	0.000	11.592	0.000	11.780	0.000	10.868	0.000	10.617	0.000
83	12.868	0.000	12.406	0.000	12.242	0.000	12.618	0.000	11.606	0.000	11.267	0.000
84	13.266	0.000	12.754	0.000	12.528	0.000	13.016	0.000	11.954	0.000	11.553	0.000
85	12.958	0.000	12.346	0.000	11.945	0.000	12.708	0.000	11.546	0.000	10.970	0.001
86	13.198	0.000	12.511	0.000	11.886	0.000	12.948	0.000	11.711	0.000	10.911	0.001
87	13.356	0.000	12.694	0.000	12.206	0.000	13.106	0.000	11.894	0.000	11.231	0.001

88	13.220	0.000	12.397	0.000	12.034	0.000	12.970	0.000	11.597	0.000	11.059	0.001
89	13.207	0.000	12.419	0.000	12.156	0.000	12.957	0.000	11.619	0.000	11.181	0.001
90	13.304	0.000	12.456	0.000	12.205	0.000	13.054	0.000	11.656	0.000	11.230	0.001
91	13.757	0.000	12.996	0.000	12.845	0.000	13.507	0.000	12.196	0.000	11.870	0.001
92	13.824	0.000	12.938	0.000	12.699	0.000	13.574	0.000	12.138	0.000	11.724	0.000
93	14.062	0.000	13.263	0.000	12.875	0.000	13.812	0.000	12.463	0.000	11.900	0.000
94	14.184	0.000	13.484	0.000	13.134	0.000	13.934	0.000	12.684	0.000	12.159	0.000
95	14.544	0.000	13.795	0.000	13.420	0.000	14.294	0.000	12.995	0.000	12.445	0.000
96	14.912	0.000	14.200	0.000	13.687	0.000	14.662	0.000	13.400	0.000	12.712	0.000
97	15.185	0.000	14.499	0.000	13.861	0.000	14.935	0.000	13.699	0.000	12.886	0.000
98	14.966	0.000	14.367	0.000	13.804	0.000	14.716	0.000	13.567	0.000	12.829	0.000
99	14.951	0.000	14.378	0.000	13.876	0.000	14.701	0.000	13.578	0.000	12.901	0.000
100			14.586	0.000	13.985	0.000			13.786	0.000	13.010	0.000
101			14.857	0.000	14.381	0.000			14.057	0.000	13.406	0.000
102			14.922	0.000	14.446	0.000			14.122	0.000	13.471	0.000

103			14.595	0.000	14.019	0.000			13.795	0.000	13.044	0.000
104			14.750	0.000	14.061	0.000			13.950	0.000	13.086	0.000
105			14.608	0.000	13.958	0.000			13.808	0.000	12.983	0.000
106			15.404	0.000	14.816	0.000			14.604	0.000	13.841	0.000
107			15.493	0.000	14.744	0.000			14.693	0.000	13.769	0.000
108			15.979	0.000	15.167	0.000			15.179	0.000	14.192	0.000
109			15.884	0.000	15.171	0.000			15.084	0.000	14.196	0.000
110			15.357	0.000	14.278	0.000			14.515	0.000	13.251	0.000
111			15.737	0.000	15.223	0.000			14.937	0.000	14.248	0.000
112			15.651	0.000	14.950	0.000			14.851	0.000	13.975	0.000
113			15.500	0.000	14.874	0.000			14.700	0.000	13.899	0.000
114			15.517	0.000	14.916	0.000			14.717	0.000	13.941	0.000
115			15.971	0.000	15.408	0.000			15.171	0.000	14.433	0.000
116			15.571	0.000	14.783	0.000			14.771	0.000	13.808	0.000
117			15.724	0.000	15.023	0.000			14.924	0.000	14.048	0.000

118			15.910	0.000	15.259	0.000			15.110	0.000	14.284	0.000
119			16.210	0.000	15.397	0.000			15.410	0.000	14.422	0.000
120			16.277	0.000	15.453	0.000			15.477	0.000	14.478	0.000
121			16.597	0.000	15.846	0.000			15.797	0.000	14.871	0.000
122			17.091	0.000	16.440	0.000			16.291	0.000	15.465	0.000
123			16.413	0.000	15.737	0.000			15.613	0.000	14.762	0.000
124			16.326	0.000	15.637	0.000			15.526	0.000	14.662	0.000
125			16.643	0.000	16.067	0.000			15.843	0.000	15.092	0.000
126			16.519	0.000	15.844	0.000			15.719	0.000	14.869	0.000
127			16.502	0.000	15.739	0.000			15.702	0.000	14.764	0.000
128			16.480	0.000	15.567	0.000			15.680	0.000	14.592	0.000
129			16.687	0.000	15.861	0.000			15.887	0.000	14.886	0.000
130			17.024	0.000	16.311	0.000			16.224	0.000	15.336	0.000
131			17.092	0.000	16.329	0.000			16.292	0.000	15.354	0.000
132			17.061	0.000	16.424	0.000			16.261	0.000	15.449	0.000

133			17.341	0.000	16.815	0.000			16.541	0.000	15.840	0.000
134			17.300	0.000	16.749	0.000			16.500	0.000	15.774	0.000
135			17.797	0.000	17.347	0.000			16.997	0.000	16.372	0.000
136			17.389	0.000	17.039	0.000			16.589	0.000	16.064	0.000
137			17.318	0.000	17.167	0.000			16.518	0.000	16.192	0.000
138			17.594	0.000	17.669	0.000			16.794	0.000	16.694	0.000
139			17.936	0.000	18.123	0.000			17.136	0.000	17.148	0.000
140			18.024	0.000	18.324	0.000			17.224	0.000	17.349	0.000
141			17.787	0.000	18.124	0.000			16.987	0.000	17.149	0.000
142			17.810	0.000	18.671	0.000			17.010	0.000	17.696	0.000
143					18.588	0.000					17.613	0.000
144					18.703	0.000					17.728	0.000
145					18.953	0.000					17.978	0.000
146					18.200	0.000					17.225	0.000
147					18.541	0.000					17.566	0.000

148					18.958	0.000					17.983	0.000
149					19.276	0.000					18.301	0.000
150					19.713	0.000					18.738	0.000
151					19.404	0.000					18.429	0.000
152					20.126	0.000					19.151	0.000
153					19.818	0.000					18.843	0.000
154					19.798	0.000					18.823	0.000
155					19.873	0.000					18.898	0.000
156					20.133	0.000					19.158	0.000
157					19.948	0.000					18.973	0.000
158					19.928	0.000					18.953	0.000
159					20.070	0.000					19.095	0.000
160					20.108	0.000					19.133	0.000
161					19.604	0.000					18.629	0.000
162					19.885	0.000					18.910	0.000

163					19.698	0.000					18.723	0.000
164					19.584	0.000					18.609	0.000
165					20.144	0.000					19.169	0.000
166					20.056	0.000					19.081	0.000
167					19.828	0.000					18.853	0.000
168					19.751	0.000					18.776	0.000
169					20.376	0.000					19.401	0.000
170					20.160	0.000					19.185	0.000
171					20.476	0.000					19.501	0.000
172					20.606	0.000					19.631	0.000
173					20.373	0.000					19.398	0.000
174					20.086	0.000					19.111	0.000
175					20.114	0.000					19.139	0.000
176					20.358	0.000					19.383	0.000
177					20.475	0.000					19.500	0.000

178					20.442	0.000					19.467	0.000
179					20.567	0.000					19.592	0.000
180					19.661	0.000					18.686	0.000
181					19.830	0.000					18.855	0.000
182					19.848	0.000					18.873	0.000
183					19.715	0.000					18.740	0.000
184					19.540	0.000					18.565	0.000
185					19.708	0.000					18.733	0.000

Appendix 2A. F-test statistics for daily equal variances of cumulative net returns: corn basis trading and pre-spreading100

Trade days	March/March100	May/May 100	July/July 100	Trade days	March/March100	May/May 100	July/July 100
2	0.462	0.147	0.070	39	1.161	1.391	1.323
3	0.558	0.221	0.117	40	1.111	1.268	1.122
4	0.809	0.364	0.221	41	1.144	1.371	1.237
5	0.867	0.440	0.275	42	1.132	1.377	1.305
6	0.973	0.502	0.347	43	1.125	1.351	1.308
7	0.869	0.488	0.361	44	1.106	1.278	1.237
8	1.091	0.755	0.549	45	1.124	1.355	1.352
9	1.149	0.753	0.589	46	1.118	1.360	1.370
10	1.078	0.788	0.622	47	1.127	1.352	1.356
11	1.098	0.825	0.707	48	1.138	1.382	1.405
12	1.011	0.827	0.700	49	1.143	1.399	1.441
13	1.013	0.844	0.701	50	1.151	1.397	1.431
14	0.954	0.823	0.703	51	1.137	1.338	1.355
15	0.922	0.770	0.659	52	1.130	1.325	1.348
16	0.945	0.804	0.678	53	1.127	1.327	1.345
17	0.965	0.864	0.756	54	1.135	1.356	1.373
18	0.978	0.815	0.707	55	1.138	1.375	1.399
19	0.999	0.853	0.733	56	1.153	1.412	1.479
20	1.003	0.858	0.734	57	1.147	1.398	1.469
21	1.026	0.933	0.802	58	1.145	1.389	1.452
22	1.048	0.969	0.864	59	1.131	1.346	1.412
23	1.047	0.990	0.878	60	1.145	1.388	1.484
24	1.025	0.984	0.904	61	1.157	1.406	1.499
25	1.030	1.010	0.902	62	1.144	1.408	1.475
26	1.026	1.059	0.962	63	1.156	1.410	1.494
27	1.065	1.107	1.000	64	1.157	1.401	1.492
28	1.075	1.119	1.022	65	1.160	1.425	1.523
29	1.042	1.086	0.982	66	1.146	1.377	1.434
30	1.076	1.184	1.105	67	1.185	1.473	1.511
31	1.094	1.183	1.070	68	1.180	1.475	1.544
32	1.072	1.149	1.046	69	1.190	1.483	1.535
33	1.103	1.208	1.076	70	1.180	1.439	1.446
34	1.095	1.235	1.122	71	1.184	1.409	1.405
35	1.103	1.291	1.172	72	1.190	1.426	1.338
36	1.094	1.303	1.172	73	1.183	1.439	1.386
37	1.089	1.296	1.158	74	1.171	1.399	1.356
38	1.115	1.319	1.186	75	1.156	1.339	1.287

76	1.162	1.342	1.309	88	1.101	1.231	1.244
77	1.164	1.380	1.385	89	1.098	1.215	1.227
78	1.157	1.355	1.341	90	1.097	1.200	1.196
79	1.141	1.327	1.259	91	1.098	1.216	1.185
80	1.133	1.292	1.242	92	1.106	1.225	1.190
81	1.125	1.270	1.196	93	1.107	1.239	1.221
82	1.128	1.290	1.225	94	1.104	1.218	1.191
83	1.118	1.266	1.242	95	1.102	1.228	1.180
84	1.126	1.283	1.238	96	1.099	1.181	1.145
85	1.124	1.281	1.228	97	1.109	1.189	1.146
86	1.112	1.258	1.240	98	1.088	1.173	1.117
87	1.109	1.250	1.230	99	1.105	1.185	1.114

Appendix 2B. F-test statistics for daily equal variances of cumulative net returns: basis trading with different contracts for the March storage period.

Trade days	March/ May	March/ July	Trade days	March/ May	March/ July	Trade days	March/ May	March/ July
2	1.00	0.85	39	1.06	1.04	76	0.98	0.97
3	1.04	0.86	40	0.98	0.93	77	0.99	0.96
4	1.09	0.87	41	1.01	0.97	78	0.97	0.96
5	1.18	1.00	42	1.01	0.98	79	0.98	0.95
6	1.20	1.09	43	1.02	0.97	80	0.98	0.96
7	1.17	1.00	44	1.01	0.99	81	0.98	0.95
8	1.07	0.86	45	0.96	0.90	82	0.99	0.97
9	1.07	0.87	46	0.90	0.86	83	0.98	0.94
10	0.98	0.82	47	0.94	0.88	84	1.02	0.99
11	0.96	0.76	48	0.96	0.93	85	0.98	0.94
12	0.90	0.74	49	0.94	0.89	86	0.99	0.95
13	0.87	0.77	50	0.96	0.92	87	0.95	0.91
14	0.80	0.70	51	0.99	0.94	88	0.94	0.90
15	0.80	0.70	52	0.96	0.90	89	0.93	0.90
16	0.82	0.72	53	0.95	0.93	90	0.94	0.90
17	0.83	0.76	54	0.94	0.92	91	0.92	0.85
18	0.86	0.78	55	0.97	0.95	92	0.93	0.86
19	0.87	0.78	56	0.99	0.98	93	0.94	0.90
20	0.88	0.80	57	0.97	0.95	94	0.91	0.87
21	0.86	0.80	58	0.95	0.93	95	0.88	0.84
22	0.85	0.77	59	0.96	0.94	96	0.91	0.88
23	0.82	0.74	60	0.98	0.98	97	0.92	0.86
24	0.84	0.74	61	0.98	0.97	98	0.94	0.89
25	0.89	0.80	62	0.98	0.99	99	0.94	0.90
26	0.90	0.85	63	1.00	1.00			
27	0.92	0.84	64	0.97	0.99			
28	0.91	0.81	65	0.95	0.99			
29	0.90	0.81	66	0.96	0.98			
30	0.90	0.80	67	1.00	1.04			
31	0.95	0.87	68	1.01	1.05			
32	0.95	0.87	69	1.01	1.06			
33	0.95	0.85	70	0.99	1.05			
34	0.96	0.89	71	1.01	1.04			
35	0.95	0.92	72	0.99	1.01			
36	0.96	0.90	73	0.98	1.02			
37	1.00	0.93	74	0.97	1.00			

Appendix 2C. F-test statistics for daily equal variances of cumulative net returns: corn basis trading with different contracts for the May storage period.

Trading days	May/July	Trading days	May/July	Trading days	May/July	Trading days	May/July
2	0.85	38	0.96	75	1.02	112	0.87
3	0.83	39	0.98	76	0.98	113	0.94
4	0.80	40	0.95	77	0.97	114	0.90
5	0.85	41	0.96	78	0.99	115	0.91
6	0.91	42	0.97	79	0.97	116	0.91
7	0.85	43	0.95	80	0.97	117	0.91
8	0.81	44	0.98	81	0.97	118	0.88
9	0.81	45	0.94	82	0.98	119	0.87
10	0.84	46	0.95	83	0.96	120	0.85
11	0.78	47	0.94	84	0.97	121	0.85
12	0.82	48	0.96	85	0.96	122	0.88
13	0.88	49	0.95	86	0.96	123	0.88
14	0.87	50	0.96	87	0.96	124	0.85
15	0.87	51	0.95	88	0.95	125	0.83
16	0.88	52	0.95	89	0.97	126	0.82
17	0.91	53	0.98	90	0.96	127	0.83
18	0.91	54	0.97	91	0.93	128	0.83
19	0.89	55	0.98	92	0.93	129	0.84
20	0.91	56	0.98	93	0.95	130	0.84
21	0.94	57	0.98	94	0.96	131	0.84
22	0.90	58	0.98	95	0.95	132	0.85
23	0.91	59	0.98	96	0.96	133	0.85
24	0.88	60	1.00	97	0.94	134	0.86
25	0.90	61	0.99	98	0.95	135	0.88
26	0.94	62	1.02	99	0.96	136	0.89
27	0.91	63	1.00	100	0.97	137	0.89
28	0.89	64	1.02	101	0.95	138	0.89
29	0.91	65	1.04	102	0.96	139	0.93
30	0.90	66	1.02	103	0.93	140	0.98
31	0.92	67	1.04	104	0.93	141	1.00
32	0.92	68	1.04	105	0.93	142	0.94
33	0.89	69	1.06	106	0.93		
34	0.92	70	1.07	107	0.93		
35	0.97	71	1.04	108	0.94		
36	0.94	72	1.02	109	0.93		
37	0.93	73	1.04	110	0.98		
		74	1.02	111	0.89		

Appendix 3. Paired t-test[ii] results for daily net returns mean differences: basis trading with different contracts, same period.

Corn March contract period

Trading days	March-May	p-value	March-July	p-value	Trading days	March-May	p-value	March-July	p-value
2	0.086	0.198	0.112	0.134	27	-0.126	0.270	-0.125	0.367
3	0.199	0.017*	0.200	0.074	28	-0.063	0.390	-0.200	0.330
4	0.049	0.327	0.162	0.168	29	-0.163	0.278	-0.301	0.269
5	-0.127	0.200	-0.301	0.099	30	-0.314	0.132	-0.613	0.124
6	-0.076	0.314	-0.338	0.087	31	-0.576	0.051	-0.925	0.062
7	-0.226	0.065	-0.326	0.114	32	-0.501	0.087	-0.951	0.060
8	-0.252	0.100	-0.513	0.077	33	-0.476	0.077	-0.950	0.073
9	-0.364	0.059	-0.763	0.053	34	-0.289	0.167	-0.825	0.103
10	-0.313	0.057	-0.601	0.091	35	-0.450	0.112	-0.913	0.102
11	-0.301	0.049	-0.863	0.032*	36	-0.500	0.096	-0.975	0.101
12	-0.339	0.024*	-0.726	0.038*	37	-0.377	0.157	-0.963	0.105
13	-0.413	0.022*	-0.850	0.019*	38	-0.276	0.177	-0.750	0.121
14	-0.426	0.047*	-0.912	0.030*	39	-0.301	0.177	-0.676	0.147
15	-0.350	0.085	-0.838	0.031*	40	-0.126	0.344	-0.488	0.229
16	-0.226	0.162	-0.787	0.039*	41	-0.351	0.138	-0.562	0.199
17	-0.300	0.112	-0.763	0.049*	42	-0.251	0.242	-0.438	0.269
18	-0.239	0.138	-0.638	0.078	43	-0.289	0.242	-0.412	0.284
19	-0.238	0.114	-0.575	0.100	44	-0.226	0.278	-0.363	0.295
20	-0.076	0.352	-0.288	0.229	45	-0.138	0.346	-0.200	0.380
21	-0.163	0.228	-0.350	0.198	46	-0.052	0.445	-0.213	0.372
22	-0.314	0.120	-0.437	0.206	47	-0.150	0.353	-0.225	0.373
23	-0.401	0.069	-0.488	0.171	48	-0.014	0.486	-0.138	0.419
24	-0.189	0.195	-0.313	0.253	49	-0.063	0.435	-0.100	0.445

25	-0.138	0.250	-0.063	0.443	50	-0.126	0.385	-0.288	0.345
26	-0.013	0.475	-0.037	0.462	51	-0.127	0.381	-0.288	0.340
52	-0.075	0.425	-0.213	0.381	78	0.399	0.249	0.512	0.273
53	-0.038	0.462	-0.012	0.492	79	0.298	0.306	0.287	0.375
54	-0.038	0.461	0.087	0.447	80	0.336	0.290	0.511	0.294
55	-0.025	0.473	0.163	0.399	81	0.249	0.342	0.412	0.337
56	-0.014	0.487	0.087	0.445	82	0.362	0.269	0.438	0.322
57	0.074	0.423	0.237	0.354	83	0.462	0.227	0.626	0.257
58	0.048	0.450	0.174	0.389	84	0.512	0.197	0.738	0.223
59	-0.113	0.385	0.012	0.492	85	0.612	0.174	1.012	0.153
60	-0.126	0.374	-0.001	0.499	86	0.687	0.135	1.312	0.094
61	0.049	0.447	0.175	0.386	87	0.662	0.141	1.150	0.116
62	0.112	0.370	0.324	0.304	88	0.823	0.091	1.187	0.099
63	0.123	0.360	0.213	0.366	89	0.787	0.116	1.051	0.143
64	0.112	0.371	0.374	0.263	90	0.849	0.094	1.099	0.136
65	0.162	0.327	0.462	0.204	91	0.761	0.121	0.912	0.185
66	0.137	0.367	0.400	0.252	92	0.886	0.084	1.125	0.131
67	0.062	0.442	0.375	0.270	93	0.799	0.101	1.187	0.122
68	0.174	0.348	0.463	0.234	94	0.700	0.140	1.050	0.156
69	0.236	0.269	0.512	0.181	95	0.748	0.112	1.124	0.152
70	0.161	0.356	0.512	0.204	96	0.712	0.129	1.225	0.120
71	0.262	0.289	0.687	0.165	97	0.687	0.137	1.325	0.104
72	0.275	0.283	0.638	0.198	98	0.599	0.167	1.163	0.135
73	0.336	0.255	0.550	0.242	99	0.573	0.179	1.074	0.135
74	0.337	0.259	0.450	0.293					
75	0.262	0.331	0.449	0.303					
76	0.250	0.345	0.476	0.289					
77	0.237	0.339	0.375	0.329					

Appendix 4. Paired t-test results for daily net returns mean differences: basis trading with different contracts in May storage period

Trading days	May-July	p-value	Trading days	May-July	p-value	Trading days	May-July	p-value	Trading days	May-July	p-value
2	0.026	0.399	25	0.076	0.387	48	-0.124	0.363	71	0.425	0.108
3	0.002	0.496	26	-0.024	0.460	49	-0.037	0.464	72	0.363	0.178
4	0.112	0.174	27	0.001	0.499	50	-0.162	0.339	73	0.214	0.305
5	-0.174	0.155	28	-0.138	0.322	51	-0.161	0.336	74	0.113	0.397
6	-0.263	0.029*	29	-0.137	0.323	52	-0.138	0.371	75	0.188	0.323
7	-0.100	0.253	30	-0.300	0.181	53	0.025	0.472	76	0.226	0.264
8	-0.262	0.136	31	-0.349	0.142	54	0.125	0.368	77	0.139	0.368
9	-0.400	0.064	32	-0.450	0.068	55	0.188	0.309	78	0.113	0.394
10	-0.288	0.157	33	-0.474	0.109	56	0.101	0.388	79	-0.011	0.490
11	-0.562	0.041*	34	-0.536	0.100	57	0.163	0.323	80	0.175	0.351
12	-0.387	0.072	35	-0.463	0.126	58	0.126	0.352	81	0.163	0.366
13	-0.437	0.032*	36	-0.474	0.131	59	0.126	0.355	82	0.076	0.436
14	-0.487	0.026*	37	-0.586	0.101	60	0.125	0.371	83	0.164	0.367
15	-0.488	0.021*	38	-0.474	0.122	61	0.126	0.357	84	0.226	0.323
16	-0.561	0.014*	39	-0.375	0.169	62	0.213	0.295	85	0.400	0.197
17	-0.463	0.028*	40	-0.362	0.192	63	0.089	0.409	86	0.626	0.102
18	-0.399	0.069	41	-0.211	0.314	64	0.262	0.238	87	0.488	0.148
19	-0.337	0.106	42	-0.187	0.334	65	0.300	0.178	88	0.363	0.191
20	-0.212	0.168	43	-0.123	0.377	66	0.263	0.204	89	0.263	0.267
21	-0.187	0.203	44	-0.137	0.351	67	0.313	0.153	90	0.250	0.289
22	-0.124	0.343	45	-0.062	0.434	68	0.289	0.173	91	0.151	0.368
23	-0.087	0.379	46	-0.161	0.334	69	0.276	0.179	92	0.239	0.303
24	-0.125	0.339	47	-0.075	0.421	70	0.351	0.131	93	0.388	0.211

94	0.351	0.243	121	0.751	0.204
95	0.376	0.259	122	0.651	0.245
96	0.513	0.169	123	0.677	0.234
97	0.638	0.121	124	0.688	0.242
98	0.563	0.155	125	0.576	0.293
99	0.501	0.154	126	0.675	0.272
100	0.601	0.133	127	0.763	0.235
101	0.476	0.208	128	0.913	0.179
102	0.476	0.192	129	0.826	0.226
103	0.576	0.174	130	0.713	0.259
104	0.688	0.131	131	0.763	0.247
105	0.650	0.143	132	0.638	0.294
106	0.588	0.186	133	0.526	0.331
107	0.750	0.106	134	0.551	0.329
108	0.813	0.090	135	0.450	0.353
109	0.713	0.153	136	0.350	0.376
110	1.079	0.047*	137	0.151	0.451
111	0.513	0.265	138	-0.075	0.478
112	0.701	0.175	139	-0.187	0.446
113	0.626	0.204	140	-0.300	0.416
114	0.601	0.242	141	-0.337	0.406
115	0.563	0.255	142	-0.861	0.294
116	0.788	0.165			
117	0.701	0.193			
118	0.651	0.231			
119	0.813	0.171			
120	0.825	0.170			

Appendix 5. One sample t-test for mean significance: soybean basis trading and pre-spreading strategies daily cumulative net returns

Trade days	March	p-value	March100	p-value	May	p-value	May100	p-value	July	p-value	July100	p-value
2	-1.14	0.06	-0.83	0.21	-1.43	0.03	-0.43	0.62	-1.61	0.04	-0.51	0.65
3	-0.71	0.29	-0.40	0.58	-0.82	0.31	0.18	0.86	-1.28	0.13	-0.18	0.88
4	0.03	0.96	0.34	0.67	-0.25	0.75	0.75	0.45	-0.58	0.48	0.52	0.64
5	0.83	0.42	1.14	0.30	0.28	0.80	1.28	0.34	0.06	0.96	1.16	0.41
6	0.51	0.67	0.82	0.51	-0.28	0.80	0.72	0.57	-0.41	0.74	0.69	0.64
7	0.15	0.89	0.46	0.68	-0.13	0.90	0.87	0.49	0.05	0.96	1.15	0.43
8	-1.58	0.31	-1.27	0.42	-0.73	0.69	0.27	0.89	-0.43	0.82	0.67	0.75
9	1.04	0.50	1.35	0.39	2.62	0.20	3.62	0.08	3.51	0.14	4.61	0.07
10	2.36	0.27	2.66	0.22	4.14	0.19	5.14	0.11	4.91	0.17	6.01	0.10
11	1.62	0.42	1.93	0.34	3.67	0.21	4.67	0.11	4.12	0.20	5.22	0.12
12	2.33	0.28	2.64	0.24	4.42	0.14	5.42	0.07	4.81	0.13	5.91	0.08
13	2.28	0.33	2.59	0.28	4.52	0.15	5.52	0.08	5.31	0.13	6.41	0.08
14	2.81	0.25	3.12	0.21	4.97	0.10	5.97	0.05	5.58	0.09	6.68	0.05
15	2.87	0.25	3.18	0.21	5.25	0.10	6.25	0.05	5.80	0.09	6.90	0.05
16	3.85	0.16	4.16	0.13	6.17	0.09	7.17	0.05	6.76	0.09	7.86	0.05
17	4.73	0.10	5.04	0.08	7.00	0.07	8.00	0.03	7.98	0.06	9.08	0.04
18	5.10	0.11	5.40	0.09	7.74	0.06	8.74	0.03	8.69	0.05	9.79	0.03
19	4.65	0.11	4.96	0.09	6.84	0.05	7.84	0.02	7.93	0.04	9.03	0.02
20	4.86	0.09	5.17	0.08	7.09	0.04	8.09	0.02	8.09	0.04	9.19	0.02
21	5.21	0.06	5.52	0.04	7.66	0.02	8.66	0.01	8.35	0.06	10.12	0.04
22	7.07	0.01	7.38	0.01	9.22	0.00	10.22	0.00	9.99	0.00	11.09	0.00
23	8.75	0.00	9.06	0.00	10.83	0.00	11.83	0.00	11.88	0.00	12.98	0.00
24	8.25	0.00	8.56	0.00	10.54	0.00	11.54	0.00	11.51	0.00	12.61	0.00

25	8.50	0.00	8.81	0.00	10.26	0.00	11.26	0.00	10.99	0.00	12.09	0.00
26	8.73	0.00	9.04	0.00	10.51	0.00	11.51	0.00	11.08	0.00	12.18	0.00
27	9.79	0.00	10.10	0.00	11.56	0.00	12.56	0.00	12.03	0.00	13.13	0.00
28	9.62	0.00	9.93	0.00	11.53	0.00	12.53	0.00	12.24	0.00	13.34	0.00
29	10.51	0.00	10.81	0.00	12.57	0.00	13.57	0.00	13.43	0.00	14.53	0.00
30	11.54	0.00	11.85	0.00	14.36	0.00	15.36	0.00	15.61	0.00	16.71	0.00
31	11.31	0.00	11.62	0.00	13.77	0.00	14.77	0.00	15.23	0.00	16.33	0.00
32	11.76	0.00	12.07	0.00	14.33	0.00	15.33	0.00	15.69	0.00	16.79	0.00
33	11.79	0.00	12.10	0.00	13.88	0.00	14.88	0.00	15.28	0.00	16.38	0.00
34	11.67	0.00	11.98	0.00	13.79	0.00	14.79	0.00	15.43	0.00	16.53	0.00
35	12.48	0.00	12.78	0.00	14.91	0.00	15.91	0.00	16.46	0.00	17.56	0.00
36	12.48	0.00	12.79	0.00	14.78	0.00	15.78	0.00	15.97	0.00	17.07	0.00
37	13.04	0.00	13.35	0.00	15.08	0.00	16.08	0.00	16.43	0.00	17.53	0.00
38	12.94	0.00	13.25	0.00	14.80	0.00	15.80	0.00	16.07	0.00	17.17	0.00
39	14.20	0.00	14.51	0.00	16.18	0.00	17.18	0.00	17.20	0.00	18.30	0.00
40	12.89	0.00	13.20	0.00	15.53	0.00	16.53	0.00	16.50	0.00	17.60	0.00
41	12.90	0.00	13.21	0.00	15.42	0.00	16.42	0.00	16.54	0.00	17.64	0.00
42	14.42	0.00	14.73	0.00	17.13	0.00	18.13	0.00	18.53	0.00	19.63	0.00
43	13.14	0.00	13.45	0.00	15.74	0.00	16.74	0.00	17.18	0.00	18.28	0.00
44	13.39	0.00	13.70	0.00	15.88	0.00	16.88	0.00	17.30	0.00	18.40	0.00
45	13.30	0.00	13.61	0.00	15.95	0.00	16.95	0.00	17.09	0.00	18.19	0.00
46	12.81	0.00	13.12	0.00	14.96	0.00	15.96	0.00	16.15	0.00	17.25	0.00
47	12.07	0.01	12.38	0.01	14.16	0.00	15.16	0.00	15.36	0.00	16.46	0.00
48	12.27	0.01	12.58	0.00	14.37	0.00	15.37	0.00	15.55	0.00	16.65	0.00
49	12.15	0.01	12.46	0.01	14.65	0.00	15.65	0.00	15.82	0.00	16.92	0.00
50	12.46	0.01	12.77	0.01	14.72	0.00	15.72	0.00	16.18	0.00	17.28	0.00
51	12.61	0.00	12.92	0.00	14.65	0.00	15.65	0.00	16.03	0.00	17.13	0.00
52	11.72	0.01	12.03	0.01	13.43	0.00	14.43	0.00	14.59	0.00	15.69	0.00

53	11.68	0.01	11.99	0.01	12.95	0.01	13.95	0.00	13.91	0.00	15.01	0.00
54	12.12	0.01	12.42	0.01	12.86	0.01	13.86	0.00	13.63	0.00	14.73	0.00
55	11.25	0.01	11.56	0.01	12.13	0.01	13.13	0.01	12.77	0.01	13.87	0.01
56	11.27	0.01	11.58	0.01	11.72	0.01	12.72	0.01	12.61	0.01	13.71	0.00
57	10.98	0.01	11.29	0.01	11.58	0.01	12.58	0.01	12.35	0.01	13.45	0.01
58	10.45	0.01	10.76	0.01	11.10	0.01	12.10	0.01	11.81	0.01	12.91	0.01
59	10.55	0.01	10.86	0.01	10.78	0.02	11.78	0.01	11.28	0.02	12.38	0.01
60	10.34	0.01	10.65	0.01	10.51	0.03	11.51	0.02	11.17	0.02	12.27	0.02
61	7.39	0.07	7.70	0.06	7.31	0.13	8.31	0.10	7.86	0.10	8.96	0.07
62	11.83	0.00	12.15	0.00	10.19	0.02	11.19	0.01	10.68	0.02	11.78	0.01
63	12.48	0.00	12.81	0.00	10.57	0.02	11.57	0.01	11.06	0.01	12.16	0.01
64	12.28	0.00	12.60	0.00	10.17	0.03	11.17	0.02	11.00	0.02	12.10	0.01
65	12.57	0.00	12.89	0.00	10.53	0.02	11.53	0.01	10.99	0.02	12.09	0.01
66	12.56	0.00	12.88	0.00	10.46	0.02	11.46	0.02	10.91	0.02	12.01	0.02
67	12.39	0.00	12.71	0.00	10.38	0.03	11.38	0.02	10.68	0.02	11.78	0.02
68	12.37	0.00	12.69	0.00	10.58	0.03	11.58	0.02	11.06	0.02	12.16	0.02
69	12.10	0.00	12.43	0.00	10.29	0.03	11.29	0.02	10.29	0.03	11.39	0.03
70	12.29	0.00	12.62	0.00	10.36	0.03	11.36	0.02	10.12	0.04	11.22	0.03
71	11.02	0.01	11.34	0.01	9.03	0.06	10.03	0.05	8.93	0.08	10.03	0.06
72	11.29	0.01	11.61	0.01	9.30	0.06	10.30	0.04	9.10	0.08	10.20	0.06
73	10.79	0.01	11.12	0.01	8.61	0.08	9.61	0.06	8.36	0.11	9.46	0.08
74	9.98	0.02	10.31	0.02	7.75	0.13	8.75	0.10	7.03	0.20	8.13	0.16
75	10.44	0.01	10.77	0.01	8.09	0.12	9.09	0.09	7.66	0.17	8.76	0.13
76	10.34	0.01	10.66	0.01	8.07	0.12	9.07	0.09	7.49	0.18	8.59	0.14
77	10.00	0.01	10.33	0.01	7.80	0.12	8.80	0.09	7.40	0.17	8.50	0.13
78	10.25	0.01	10.58	0.01	8.14	0.10	9.14	0.08	7.90	0.14	9.00	0.11
79	11.03	0.01	11.36	0.01	8.97	0.09	9.97	0.06	8.92	0.12	10.02	0.09
80	11.13	0.01	11.45	0.01	8.75	0.10	9.75	0.07	8.53	0.13	9.63	0.10

81	11.04	0.01	11.36	0.01	8.91	0.09	9.91	0.07	8.62	0.13	9.72	0.10
82	10.97	0.01	11.29	0.01	8.65	0.10	9.65	0.07	8.25	0.15	9.35	0.11
83	11.19	0.01	11.51	0.01	8.74	0.10	9.74	0.07	8.71	0.13	9.81	0.10
84	10.04	0.02	10.36	0.02	7.58	0.15	8.58	0.11	7.21	0.21	8.31	0.16
85	10.61	0.01	10.93	0.01	8.16	0.12	9.16	0.09	7.28	0.20	8.38	0.16
86	10.33	0.01	10.66	0.01	7.66	0.14	8.66	0.11	7.28	0.21	8.38	0.16
87	10.66	0.01	10.98	0.01	8.06	0.12	9.06	0.09	7.72	0.17	8.82	0.13
88	10.86	0.01	11.18	0.01	8.14	0.13	9.14	0.10	8.08	0.16	9.18	0.13
89	10.55	0.02	10.87	0.02	7.49	0.16	8.49	0.12	7.10	0.22	8.20	0.17
90	10.20	0.02	10.52	0.02	7.28	0.17	8.28	0.13	7.15	0.20	8.25	0.16
91	10.15	0.02	10.48	0.02	7.45	0.15	8.45	0.11	7.44	0.18	8.54	0.14
92	9.74	0.02	10.07	0.02	7.19	0.16	8.19	0.12	7.34	0.18	8.44	0.14
93	9.90	0.02	10.23	0.02	7.55	0.14	8.55	0.11	7.44	0.18	8.54	0.14
94	10.49	0.01	10.81	0.01	8.26	0.11	9.26	0.08	8.10	0.15	9.20	0.11
95	10.21	0.01	10.53	0.01	8.05	0.12	9.05	0.09	7.90	0.16	9.00	0.12
96	10.29	0.02	10.62	0.02	8.44	0.13	9.44	0.10	8.23	0.17	9.33	0.13
97	10.28	0.02	10.60	0.02	8.13	0.13	9.13	0.10	8.10	0.15	9.20	0.12
98	9.49	0.03	9.81	0.03	7.64	0.16	8.64	0.12	7.21	0.21	8.31	0.17
99	8.87	0.03	9.19	0.03	6.97	0.17	7.97	0.12	6.37	0.24	7.47	0.19
100					7.42	0.15	8.42	0.11	6.85	0.22	7.95	0.17
101					6.69	0.19	7.69	0.14	5.62	0.31	6.72	0.24
102					6.02	0.24	7.02	0.18	5.32	0.33	6.42	0.26
103					6.65	0.19	7.65	0.14	5.81	0.29	6.91	0.23
104					6.30	0.22	7.30	0.16	5.31	0.33	6.41	0.26
105					6.41	0.22	7.41	0.17	6.01	0.31	7.11	0.24
106					6.13	0.24	7.13	0.18	5.72	0.32	6.82	0.25
107					5.87	0.27	6.87	0.21	5.30	0.37	6.40	0.30
108					5.70	0.28	6.70	0.21	4.94	0.40	6.04	0.32

109					5.27	0.32	6.27	0.25	4.22	0.48	5.32	0.39
110					4.99	0.36	5.99	0.27	3.98	0.51	5.08	0.41
111					4.67	0.38	5.67	0.29	3.63	0.54	4.73	0.44
112					4.69	0.37	5.69	0.28	3.76	0.53	4.86	0.43
113					4.39	0.40	5.39	0.31	3.68	0.53	4.78	0.43
114					4.38	0.39	5.38	0.30	3.54	0.55	4.64	0.44
115					3.92	0.44	4.92	0.34	2.86	0.62	3.96	0.51
116					3.97	0.44	4.97	0.34	2.98	0.61	4.08	0.50
117					3.37	0.51	4.37	0.40	2.14	0.71	3.24	0.59
118					4.01	0.43	5.01	0.33	2.76	0.64	3.86	0.52
119					3.24	0.53	4.24	0.42	1.95	0.74	3.05	0.62
120					3.29	0.52	4.29	0.41	2.24	0.71	3.34	0.59
121					3.31	0.51	4.31	0.40	2.40	0.69	3.50	0.57
122					2.92	0.57	3.92	0.45	2.41	0.68	3.51	0.56
123					2.95	0.55	3.95	0.44	1.95	0.73	3.05	0.60
124					2.82	0.57	3.82	0.45	1.40	0.81	2.50	0.68
125					2.61	0.61	3.61	0.48	0.97	0.87	2.07	0.73
126					3.14	0.54	4.14	0.42	0.85	0.89	1.95	0.75
127					3.56	0.49	4.56	0.38	1.59	0.79	2.69	0.66
128					3.24	0.52	4.24	0.41	0.98	0.87	2.08	0.73
129					1.54	0.78	2.54	0.65	-0.56	0.93	0.54	0.93
130					3.18	0.54	4.18	0.43	1.25	0.84	2.35	0.71
131					3.58	0.47	4.58	0.36	1.73	0.77	2.83	0.65
132					3.26	0.51	4.26	0.40	1.39	0.82	2.49	0.69
133					3.52	0.48	4.52	0.38	1.85	0.76	2.95	0.64
134					3.41	0.50	4.41	0.39	1.47	0.81	2.57	0.68
135					3.33	0.50	4.33	0.39	1.05	0.86	2.15	0.73
136					3.57	0.48	4.57	0.37	1.86	0.76	2.96	0.64

137					3.41	0.49	4.41	0.38	1.87	0.76	2.97	0.63
138					3.68	0.46	4.68	0.36	2.71	0.65	3.81	0.54
139					4.03	0.41	5.03	0.32	3.09	0.59	4.19	0.48
140					4.57	0.35	5.57	0.26	3.72	0.52	4.82	0.42
141					4.44	0.37	5.44	0.28	3.80	0.51	4.90	0.41
142					4.18	0.40	5.18	0.31	3.82	0.52	4.92	0.42
143									4.42	0.45	5.52	0.36
144									4.21	0.46	5.31	0.37
145									5.00	0.38	6.10	0.30
146									4.10	0.47	5.20	0.38
147									5.13	0.38	6.23	0.30
148									5.72	0.32	6.82	0.26
149									5.97	0.30	7.07	0.24
150									5.83	0.32	6.93	0.25
151									5.77	0.33	6.87	0.26
152									6.05	0.30	7.15	0.24
153									5.75	0.32	6.85	0.26
154									5.96	0.30	7.06	0.24
155									6.40	0.27	7.50	0.22
156									6.51	0.26	7.61	0.21
157									6.44	0.27	7.54	0.22
158									6.42	0.26	7.52	0.20
159									6.22	0.27	7.32	0.21
160									6.30	0.27	7.40	0.21
161									6.65	0.23	7.75	0.18
162									6.76	0.22	7.86	0.17
163									7.25	0.20	8.35	0.15
164									7.58	0.18	8.68	0.14

165									7.57	0.20	8.67	0.16
166									7.58	0.19	8.68	0.15
167									7.74	0.18	8.84	0.14
168									7.51	0.20	8.61	0.16
169									7.10	0.22	8.20	0.18
170									6.93	0.23	8.03	0.18
171									7.07	0.22	8.17	0.18
172									7.01	0.22	8.11	0.17
173									6.91	0.23	8.01	0.18
174									6.55	0.25	7.65	0.20
175									5.68	0.27	6.78	0.21
176									5.64	0.27	6.74	0.21
177									5.81	0.26	6.91	0.21
178									5.55	0.30	6.65	0.24
179									5.34	0.32	6.44	0.25
180									4.09	0.47	5.19	0.38
181									6.08	0.26	7.18	0.21
182									5.89	0.28	6.99	0.22
183									5.77	0.29	6.87	0.23
184									5.49	0.34	6.59	0.28
185									4.42	0.43	5.52	0.34

Appendix 6 A. F-test statistics for daily equal variances of net returns: soybean basis trading and pre-spreading100.

Trading days	March/March100	May/May100	July/July100	Trading days	March/March100	May/May100	July/July100
2	0.81	0.54	0.41*	28	0.96	1.00	0.93
3	0.86	0.62	0.47	29	0.97	1.06	0.96
4	0.85	0.64	0.51	30	0.97	1.04	0.97
5	0.90	0.73	0.68	31	0.96	1.02	0.95
6	0.93	0.76	0.71	32	0.95	1.01	0.94
7	0.93	0.74	0.68	33	0.95	1.00	0.93
8	0.98	0.84	0.86	34	0.95	0.98	0.90
9	0.96	0.98	0.92	35	0.95	0.97	0.90
10	0.98	1.01	0.97	36	0.95	0.98	0.90
11	0.96	1.01	0.93	37	0.95	0.99	0.91
12	0.95	1.00	0.93	38	0.95	0.97	0.90
13	0.96	1.01	0.95	39	0.97	0.99	0.92
14	0.96	1.01	0.94	40	0.95	0.96	0.90
15	0.98	1.03	0.97	41	0.95	0.95	0.89
16	1.00	1.06	1.01	42	0.96	0.97	0.92
17	1.00	1.06	1.03	43	0.96	0.96	0.91
18	1.01	1.07	1.04	44	0.97	0.99	0.94
19	1.01	1.09	1.04	45	0.97	0.97	0.93
20	1.01	1.08	1.02	46	0.97	0.97	0.93
21	1.01	1.12	1.02	47	0.97	0.97	0.92
22	0.99	1.11	1.03	48	0.96	0.96	0.92
23	0.98	1.11	1.03	49	0.96	0.97	0.92
24	0.97	1.08	1.00	50	0.96	0.97	0.92
25	0.97	1.04	0.97	51	0.96	0.97	0.92

26	0.96	1.02	0.94	52	0.96	0.97	0.93
27	0.96	1.00	0.94	53	0.96	0.96	0.91
54	0.96	0.96	0.91	84	0.95	0.95	0.93
55	0.96	0.96	0.92	85	0.95	0.95	0.93
56	0.96	0.96	0.91	86	0.95	0.95	0.93
57	0.96	0.96	0.91	87	0.95	0.96	0.93
58	0.96	0.96	0.90	88	0.96	0.96	0.94
59	0.96	0.96	0.91	89	0.96	0.96	0.93
60	0.96	0.96	0.92	90	0.95	0.95	0.93

Appendix 6B. F-test statistics for daily equal variances of net returns: soybean basis trading with different contracts.

Trade days	March/May	March/July	Trade days	March/May	March/July	Trade days	March/May	March/July
2	0.87[iii]	0.69	27	0.93	0.83	52	0.96	0.92
3	0.72	0.70	28	0.95	0.82	53	0.97	0.95
4	0.93	0.91	29	0.91	0.74	54	0.91	0.89
5	0.87	0.82	30	0.91	0.71	55	0.88	0.87
6	1.26	1.02	31	1.04	0.84	56	0.91	0.91
7	1.05	0.84	32	0.96	0.74	57	0.92	0.91
8	0.75	0.67	33	0.96	0.79	58	0.88	0.84
9	0.62	0.46	34	1.04	0.92	59	0.81	0.76
10	0.49	0.38	35	1.12	0.98	60	0.83	0.80
11	0.50	0.42	36	1.04	0.96			
12	0.57	0.50	37	1.02	0.95			
13	0.59	0.48	38	1.04	0.99			
14	0.69	0.58	39	1.13	1.09			
15	0.68	0.58	40	1.11	1.05			
16	0.61	0.51	41	1.16	1.10			
17	0.62	0.49	42	1.15	1.05			
18	0.66	0.54	43	1.12	1.02			
19	0.75	0.60	44	1.11	1.03			
20	0.78	0.62	45	1.06	0.97			
21	0.84	0.22	46	1.01	0.94			
22	0.97	0.78	47	0.96	0.92			
23	0.95	0.74	48	1.01	0.99			
24	1.02	0.84	49	1.05	1.03			
25	1.03	0.87	50	1.05	1.03			
26	1.05	0.87	51	1.01	1.01			

Appendix 7. One tail paired t-test results for daily net returns mean differences: different contracts, same period. Soybean.

Trade day	March-May	p-value	March-May100	p-value	Trade day	March-May	p-value	March-May100	p-value	Trade day	March-May	p-value	March-May100	p-value
2	0.48	0.02	-0.52	0.20	25	-1.00	0.11	-2.00	0.02*	48	0.04	0.49	-0.96	0.22
3	0.23	0.23	-0.77	0.12	26	-0.88	0.17	-1.88	0.04*	49	-0.32	0.37	-1.32	0.13
4	0.36	0.16	-0.64	0.17	27	-0.95	0.10	-1.95	0.02*	50	-0.12	0.45	-1.12	0.18
5	0.34	0.20	-0.66	0.17	28	-0.83	0.14	-1.83	0.03*	51	-0.01	0.50	-1.01	0.21
6	0.09	0.41	-0.91	0.09	29	-0.99	0.12	-1.99	0.02*	52	0.23	0.42	-0.77	0.28
7	-0.27	0.27	-1.27	0.03*[iv]	30	-1.41	0.11	-2.41	0.03*	53	0.74	0.27	-0.26	0.42
8	-1.01	0.07	-2.01	0.01*	31	-1.18	0.10	-2.18	0.02*	54	1.02	0.20	0.02	0.49
9	-1.27	0.04	-2.27	0.00*	32	-1.49	0.06	-2.49	0.01*	55	0.79	0.25	-0.21	0.44
10	-1.54	0.09	-2.54	0.02*	33	-1.06	0.09	-2.06	0.01*	56	1.19	0.16	0.19	0.45
11	-1.64	0.09	-2.64	0.02*	34	-0.86	0.13	-1.86	0.02*	57	1.11	0.19	0.11	0.47
12	-1.66	0.08	-2.66	0.02*	35	-0.89	0.13	-1.89	0.02*	58	1.16	0.20	0.16	0.46
13	-1.79	0.08	-2.79	0.02*	36	-0.77	0.17	-1.77	0.03*	59	1.35	0.18	0.35	0.42
14	-1.75	0.07	-2.75	0.02*	37	-0.73	0.15	-1.73	0.03*	60	1.43	0.15	0.43	0.39
15	-1.90	0.07	-2.90	0.02*	38	-0.35	0.32	-1.35	0.08					
16	-1.96	0.10	-2.96	0.03*	39	-0.17	0.41	-1.17	0.10					
17	-2.06	0.10	-3.06	0.03*	40	-0.90	0.12	-1.90	0.02*					
18	-2.34	0.09	-3.34	0.03*	41	-0.70	0.19	-1.70	0.05*					
19	-1.61	0.12	-2.61	0.03*	42	-0.64	0.25	-1.64	0.07					
20	-1.51	0.10	-2.51	0.02*	43	-0.56	0.29	-1.56	0.09					
21	-1.70	0.08	-2.70	0.02*	44	-0.44	0.33	-1.44	0.10					
22	-1.39	0.08	-2.39	0.01*	45	-0.52	0.30	-1.52	0.09					
23	-1.28	0.08	-2.28	0.01*	46	-0.07	0.47	-1.07	0.19					
24	-1.55	0.06	-2.55	0.01*	47	-0.01	0.50	-1.01	0.21					

Trade day	March-July	p-value	March-July100	p-value	Trade day	March-July	p-value	March-July100	p-value	Trade day	March-July	p-value	March-July100	p-value
2	0.65	0.05*	-0.45	0.30	28	-1.53	0.10	-2.63	0.02*	54	0.25	0.43	-0.85	0.30
3	0.69	0.09	-0.41	0.32	29	-1.85	0.09	-2.95	0.02*	55	0.15	0.46	-0.95	0.27
4	0.69	0.10	-0.41	0.33	30	-2.66	0.07	-3.76	0.02*	56	0.30	0.41	-0.80	0.31
5	0.56	0.13	-0.54	0.27	31	-2.64	0.04*	-3.74	0.01*	57	0.34	0.41	-0.76	0.33
6	0.22	0.36	-0.88	0.18	32	-2.85	0.05*	-3.95	0.01*	58	0.45	0.40	-0.65	0.37
7	-0.46	0.25	-1.56	0.05*	33	-2.46	0.04*	-3.56	0.01*	59	0.85	0.32	-0.25	0.45
8	-1.31	0.09	-2.41	0.02*	34	-2.50	0.03*	-3.60	0.01*	60	0.76	0.33	-0.34	0.43
9	-2.16	0.02*	-3.26	0.00*	35	-2.44	0.04*	-3.54	0.01*					
10	-2.31	0.07	-3.41	0.02*	36	-1.96	0.06	-3.06	0.01*					
11	-2.09	0.08	-3.19	0.02*	37	-2.08	0.04*	-3.18	0.01*					
12	-2.05	0.08	-3.15	0.02*	38	-1.63	0.07	-2.73	0.01*					
13	-2.58	0.06	-3.68	0.02*	39	-1.20	0.14	-2.30	0.03*					
14	-2.36	0.06	-3.46	0.02*	40	-1.86	0.06	-2.96	0.01*					
15	-2.45	0.07	-3.55	0.02*	41	-1.83	0.07	-2.93	0.02*					
16	-2.55	0.10	-3.65	0.04*	42	-2.04	0.07	-3.14	0.02*					
17	-3.05	0.09	-4.15	0.03*	43	-2.00	0.08	-3.10	0.02*					
18	-3.29	0.08	-4.39	0.03*	44	-1.85	0.10	-2.95	0.03*					
19	-2.70	0.10	-3.80	0.03*	45	-1.66	0.14	-2.76	0.04*					
20	-2.51	0.09	-3.61	0.03*	46	-1.26	0.20	-2.36	0.07					
21	-2.90	0.07	-5.50	0.04*	47	-1.21	0.21	-2.31	0.08					
22	-2.15	0.09	-3.25	0.02*	48	-1.14	0.21	-2.24	0.07					
23	-2.33	0.07	-3.43	0.01*	49	-1.49	0.14	-2.59	0.04*					
24	-2.53	0.05	-3.63	0.01*	50	-1.59	0.12	-2.69	0.04*					
25	-1.73	0.08	-2.83	0.02*	51	-1.39	0.15	-2.49	0.05*					
26	-1.44	0.14	-2.54	0.04*	52	-0.94	0.27	-2.04	0.11					

Appendix 8. One sample t-test for mean significance of daily cumulative net returns from un-hedged corn and soybean storage.

Trade day	Corn	p-value	Soybean	p-value	Trade day	Corn	p-value	Soybean	p-value	Trade day	Corn	p-value	Soybean	p-value
2	-3.19	0.09	-11.43	0.00	30	15.32	0.12	32.09	0.10	58	19.89	0.09	37.44	0.08
3	0.02	0.99	-10.29	0.02	31	12.38	0.18	25.09	0.17	59	22.38	0.06	41.77	0.06
4	-0.43	0.91	-10.38	0.14	32	15.57	0.11	29.55	0.12	60	24.12	0.05	45.28	0.04
5	0.52	0.90	-8.34	0.24	33	15.26	0.10	27.30	0.11	61	25.26	0.04	45.49	0.05
6	2.66	0.59	-2.31	0.76	34	14.02	0.11	28.12	0.10	62	28.01	0.03	54.65	0.01
7	6.37	0.30	6.98	0.38	35	15.27	0.10	29.67	0.11	63	30.00	0.02	57.13	0.01
8	6.04	0.46	7.11	0.58	36	13.71	0.12	25.93	0.14	64	29.97	0.01	57.77	0.01
9	8.94	0.23	13.05	0.27	37	13.37	0.14	27.98	0.13	65	30.20	0.01	60.03	0.01
10	9.49	0.20	10.98	0.41	38	12.16	0.24	25.67	0.19	66	30.13	0.01	60.38	0.01
11	7.60	0.34	6.26	0.66	39	15.12	0.14	31.63	0.10	67	30.24	0.01	60.58	0.01
12	7.03	0.39	7.17	0.60	40	15.32	0.13	31.62	0.08	68	28.95	0.02	57.83	0.01
13	7.53	0.29	9.16	0.46	41	15.68	0.12	32.28	0.08	69	29.20	0.02	54.84	0.01
14	11.8	0.12	14.50	0.22	42	16.08	0.13	36.20	0.06	70	27.22	0.05	55.27	0.02
15	11.5	0.14	12.38	0.32	43	14.27	0.19	31.41	0.12	71	27.33	0.07	53.09	0.03
16	11.0	0.19	12.70	0.37	44	14.95	0.18	32.53	0.12	72	29.37	0.05	60.20	0.02
17	11.3	0.19	18.37	0.18	45	14.06	0.19	30.77	0.12	73	28.35	0.07	57.76	0.02
18	8.71	0.33	16.10	0.25	46	13.77	0.22	30.58	0.13	74	29.19	0.04	57.50	0.02
19	10.1	0.27	18.89	0.16	47	12.80	0.29	29.32	0.16	75	29.01	0.05	57.07	0.02
20	10.6	0.25	17.05	0.22	48	12.49	0.28	28.76	0.15	76	29.64	0.04	57.39	0.02
21	13.4	0.12	21.44	0.11	49	12.75	0.28	29.60	0.15	77	29.59	0.04	58.56	0.01
22	13.0	0.14	20.54	0.12	50	15.79	0.18	34.82	0.10	78	30.51	0.03	53.19	0.01
23	15.0	0.10	25.24	0.08	51	15.81	0.17	35.11	0.08	79	33.07	0.02	52.82	0.01
24	15.8	0.10	29.25	0.05	52	16.87	0.13	36.26	0.08	80	31.29	0.04	53.95	0.02
25	15.8	0.10	28.56	0.06	53	18.18	0.10	36.67	0.07	81	30.11	0.03	51.85	0.02
26	14.7	0.15	24.68	0.14	54	19.53	0.07	36.34	0.06	82	30.72	0.04	51.77	0.03

27	16.0	0.14	26.73	0.10	55	19.57	0.07	36.11	0.07	83	31.88	0.04	51.66	0.04
28	16.8	0.11	29.87	0.09	56	19.45	0.09	34.90	0.09	84	32.44	0.04	52.25	0.03
29	15.8	0.11	29.71	0.08	57	18.79	0.11	34.26	0.10	85	32.15	0.05	50.85	0.04
86	31.9	0.05	52.80	0.04	118	38.95	0.02	69.66	0.01	150	42.56	0.02	89.78	0.00
87	33.4	0.04	54.64	0.05	119	37.86	0.02	67.71	0.01	151	42.18	0.02	87.73	0.00
88	33.2	0.04	56.33	0.03	120	37.21	0.02	70.62	0.01	152	42.96	0.02	93.47	0.00
89	35.0	0.04	55.49	0.03	121	37.67	0.02	72.58	0.01	153	43.59	0.02	91.07	0.00
90	34.4	0.03	56.56	0.03	122	39.92	0.02	78.66	0.01	154	45.30	0.02	94.01	0.00
91	34.7	0.03	57.38	0.02	123	40.62	0.03	75.31	0.01	155	47.21	0.02	92.50	0.00
92	34.3	0.04	55.62	0.03	124	44.82	0.02	71.12	0.02	156	47.50	0.02	97.02	0.00
93	36.3	0.04	58.54	0.02	125	45.33	0.03	68.39	0.02	157	47.36	0.03	94.17	0.00
94	36.7	0.04	58.11	0.02	126	46.38	0.02	69.04	0.01	158	47.74	0.02	90.99	0.00
95	35.9	0.03	55.45	0.03	127	46.21	0.02	73.54	0.01	159	47.09	0.02	93.43	0.00
96	38.0	0.03	57.87	0.03	128	47.38	0.02	77.84	0.01	160	46.21	0.03	90.64	0.00
97	39.0	0.03	61.48	0.03	129	46.85	0.02	74.29	0.01	161	46.97	0.03	89.44	0.00
98	40.0	0.03	62.94	0.03	130	45.24	0.03	69.48	0.01	162	45.35	0.04	88.16	0.00
99	40.6	0.03	62.79	0.04	131	45.70	0.02	73.50	0.01	163	43.56	0.04	88.58	0.00
100	40.7	0.03	64.61	0.04	132	44.07	0.03	74.61	0.01	164	44.46	0.04	91.37	0.00
101	41.7	0.02	68.24	0.04	133	44.28	0.03	78.58	0.01	165	44.67	0.04	90.15	0.00
102	42.4	0.03	71.60	0.03	134	45.27	0.03	77.67	0.01	166	44.67	0.04	87.60	0.00
103	41.1	0.03	70.58	0.04	135	45.08	0.03	82.06	0.01	167	44.54	0.03	86.45	0.00
104	42.6	0.02	73.48	0.04	136	42.30	0.04	79.73	0.01	168	43.91	0.04	92.71	0.00
105	41.8	0.02	71.27	0.04	137	41.68	0.04	80.05	0.01	169	45.50	0.04	90.92	0.00
106	41.4	0.02	72.31	0.04	138	42.16	0.04	82.96	0.01	170	47.51	0.04	88.37	0.00
107	40.0	0.02	68.17	0.04	139	44.69	0.03	86.20	0.00	171	46.48	0.05	93.71	0.00
108	37.6	0.02	68.38	0.04	140	42.92	0.03	81.34	0.00	172	47.01	0.04	96.06	0.00
109	39.9	0.01	66.67	0.03	141	40.01	0.04	86.27	0.00	173	46.46	0.04	96.68	0.00
110	39.2	0.02	63.74	0.02	142	41.65	0.04	88.25	0.01	174	46.80	0.04	97.21	0.00
111	38.5	0.01	63.68	0.03	143	43.68	0.03	86.20	0.01	175	45.95	0.05	94.76	0.00
112	39.3	0.01	68.91	0.02	144	44.80	0.03	86.86	0.01	176	46.50	0.05	97.04	0.00

113	41.9	0.01	70.82	0.02	145	46.64	0.02	87.67	0.00	177	46.25	0.06	98.47	0.01
114	41.1	0.01	75.27	0.01	146	44.83	0.02	85.39	0.00	178	47.53	0.05	101.06	0.01
115	41.5	0.01	73.56	0.01	147	42.79	0.02	90.53	0.00	179	46.37	0.05	100.70	0.00
116	39.9	0.01	68.37	0.02	148	44.45	0.02	90.81	0.00	180	44.22	0.06	105.12	0.00
117	39.4	0.02	70.70	0.01	149	43.83	0.02	90.62	0.00	181	39.49	0.08	104.85	0.00

[i] One sample t-tests are two tailed and tested at 5% significance

[ii] All paired t-tests are one tailed and tested at 5% significance

[iii] March contract strategies variances have 20 d.f. until 60 trading days, from day 61 they have 19 d.f. and May and July contract strategies have 19 d.f. for all days for both corn and soybean storage. Thus F higher critical value for test with 20/20 d.f. is 2.12, 20/19 is 2.15 and 19/19 is 2.16 at 5% level of significance

[iv] *-significance at 5% level for all tests