BASIS CONVERGENCE IN THE SOYBEAN FUTURES COMPLEX

BY

PETER P. KOZIARA

THESIS

Submitted in partial fulfillment of the requirements
for the degree of Master of Science in Agricultural and Applied Economics
in the Graduate College of the
University of Illinois at Urbana-Champaign, 2012

Urbana, Illinois

Adviser:

Professor Scott Irwin

ABSTRACT

This thesis examined basis convergence in the soybean futures complex. Soybeans, soybean oil, and soybean meal were surveyed for convergence during the sample period of January 2000 to September 2011. Explanations of non-convergence were hypothesized to be due to a wedge between the actual physical rate of storage and the maximum storage rate embedded in futures contracts that trade on the Chicago Board of Trade. Testing for explanations of this wedge, it was found that inventory at deliverable locations was significant in explaining the wedge at two deliverable locations for soybeans and soybean oil. Credit also played a role in explaining the wedge for two locations for soybeans. Further graphical evidence is presented linking the wedge to the deliverable instrument market, the cash-futures basis, and deliverable stocks (inventory) at locations listed for delivery on Chicago Board of Trade futures contracts.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

1.1 Background

Agricultural futures markets have had a long and developed history beginning at the Chicago Board of Trade (CBOT) in the late 1800's. Futures exchanges (such as the CBOT) provide a central marketplace where hedgers and speculators gather to trade futures contracts. These contracts have existed for a wide array of commodities that include agriculture, energy, metals, and financials. Although many contracts remain active, a lengthy number have ceased to exist due to structural changes in the market. Numerous futures markets have failed by design or did not attract a large enough group of hedgers and speculators to transact business. Regardless, futures markets have survived through time with adaptation and revision, but that is not to say they have not experienced problems along the way.

Some notable examples of "failed" futures markets include the frozen pork belly futures contract and the distillers' dried grain futures contract. Although frozen pork belly futures were not an initial failure, the structure of the market over time had changed. The contract no longer provided adequate hedging needs for producers as the demand to freeze and store the commodity dissipated. Frozen pork belly futures were delisted in July 2011. The distillers' dried grain futures contract is a notable new and current example of a futures market that has not attracted enough hedgers and speculators to transact business in since it was listed for trade in April 2010. One factor for the lack of trade is an absence of a set standard or deliverable grade that is on par with the specifications outlined in the CBOT futures contract.

Recently, several of the most actively traded contracts at the CBOT encountered problems. Starting in 2005, issues with price transparency and delivery systems began to emerge for CBOT agricultural futures contracts. The most transparent problem faced was the expiring futures settling above the cash price during delivery. Normally, in markets where there is cash settlement this could not exist. An arbitrageur would sell the expensive asset (futures), buy the cheap asset (cash), and force convergence between the futures and cash price. In grain markets this is the same idea, however, for CBOT agricultural futures contracts a third market exists – the shipping certificate and warehouse receipt market. Upon delivery of a CBOT agricultural futures contract a certificate/warehouse receipt is furnished by the short futures holder. This certificate specifies where the commodity that is being delivered is available to the taker of delivery who is long futures contracts. This is precisely where the problem between the futures and cash prices is concentrated. Embedded in each futures contract is a storage rate set for grain just as there is in a country elevator or warehouse. Usually this rate at a country elevator or warehouse is determined by the market. If ample supplies of the commodity exist at the elevator, the elevator will charge a high storage rate to store the commodity. If a low supply of commodity exists at the elevator, the elevator will charge low storage rate for the commodity. This key difference between the cash market setting the storage rate and the storage rate set in futures contract can create an imbalance in the market. It is this difference between storage rates that is arguably is the reason for basis non-convergence between cash and futures markets.

This thesis surveys and examines three agricultural futures contracts that trade at the CBOT – soybeans, soybean oil, and soybean meal futures. These three commodities are all related through the soybean crush, where the byproducts of crushing a soybean are soybean oil and soybean meal. However, each commodity has different physical characteristics in perishability as well as different contract specifications. Each commodity also experienced basis convergence failure during the sample period of 2000 – 2011.

1.2 Objectives

The objective of this thesis is to survey and explain basis non-convergence in the soybean futures complex. These specific contracts were chosen as no work has been completed on basis convergence for soybean meal and soybean oil. Using models developed by Garcia, Irwin, and Smith (2011) this is possible. Furthermore, using the same models this paper seeks to explain which variables induce basis non-convergence in the marketplace. Like Garcia, Irwin, and Smith (2011), the goal is to first find instances of non-convergence, and during those periods derive a "wedge" term that explains the disconnect from the market price of storage to the futures contract storage rate, then seek out and test likely explanatory variables that would cause the wedge to exist. Thereafter, using the calculated wedge, graphical evidence of an estimated cost of physical storage in relation to the contract storage rate is provided. A test for basis predictability using the model is also conducted. Graphical evidence of the basis under perfect foresight is provided to track how well the model had predicted the basis. Finally, during the same time frame, further analysis focuses on the differences in storage rates to the relationship between inventories at deliverable locations and cash-futures basis during the time period analyzed.

1.3 Data and Methodology

The period surveyed was from January 3rd, 2000 to September 30th, 2011 for soybeans, soybean oil, and soybean meal. This period of time was chosen as having the most available data for all three commodities surveyed. Also, during this time only minor contract specifications within the three commodities changed (storage rate increases in soybean futures and delivery differentials in soybean oil and meal.)

To explain the story of basis non-convergence and the differences in pricing between physical storage rates and futures contract storage rates much data was needed. Cash, futures, interest rates, certificates/receipts, and inventory data was required and supplied from the following sources. Cash prices were retrieved from the United States Department of Agriculture's Agricultural Marketing Service. Futures prices were direct from the CBOT through Barchart.com. Interest rates were retrieved from the Federal Reserve Bank of the United States for treasury bills and non-financial commercial paper. London Interbank Offering Rates (LIBOR) were taken directly from the British Bankers Association (BBA.) Certificates/receipts and shipment data was collected from the Chicago Board of Trade Registrar's Office. Inventory data pertaining to soybean oil was collected from the National Oilseed Processing Association.

Using models developed by Garcia, Irwin, and Smith (2011), an estimate of the imbalance of storage rates was calculated. To explain this imbalance, several explanatory variables were tested such as inventory, storage rates, credit spreads, and a seasonal measure. Further graphical evidence of the imbalance is provided to estimate the physical rate of storage in contrast to the CBOT maximum storage rate on deliverable receipts/certificates.

1.4 Overview

The thesis is structured in the following manner. Chapter 2 provides a background of literature associated with theory of commodity storage, delivery manipulation, and more recent work on basis non-convergence. Chapter 3 details the data sources used and provides a background of the soybean industry. Chapter 4 presents descriptive statistics about the market during the selected time frame and a descriptive analysis of the relationships found in the market. Chapter 5 describes the models used in this thesis to explain the reason for basis non-convergence and then uses linear regression models to test for explanatory values that influence the wedge. Chapter 5 also provides graphical evidence of the wedge over time as well prediction analysis of the basis. Finally, Chapter 6 provides a summary and conclusions.

2. LITERATURE REVIEW

2.1. Introduction

Studies in publications and journal articles are reviewed in this section. Understanding basis convergence requires a fundamental understanding of one of the functions of futures markets - a price discovery tool for storage. This section is broken into four parts – Theory of Commodity Market Storage, Delivery Market and Manipulation Studies, Delivery Option Studies, and Studies of Recent Non-Convergence Episodes. The 'Theory of Commodity Market Storage' section reviews classical literature about the storage market implied in the futures market and functions of the futures market. The 'Delivery Markets and Manipulation Studies' section reviews issues in the futures market concerning manipulation, hedging effectiveness, and implications of changes to futures contracts. The last section, 'Studies of Recent Non-Convergence Episodes' reviews instances of basis non-convergence during the time period of 2000-2010 and rationalizes reasons for the failure of convergence most recently exhibited in futures markets. Taken together, a review of this literature should help in understanding the implications and reasons for basis non-convergence.

2.2 Theory of Commodity Market Storage

Working (1948) examined inverse carrying charges in futures markets. It was widely accepted at the time that if the difference between two sequential futures contracts exhibited a positive difference, then the market had reflected a "carrying charge", or positive carry reflecting a return on storage for that given commodity. However, when this charge becomes negative or "inverted", the holder of the commodity earns a negative return on storage. The following relationship of carry holds where F, is the price of futures contract in month m,

$$F_{m+t} - F_m > 0; \mathit{Positive\ Carrying\ Charge}$$

$$F_{m+t} - F_m \leq 0; \mathit{Inverse\ Carrying\ Charge}.$$

The aspect of duration also matters as we can only look at sequential future contracts that expire some point into the future at $m + t$. For example, if it is currently October 8th, 2010 and the nearby soybean futures contract is November 2010 the next futures contract must have expiration later than the November 2010, such as the January 2011 contract. On that same date, the market implied a positive carry as the November 2010 (F_m) contract settled at $11.35 per bushel and the January 2011 (F_{m+t}) contract settled at $11.45 per bushel. Differencing the two arrives at a 10 cent per bushel positive carrying charge.

In the 1948 paper, Working mentions differences in opinion for the explanation of inverse carrying charges. Some of them included quotes such as "The future, as against the present, is discounted" and "Cash and futures prices, though related, are not equivalent aside from the time element, at least in the United States wheat market." (Vance 1948) Contesting this argument, Working viewed these inverse carrying charges with the same rationale as positive carrying charges – they reflect anticipatory demand for storage between two future dates of a particular storable commodity.

Figure 1 presents the storage supply curve, or "Working Curve". On the x-axis the amount of supply is plotted against the price of storage (y-axis.) As we can see when the amount of supply of a particular commodity is plentiful, we expect a positive return on storage. The other side of this argument is that when supplies are low the return on storage is low. At a certain point when supplies are scarce, returns for storage turn negative as depicted in the figure. It is also important to note this figure depicts a normal storage market for physical commodities. Unlike the physical market, the futures market has a maximum storage rate for storable commodities set by the exchange. Thus, when a futures spread exhibits "full carry", or the cost of storage plus interest and insurance, there should not exist a spread greater than 100% of the carrying cost outlined in the futures contract specifications. If this happens, one could stand for delivery of the commodity, pay interest and insurance and re-deliver it into the next contract providing a risk free arbitrage[1].

In the case of negative or inverse carrying charges, the cost of holding commodities bears a "convenience yield." Simply explained it is the yield from holding stocks of any particular good (Kaldor, 1939.) In this case, a holder of a commodity would earn a loss for carrying stocks during an inversion. Dependent upon the holder of the commodity, whether it may be an operational hedger (flour mill) or a warehouse in the storage business, would determine the rationale for either holding stocks at a loss, or relinquishing stocks at prevailing market prices in the cash or "spot" market. The reasoning for holding assets when convenience yields are present is straight forward. For example, paper currency bears a convenience yield as it does not accrue interest sitting in one's wallet. However, cash at hand is more fluid in trade and exchange as not all places of business accept credit payments or checks.

[1] A hidden cost to the arbitrage would be posting margin to be short the deferred futures contract over time.

Using Chicago and Kansas City spot and futures quotations of wheat prices, Working demonstrated instances of positive and inverse carrying charges in accordance within the supply of storage framework. Futures spreads between “old crop” and “new crop” typically exhibited an inverse carrying charge. A typical explanation for this was the expectance of a large harvest in July (new crop) thereby depressing the futures price relative to May (old crop.) However, this rationale in explaining an inverse carry was flawed. According to Working’s supply of storage model, any market inversions across the futures term structure should be a function of the current supply of stocks and the demand for storage going forward. Since stocks become exhausted before the new crop is harvested, we should rationally expect pricing of a low cost of storage or even an inverse carry into the market holding stocks through the harvest.

In relation to his previous work noted above, Working (1949) outlined the supply of storage model and introduced the term, inter-temporal price. Simply explained, inter-temporal price relations are the relations between two forward prices for a given commodity at a given time. Like before, Working produced the supply of storage curve which explained positive and inverse carrying charges. That is that the market determines the price of storage whether the market is at a positive or inverse carry based on the current supplies at hand. This relationship established a link between the spot market and the futures market which allowed for pricing of deferred contracts based off of the current market clearing price of storage.

In continuation of research in storage markets, Working (1953) introduced a model to test for the effectiveness of hedging using futures contracts. This model used basis quotes defined as,

$$B_t = C_t - F_t,$$

where the basis(B_t) is the difference between the cash price (C_t) and futures price (F_t) at time period t. To test for hedging effectiveness one would need two basis quotes – the basis on any given day before the delivery window and the basis on first delivery day of that expiring futures contract. Using these quotes we could arrive at a basis and a change in basis by differencing the two basis quotes as the following illustrates.

$$B_\Delta = B_{t+1} - B_t$$

The idea behind this is that the cash should meet the future at a given time, specifically any day in the delivery window (for an outline of delivery, see appendix A.) Using the first day of delivery as a proxy on two different futures expiries, Working plotted the differences in the change of the basis on first delivery day. Working used Chicago wheat futures and Chicago cash prices for wheat delivered in December based on the September basis, and wheat delivered in July based off of the May basis. Using this data, Working applied the following ordinary least squares regression equation to estimate the predictability of the basis.

$$Basis\ \Delta_{i+t} = \beta_0 + \beta_1 X_i + u_i$$

Where the change in the basis at point $i + t$ is regressed upon β_0, the y intercept, β_1, the initial basis regression coefficient, and X_i, the initial basis at point i . There is an included error term, u_i, to account for the approximation of the model. The resulting predictability of the basis for September-December contracts was explained 83.9% by the basis on first delivery day and for July-May contracts, 97.5% of the predictability of the basis was explained by the basis on first delivery day. Figure 2 plots the basis of on first delivery day of the deferred futures against the change in basis to the first delivery day of the deferred futures basis. This is the theoretical plot not accounting for load out fees for delivery. As we can see, perfect predictability of the basis dictates that the regression coefficient is -1(β_1), whereby the basis on any given day should predict the change in basis to some point in the delivery window of the futures contracts. Put another way, the expected return for storage from one point in time to the expiration of the futures contract.

The predictability of the basis test was important as it not only tested for hedging effectiveness but also gave insight to cash-futures convergence. In the case that cash did not meet futures, then hedging effectiveness of the futures contracts was diminished. As futures contracts are tied to the cash commodity, hedgers could experience unexpected gains or losses attributed to the lack of effectiveness of futures as a hedging instrument which could pose a long term threat to the subsistence of the contract. As Hieronymus (1977) stated, “When a contract is out of balance the disadvantaged side ceases trading and the contract disappears.”

2.3 Delivery Market and Manipulation Studies

Manipulations, corners, and squeezes, have been an important issue in the marketplace. Although manipulations can happen in any market, speculators in futures markets have at times been associated with large manipulation attempts. As Hieronymus (1977) stated, “The first fifty years of the history of futures trading in the U.S. is the history of feverish speculative activity, of contests among giants, and of attempts to manipulate prices.” Notable corners included the Hutchinson corner of 1888, where Benjamin P. Hutchinson owned and accumulated much of the cash wheat stocks in Chicago granting Hutchinson monopoly power for a short period of time. During this time the price of wheat in Chicago was “distorted” for several days which led him to profit somewhere around $1.00 per bushel from the short contract holders (Hieronymus, 1977.) This and many other manipulations were documented and over time new market regulations and changes to contract specifications were introduced to deter market manipulators.

Gray (1980) describes manipulation in the market. Gray notes that manipulation is a vague term in itself. For manipulation to be proven there must be a proven intent as well as an economic result, which is the artificiality of prices. Gray lists economic indicators of manipulation – net concentration of positions, size of open interest in the expiring contract, the relationship between open interest and supplies available for delivery, the relationship between the size of positions held in “concentrated” hands and supplies available for delivery, and the definition of deliverable supplies. Gray also notes preventative measures to deter would be manipulators such as the addition of deliverable locations, extension of delivery periods, and the allowance for different grades or qualities to be delivered on a futures contract. Other options that can be exercised if manipulation has been perceived are margin increases, position limits, forced liquidation, or optional settlement which is decided upon by the exchanges and the Commodity Futures Trading Commission (CFTC.) Gray concludes that more work need be completed in this area of research. However, Gray remarks that futures markets in general have worked well and with the growing interest in them, confidence in the marketplace has increased.

In a detailed study, Peck and Williams (1991) examined delivery markets for Chicago Board of Trade corn, wheat, and soybean futures contracts. They also examined Kansas City wheat contracts as well as COMEX copper for comparative purposes. Starting with deliveries in futures markets, Peck and Williams discovered that deliveries have positive correlation with that of open interest and that deliveries in the futures market have increased during the time sample of their study (1964-1988.) Furthermore there was a tendency for deliveries to be made early in the month rather than later in the month and were more likely to occur at locations where deliverable stocks are multiple the amounts of available stocks.

Deliverable locations in the futures contracts were also analyzed. Since the 1970's Chicago and Toledo have trended downward as terminal markets for deliverable corn, wheat, and soybeans. This was examined by using daily shipments and receipts data for locations of Chicago and Toledo. In fact, with the addition to of Toledo in 1973 as a deliverable location on CBOT wheat, corn, and soybeans, there were increased deliveries to markets that have lost their primary market status. This can also be seen by the decreasing export market utilizing the great lakes. For example, in 1977 the percentage of exports through the great lakes was 26% for wheat, 14% for corn, 22% for soybeans. Compared to 1985, all but wheat showed a marked decline (28% wheat, 6% corn, 12% soybeans.)

An analysis of the concentration in the futures market examined by Peck and Williams had interesting results. Using 1982-1989 futures data, Peck and Williams pooled the largest four long and short futures contract holders and examined the price effects on deliveries during the delivery window. Their results concluded that net concentration of futures was associated with the price decline of the spread. This was true of wheat and corn, which had the four largest traders holding 300-400% of the deliverable supplies into the delivery month. Spreads would decline .003 cents/bushel for wheat, 0.002 cents/bushel for corn, but for soybeans there would increase 0.012 cents/bushel per the net concentration in futures positions relative to deliverable stocks. The coefficient of determination was .438 for wheat, .356 for corn, and .363 for soybeans. This value explained the variation of concentration in futures relative to deliverable stocks against the change in the price spread.

In another detailed study, Pirrong (1993) conducted tests on convergence in Chicago Board of Trade agricultural futures contracts during the 1984-1989 period. It is in this publication that we first hear the term "wedge" be described as the difference between cash and futures prices[2]. Pirrong explains that this wedge could reflect many costs such as load out, demurrage, interest, and storage costs making theoretical perfect convergence not possible. Convergence therefore is defined if the basis falls in between the high and low band of costs of load out at the cheapest to deliver location. Figure 3 visually demonstrates this using 6 cents/bushel as the loadout costs. Pirrong's results of cash-futures convergence at the cheapest-to-deliver location were tested and results were as follows, for corn 55 out of 595 days within delivery month fell outside the no-arbitrage bounds, soybeans 55 out of 595 days, and wheat 78 out of 423. An explanation of these results was that in 1988, which had most of the occurrences of failures to converge for all three commodities in question, was due to an impressive amount of stocks currently held at these facilities. This responded with elevator managers being light on purchasing extra grain since capacities were operating at unusually high levels. Furthermore, much of these convergence failures may be attributed to the fact that Chicago was not in fact the

[2] This "wedge" is defined differently than the Garcia, Irwin, and Smith (2011) definition which will be presented in Chapter 5.

cheapest deliverable location and that Toledo was since they received the bulk of deliveries. Pirrong explains that this may be a reporting issue on the elevator's behalf as the Chicago prices were being undercut and not representative of actual bid prices. Another issue was liquidity concerns in the remaining days of the delivery window. When approaching the end of the delivery window, volume and liquidity becomes sparse. Pirrong explains that this could be a reason why there was imbalance in prices in the futures resulting in inaccurate futures prices. Barring these instances, Pirrong reasons that basis convergence was facilitated rather well for corn, soybeans, and wheat.

Pirrong also examines delivery process manipulation. When approaching the delivery window in an expiring futures contract, there are many options both a long and short trader could use to settle the contract (See Appendix A for a breakdown of delivery). Pirrong finds that transactions costs of delivery in the futures market are the main drivers of reasons for delivery and in turn can increase chances of manipulation. Mainly, it is these costs that tend to distort prices in the delivery month and can have an impact on the possibility of manipulation. Pirrong, like Gray (1980), believes that to deter manipulation contract specifications can be changed to reflect a wider array of delivery locations, deliverable qualities, and changes to the delivery window. These changes would deter and make it tougher for a would-be manipulator to "corner" the market.

2.4 Studies of Recent Non-Convergence Episodes

Irwin, Garcia, Good, and Kunda (2009, 2011) researched convergence problems within the Chicago Board of Trade's agricultural futures complex. Corn, soybeans, and wheat futures were examined in this study starting from January 2000 to March 2009. From the study it was apparent that large carries in the market were positively correlated with basis non-convergence, which prompted traders to accept delivery on agricultural futures contracts that exhibited large returns on storage, hold them into the future, and earn a riskless rate greater than the financing rate.

Irwin et al (2009, 2011) also observed that when the cost of financial carry was above 80% in the futures market, it was likely going to result in a failure of basis convergence. Using Working's (1953) test for convergence, Irwin et al separated the data into two sets – the basis on first delivery day where the carry in the futures markets was less than 80% and the basis on first delivery day where carries were above 80%. Using ordinary least squares regression, Irwin et al demonstrated that basis convergence was significantly better in times when carries were less than 80%. For corn, .77(.21) of the variation of predictability of the basis was explained when carries were less than (greater than) 80%. Soybeans, .66 (.39) of the variation of the predictability of the basis was explained when carries were less than (greater than) 80%. Finally for wheat, .27 (.07) of the variation of the variation of the predictability of the basis was explained when carries were less than (greater than) 80%. According to Irwin et al, it was theorized that the basis non-convergence was mainly due to exchange-regulated storage rates not reflecting actual market rates. Realizing problems within the grain complex and complaints amongst hedgers, the Chicago Board of Trade promptly changed storage rates in corn and soybeans from 15/100 cents/bushel per day to 16.5/100 cents/bushel per day in July 2008. For wheat they implemented the variable storage rate system or VSR (Seamon, 2009.) VSR enabled the market to determine the pricing structure for the storage rate embedded in the wheat contract based off of a running average of the cost of carry. For a full explanation of the VSR, see Appendix B.

Aulerich, Fishe, and Harris (2011) explained that a non-converging basis could be the result of delivery options. Based on their research, Aulerich, Fishe, and Harris used an option pricing model for corn, wheat, and soybeans to estimate the price of delivery options which to the authors is responsible partly for episodes of non-convergence between cash and futures prices.   Unlike Hraniova and Tomek (2002, 2005), where delivery options are based off of the options embedded in the timing and location of the delivery, Aulerich, Fishe, and Harris focused on the long-side embedded option.   The long option according to Aulerich, Fishe, and Harris, "is paying the short for the commodity *plus* the value of the exchange option. Thus, this option increases the futures price relative to the cash price, causing a negative basis…" This long option is directly tied to the deliverable asset on a corn, wheat, or soybeans futures contract – the deliverable shipping certificate. Using data for corn, wheat, and soybeans from January 2000 to May 2008, Aulerich, Fishe, and Harris found that cash-futures volatilities are significantly positively related to wedge between cash and futures prices during the delivery window, helping explain reasons for non-convergence.

Garcia, Irwin, and Smith (2011) sought an explanation for reasons for basis convergence failures. Using a rational expectations model, Garcia, Irwin, and Smith deduced that convergence failure may be based on two instances – the contract storage rate in the futures is set too low compared to the price of physical grain storage and the difference in capital costs between the regular firms and the financial firms who carry the instruments. Like before, Irwin et al (2009, 2011) reasoned that raising storage rates in the futures contract would prompt users to load out on held delivery certificates. Loading out delivery certificates would then depress the futures price in relation to the cash price and re-establish convergence.

Garcia, Irwin, and Smith (2011) tested different variables to explain the wedge – the difference of actual physical storage in the market and the contract storage rate embedded in the futures. Variables tested include grain inventory at deliverable locations, contract storage rates, inventories of materials and supplies divided by total sales for food product manufacturing firms, a credit spread measure, market positions of commodity index traders, and per contract variables to capture seasonality. Their results conclude that inventory at deliverable locations is significant in explaining the wedge; however, the other variables mentioned are not statistically significant in explaining the cause of this wedge. However, the signs of the coefficients in explaining the wedge were on par with what was expected. For example, the seasonality component would be expected to see the largest wedge occur after the harvest is completed. This was precisely the case for all commodities surveyed – CBOT corn, soybeans, wheat, and KCBOT wheat.

2.5 Summary

This chapter reviewed literature related to the theoretical pricing of storage, delivery options, contract performance, manipulation in the marketplace, and basis non-convergence studies. A background in these topics helps the reader understand the causes and implications of a non-converging basis.

The first section, 'Theory of Commodity Market Storage' section reviewed literature related to the pricing of storage in the market. It was shown by Working that supplies of a given commodity determine the price of storage in the market. The price of storage is furthermore implied in the term structure of forward markets. This discovery of price of storage allowed practitioners in the trade to make more rational decisions in the handling of commodities.

The following section, 'Delivery Market and Manipulation Studies', reviewed literature related to manipulation in the futures markets and possible methods of deterring it. Amendments to contract specifications, forced liquidation, position limits, the expansion of deliverable grades and territories, were found to be valid options to deter manipulation in the futures market. Specifically delivery markets were tested to determine what economic factors facilitate delivery in the futures market. It was found that stocks at deliverable locations, the basis, and term spread in the futures market were significant in determining whether or not delivery is likely. The intent of delivery was found to be more prevalent when deliverable stocks at facilities are large coinciding with a weak basis (cash minus futures) and a large term spread in the market.

Lastly, the 'Studies of Recent Non-Convergence Episodes' section reviewed literature related to episodes of non-convergence in the CBOT agricultural futures markets. Several relationships were found such as the relationship between a non-converging basis and a large term spread (carry). This non-converging basis coupled with a large term spread enticed users to accept deliveries on futures contracts, many with intentions to arbitrage grain spreads. Reasons for the basis to fail to converge were thought to have been the cause of an imbalance in storage rates between the physical market for storage and the CBOT maximum storage rate for deliverable instruments. It was found that inventories were significant in explaining this ‘wedge’ between the physical market rate and the CBOT storage rate. Delivery options were also reviewed as being a possible explanation for non-convergence. This was hypothesized to be related to the volatility on expiration which caused disconnect between the cash price and the futures price. This difference in price was thought to be the price of the delivery option to the long futures contract holder.

3. THE SOYBEAN INDUSTRY & DATA

3.1. Introduction

This section details the sources of the data, the data collection methods, and the organization of the compiled data. This should help the reader understand collectively the methods used to observe, calculate, and interpret results going forward in basis convergence studies. In addition to the data, a background of the soybean industry is presented.

3.2 The Soybean Industry

Soybeans are classified by the USDA as an oilseed crop. Other crops that fit into the oilseed category are cottonseed, canola, rapeseed, sunflower seed, and peanuts. In the US, soybeans are the leader in oilseed production, accounting for close to 90% of U.S. production (ERS/USDA, 2010.) Soybeans like other oilseeds are generally almost always either crushed for their byproducts or exported. A small percentage of soybean production is also used in feed and for future seeding. Soybeans are also used by food processors for specialty products such as soy nuts and tofu. Figure 4 displays the United States usage and total supply for each crop year from 1980-2010. As demonstrated over this period, total soybean supply, measured as the sum of the previous years ending stocks, imports, and total production have increased over time from nearly 2,500 million bushels to 3,500 million bushels. In terms of usage, the largest stake is shared by the domestic crush market and the export market. Over sample period, exports have increased from 30% to over 40% of the total US soybean supply reflected in overseas demand. The domestic crush has also seen a decline recently but still accounts to nearly over 50% of the usage of the total soybean supply. The remainder of soybean usage fits into the feed, seed, and industrial use (FSI) category, which has remained stable at 5% average use per year.

In worldwide markets, the United States is the largest producer of soybeans followed by Brazil and Argentina (2010 crop.) The United States and Brazil are the largest exporters of soybeans, accounting for over 40% and 35% of the 2010 crop, respectively. Importing countries include China, European Union, and Mexico. China of all three leads as the largest importer of soybeans in the world totaling over 12% of the worldwide supply of the 2010 crop.

Soybeans in the United States are usually planted in early to late May and are harvested from early October to late November. Production is concentrated mainly in the corn belt of the United States with Iowa, Illinois, and Minnesota producing the largest share of the total crop (over 38% of 2010 production.) Figure 5 presents soybean production on a per state basis for the 2010 crop. Other notable producing states include Indiana, Nebraska, and Ohio. Figure 6 visualizes this on a map of the United States for improved clarity. Notice that many of the producing states are near the Mississippi River. Convenient access to the river allows an efficient and affordable way of transporting soybeans down river to the Gulf of Mexico to reach export markets.

Crushing facilities, also known as soybean processing facilities, are also located mainly in the soybean producing states. Table 1 lists soybean processors in the United States. Many of the facilities listed are owned by the large “ABCD” companies – Archer Midland Daniels (ADM), Bunge Corporation, Cargill, and Louis Dreyfus. Some of these facilities are also registered as delivery facilities for CBOT soybean oil and soybean meal contracts. Figure 7 displays the deliverable territories for soybeans, soybean oil, and soybean meal. For soybean meal and oil, the facilities are pooled into territories that reflect their geographic location. For example, the Northern Territory of soybean oil lists two locations in Minnesota and one in South Dakota. Unlike the deliverable locations for soybean meal and oil, soybean deliverable locations are located at terminals along the Illinois Waterway system. This system spans a series of rivers which connects Lake Michigan to the Mississippi river in Illinois.

Soybean crushing itself refers to the physical process of crushing soybeans into its two main byproducts – oil and meal. A bushel of soybeans (weighing 60 pounds) will be crushed on average into 44 pounds of 48% protein soybean meal, 11 pounds of soybean oil, 4 pounds of hulls, and 1 pound of waste. The crush also refers to the dollar value created by selling the end products (meal and oil) and purchasing the input (soybeans.) To quote the soybean crush (or processing margin) one would use the following formula,

Soybean Crush = Soybean Meal Price * 0.022 + Soybean Oil Price * 11 – Soybeans Price

For example, using September 1st, 2009 settlement prices (September 2009 contract), soybean meal futures settled at 351.70 dollars/ton, soybean oil futures settled at .3453 cents/pound and soybean futures settled at $10.14 bushel. The crush calculation would yield $1.39 per bushel.

The byproducts of soybeans are primarily used in domestic markets. A small, but important percentage leaves the U.S. in the export market. Figure 8 and 9 detail the U.S. supply and usage for soybean meal and oil from 1980 to 2010. On average, soybean oil and meal have high domestic usage of 85% and 80% respectively. The export market is weaker with an average of 15% for soybean oil and 20% for soybean meal. Soybean oil (once refined) is mainly used in human consumption in products such as salad dressing and cooking oil. Soybean oil can also be used converted into biodiesel which is used to fuel diesel based motors. Soybean meal unlike soybean oil is primarily used for one function, feed. Only about 2% of soybean meal is not used as feed, and instead finds its way into baking goods and dietary goods.

3.3 Futures Data

Soybean, soybean oil, and soybean meal futures listed on the Chicago Board of Trade (CBOT) were used in this study. Using a price series starting on January 3rd, 2000 to September 30th, 2011, prices were compiled using end of day closing prices provided by Barchart.com Inc.

Futures contracts have specific contract terms, one of which is expiration. For soybean futures, there are seven expirations: January, March, May, July, August, September, and November. Soybean meal and oil have eight expirations: January, March, May, July, August, September, October, and December. Each futures contract calls for delivery of a shipping certificate or warehouse receipt (See Appendix A for a detailed description of the delivery process.) Each contract has multiple delivery locations with associated discounts and premiums. Figure 7 lists deliverable locations for soybean, soybean oil, and soybean meal futures. For each deliverable location there exists a delivery differential to better establish an economic par between locations. Tables 2, 3, and 4 provide a summary of differentials for soybean, soybean oil, and soybean meal futures. These premiums and discounts are added to the futures price. For example, soybean futures settled at 13.67 cents/bushel for the March 2011 contract on the first day of delivery. If the long contract holder accepted delivery of soybean futures at any location other than Chicago they would have to pay an added premium at that location. For example, if delivery was made at St. Louis the long would be expected to pay a premium of 6 cents to the futures arriving at a price of 13.73 cents/bushel. Also during contract expiration, deliveries tend to go to the location that has the least expensive cash price in the market. The reasoning for this is that if it is profitable to do so, the holder of a short futures contract can source the grain cheaply, deliver it to a facility, convert the grain into a deliverable instrument, and deliver the instrument against the futures. The greatest profit margin for this would be always where the cash grain is the least expensive; hence deliveries will usually occur at the cheapest to deliver location.

3.4 Cash Data

Cash prices of soybeans, soybean meal, and soybean oil are provided by United States Department of Agriculture's Agricultural Marketing Service. The AMS reports a series of end of day bid prices for soybeans and offer prices for soybean oil and meal at select locations throughout the United States. The midpoint of the range of bids or offers is taken as the final cash price for the locations surveyed. Bids are the prices storage facilities are willing to purchase the commodity from the seller. In the case for soybeans, usually the farmer would receive a quote from a local elevator or processor to which price they are willing to purchase grain. Offers are prices that sellers wish to sell their inventory at. In the case for soybean oil and meal, it is the lowest price soybean crushing facilities are willing to sell their inventory.

Not all deliverable locations in the CBOT futures contracts have available cash pricing from the USDA. The surveyed locations in this study for soybeans include the Chicago Switching District using Chicago elevator bids, the Ottawa-Chillicothe Shipping District using

Illinois River North of Peoria barge loading elevator bids, the Peoria-Pekin Shipping District using Illinois River South of Peoria barge loading elevator bids, and the St. Louis-East St. Louis Switching Districts using St. Louis, Missouri terminal elevator bids. For soybean oil offers, the Illinois Territory uses Decatur-Central Illinois pricing, the Eastern Iowa Territory uses Iowa pricing, the Northern Territory uses Minnesota pricing, and the Eastern Territory uses Indiana-Ohio pricing. For soybean meal offers, the Central Territory uses Decatur-Central Illinois pricing, the Missouri Territory uses Kansas City pricing, the Eastern Iowa Territory uses Iowa pricing, and the Northeast Territory uses Indiana-Ohio pricing. All locations report daily pricing with the exception being the Indiana-Ohio location which is weekly pricing.

The price series for each location above is from January 3rd, 2000 to September 30th, 2011. All soybean cash locations used have a complete price history during this time period. soybean meal and oil have a less complete price history. Starting with soybean oil, the Illinois Territory has a complete history during this time period, the Eastern Territory pricing became available July 20th, 2005, the Northern Territory and Eastern Iowa Territory pricing became available April 2nd, 2007. Soybean meal has a complete price history during our specified time frame for the Missouri Territory and the Central Territory, the Northeast Territory became available on July 20th, 2005, and the Eastern Iowa Territory pricing became available April 2nd, 2007.

It is important to mention that cash prices reported by the USDA for soybeans are of the grade, "Number 1 Yellow Soybeans." Number 1 yellow soybeans trade at a premium to number 2 yellow soybeans which are the deliverable grade for Chicago Board of Trade soybean futures contracts. Taking this into account cash prices are reduced by 6 cents/bushel to arrive at a deliverable price of number 2 yellow soybeans.

3.5 Interest Rates

The rates used in this study are the 3-Month London Interbank Rate (LIBOR), the 3-Month Treasury Bill Rate (T-Bill), and the 3-Month Non-Financial Commercial Paper Rate. The 3-Month LIBOR is an annualized rate that banks charge each other in the wholesale money market. The T-Bill rate is tied to debt issued by the United States Department of the Treasury, which is used as financing by the United States Federal Government. The non-financial commercial paper rate is the rate that non-financial firms can access to meet short term financing needs, sold in maturities from 1 to 270 days. The T-Bill and commercial paper rates are published by the Federal Reserve Bank daily whereas the British Bankers Association (BBA) publishes the LIBOR rate daily spanning over 10 currencies and 15 maturities.

3.6 Storage Rates

There is a fixed storage for holding delivery certificates or warehouse receipts at deliverable locations, embedded in the futures contract. These storage rates are set by the Chicago Board of Trade and are subject to change. Table 5 lists the storage rates for soybeans, soybean oil, and soybean meal that were taken from the CBOT rulebook under contract specifications. As the tables details there have been three contract storage rate environments in soybeans – From 1/3/2000 to 10/31/2001 3.6 cents/bushel/month, 11/1/2001 to 10/31/2008 4.5 cents/bushel/month, and 11/3/2008 to present 4.95 cents/bushel/month. Soybean oil and soybean meal have not had any storage rate changes during this time frame and stand at .09 cents/pound/month for soybean oil and 2.1 dollars/ton/month for soybean meal.

3.7 Deliverable Commodities Under Registration Data

All three futures contracts call for delivery of a warehouse receipt or shipping certificate. For soybean futures and soybean meal futures a shipping certificate is tendered, whereas a warehouse receipt is tendered for soybean oil futures. The difference between the two is simply that a warehouse receipt is title of the physical commodity in store at a specific facility. Shipping certificates work more as a substitute whereby if exercised by loadout, the deliverable facility in question must source the commodity and have it available for loadout for the end user (the holder of the certificate.) The CBOT Registrar publishes the "Deliverable Commodities Under Registration" report daily (on business days) and is a means of tracking instruments outstanding and also a useful measure to determine market activity. For example, deliveries may only be made during the delivery window for an expiring futures contract. This is the only time that increases to deliverable commodities under registration can be made. Much can be said also about the post delivery period as receipts/shipping certificates can only either decrease by loading out the grain (exercising the instrument) or remain the same until the next delivery period begins. Receipt and shipping certificate data is available from July 2003 to September 2011 for soybean oil and meal and from January 2000 to September 2011 for soybeans.

3.8 Inventory at Deliverable Locations and Territories

Like the "Deliverable Commodities Under Registration" report, the CBOT also surveys inventory activity at deliverable locations in the "Stocks of Grain" report, available on the CBOT

Registrar's website.   The stock of grain report is released weekly and surveys the stocks at deliverable locations for wheat, corn, soybeans, rice, and oats. The data series for our study is complete for the period surveyed in this paper – January 3rd, 2000 to September 30th, 2011.

Soybean Oil and Meal are not surveyed on this report. The next best source for inventory data for soybean oil is from the National Oilseed Processors Association (NOPA.) Data is available from January 2001 to September 2011 and is released monthly. Soybean meal inventories are not available as soybean meal is usually marketed when produced and has a short storage life (Schwager 1995.) For the remainder of this study, soybean meal shipping certificates will serve as a proxy for inventory.

3.9 Summary

The data used in this analysis dates from January 1st, 2000 to September 30th, 2011. Cash, futures, interest rates, storage rates, warehouse receipt/certificate data, and inventory data were collected. These sets of data will be used as empirical evidence and model inputs in Chapters 4 and 5. In addition to the data, a background of the soybean industry was presented to give the reader a better understanding of the scope of the soybean market.

4. DESCRIPTIVE ANALYSIS OF NON-CONVERGENCE

4.1 Introduction

Using the data in Chapter 3, this section presents and examines the market during the January 2000 to September 2011 time frame. During this period, basis non-convergence emerged for numerous CBOT contracts including soybean meal, oil, and soybeans. Convergence failures gave rise to other phenomena in the marketplace such as the accumulation of deliverable instruments. This chapter will provide a descriptive analysis of the causes and implications of basis non-convergence during the surveyed time frame.

4.2 The Behavior of the Market

During the period chosen in this study (January 2000 – September 2011) prices for soybeans, meal, and oil reached new absolute highs. Figure 10 displays a continuous price history chart of soybeans, soybean oil, and soybean meal futures. Soybeans are traded in cents per bushel, soybean oil is traded in cents per pound, and soybean meal is traded in dollars per ton. A continuous price history was made by using CBOT futures prices and rolling on expiration day to the next to nearby contract. In the sample period we can see similar price patterns from the commodities surveyed which is expected as they are correlated via the crush. As the output (soybean meal, soybean oil) rise in value, so will the input (soybeans) rise, and vice versa. Note that in the middle of 2008 the prices peaked for all commodities surveyed and have stayed elevated compared to earlier in the period.

The explanation for the prices during this time can be attributed to economic growth, increasing populations in the world, biofuels policy, tight worldwide stocks, the declining value of the dollar, and adverse weather conditions (Trostle 2008.) These price patterns were not limited to the soybean complex, but also were exhibited in wheat and corn (Irwin and Good 2009.)

4.3 Basis & Carry Behavior

As prices for commodities moved to unprecedented levels, the difference between cash prices and futures prices began to diverge. Starting around 2006, the basis failed to converge and prices for the futures often expired above their cash prices. The basis is the difference between the future price and the cash price, where t is any given point in time,

$$B_t = F_t - C_t.$$

The difference or basis reflects the associated costs with holding the cash commodity into the future such as insurance and storage. The basis is normally quoted as the futures being subtracted from the cash, but for this paper it is more easily intuitive in the modeling presented in Chapter 5 to have the terms reversed.

Figure 11, 12, and 13 display the basis price history at each location and for the cheapest to deliver location for soybeans, soybean oil, and soybean meal, respectively. Basis quotes were derived using the nearby contract and rolling to the next futures contract on expiration. Note the behavior of the basis of all three markets. Soybean basis normally exhibits a positive basis, but has many periods of inversion. The soybean oil basis has a fascinating price history in the case that it had a prolonged period of inversion from mid-2002 to mid-2005. Thereafter, soybean oil has been trading in an inclining and stronger basis until the last two months of this study (08/2011 – 09/2011.) Soybean meal is observed in a weak basis until 2007 when the basis became strong. Soybean meal, as mentioned earlier, does not have the capability to be stored for long periods of time. Therefore we should expect a negative basis normally for this market compared to soybeans and soybean oil.

This failure of basis convergence for all three commodities became the norm sometime after 2006 for soybeans and soybean meal futures. It was only until 2008 for soybean meal and 2009 for soybeans that the basis converged at the cheapest to deliver location. Soybean oil had not converged until the end of this study in late 2011. This failure to convergence impacted the transparency of the market and led users of the contract to question the effectiveness of futures as a suitable hedge. Other market participants, observing arbitrage opportunities, entered the market to seize mispricing opportunities within the CBOT grain complex.

As the basis failed to converge for the expiring futures contract, there was a tendency to have a large carry priced in the market. As mentioned before, the cost of carry is a measure of holding storable commodities from one period into the next. If the market is trading in positive carry, the market is implying a positive return for holding the commodity, which should be reflective of the storage, insurance, and opportunity costs. The cost of carry is normally referenced and quoted as a percentage figure of the full cost of carry. The percentage of full carry is based off of futures quotations and is computed as follows:

$$\%\ of\ Full\ Carry = \left[\frac{F2_t - F1_t}{S_t + I_t}\right] X\ 100,$$

where $F1_t$ is the chosen expiring future, $F2_t$ is a future contract expiring after $F1_t$, S_t is the cost of storage of holding the delivery instrument, and I_t is the interest opportunity cost. S_t is computed by taking the futures contract storage rate (Table 5) for the given commodity and multiplying it by the difference in days remaining between the first date of delivery of $F2_t$ and the current date t . I_t is computed in the following manner, $I_t = F1_t\ X\ \left(\frac{r_t}{365}\right) X\ n_t,$ where $F1_t$ is the future price, r_t is the financing rate(usually Libor + 200 basis points), and n_t the amount of days between the first day of delivery of $F2_t$ and the current date, t. Note also that the interest rate is assumed to be LIBOR + 200 basis points for the general market.

Figure 14 displays the percentage of full cost of carry for soybeans, soybean oil, and soybean meal on first delivery day. Each point represents the percentage of the full cost of carry on first delivery day of the futures contracts using LIBOR + 200 basis points as the interest rate. Just as was documented in the basis, relatively large carries were priced in the market starting in 2006 for soybean oil and soybeans. For example, soybeans averaged a carry of 77% on first delivery day from January 2006 to January 2008. Soybean oil exhibited the largest carries, with an average carry of 94% from January 2006 to September 2011. Several instances exceeded 100% on first delivery day. Soybean meal, like soybeans had a period of large carries from mid-2006 to January 2008, averaging 61% carry on first delivery day. Figure 15 displays the basis plotted against the percentage cost of fully carry on first delivery day of the futures contracts. Notice when there are large carries in the market there are episodes of basis non-convergence. This basis-carry relationship was first documented by Irwin et al (2009, 2011) who found that carries above 80% were associated with episodes of a non-converging basis. Several notable examples of this phenomenon are found in soybeans. For instance, the basis at the cheapest to deliver location for the September 2005 soybean contract settled at +45.25 cents and the resulting carry was 75%. The basis for soybean oil for the September 2010 contract settled at +4.4 cents/pound at the cheapest to deliver location and the resulting carry was 109%. Soybean meal's basis at the cheapest to deliver location settled at +13.8 dollars/ton for the March 2008 contract and resulted in a carry of 86%. These examples illustrate the same relationship Irwin et al (2009, 2011) discovered.

4.4 Cash & Carry

As the carries in the market were exceedingly large, this allowed users to put on the cash and carry arbitrage. As explained earlier, the cash and carry arbitrage opportunity arises when the percentage of full cost of carry is large enough that an arbitrageur can finance the cost of accepting the deliverable instrument on a futures contract, pay the associated fees with holding the deliverable instrument at the deliverable facility, and lock in a forward sale using futures. The price spread is large enough that returns then exceed the cost to finance the trade. Upon expiration of the short futures contract, the arbitrageur can complete the arbitrage by delivering on the futures contract or roll the future position forward into the next futures contract if there is another arbitrage opportunity present. This method of arbitrage is the most profitable when financing costs are low. In this analysis, LIBOR + 200 basis points was assumed as the financing rate, but often many financiers have access to cheaper financing rates. Cheaper capital costs allowed the trade to become lucrative to some financiers, but to many was still unattainable.

This cash and carry arbitrage was apparent in the market as there was a large buildup of receipts in the soybean oil market and soybean market starting in July 2005. Figure 16 displays the total deliverable receipts in all three markets in their respective units of measure. Notice in soybean oil that the buildup of receipts was the most pronounced compared to soybeans and soybean meal. Further analyzing receipt data, one interesting observation can be found in the CBOT Registrar reports. On the 8/25/2011 Deliverable Commodities Under Registration Report, under the soybean oil section, the deliverable facility at Gibson City, Illinois (Solae, LLC) was registered as owning 686 receipts of soybean oil. The previous balance was 626 receipts which were registered on 1/10/2006. This meant that receipts outstanding since 1/10/2006 totaled 626 and have been left in storage for almost 6 years earning the carry priced into the market. This was a case when the carries in the market were so large that an arbitrageur could roll their arbitrage forward continuously until it was not lucrative to hold the receipts any longer.

Figure 17, 18, and 19 go a step further and detail the receipt and shipping certificate history per location for soybeans, soybean oil, and soybean meal respectively. For soybeans (Figure 19) we can see that receipts when delivered are taken primarily at three locations – Chicago, Ottawa-Chillicothe, and Havana-Grafton. The other locations such as Lockport-Seneca and St.Louis-East St. Louis almost always receive no deliveries. This may be due to those facilities being closer to the Gulf and consequently being more concerned with merchandising than with storing grain. Soybean meal (Figure 19) has similar characteristics with two locations receiving a large amount of deliveries – Northern and Northeast Territories. Soybean oil (Figure 18) has large buildups of these receipts at all locations, but the velocity at which they were added to the territories of Iowa, Northern, Southwest, and Illinois is impressive. For the majority of the time frame that there was available data, each soybean oil delivery location continued to accumulate stocks until the basis inverted in late 2011.

4.5 Limits to Speculative Arbitrage

The CBOT in February 2009 amended the rules to holding deliverable instruments, for non-commercial use in CBOT corn, wheat, soybeans, soybean oil, soybean meal, oats, and rough rice contracts. The limits were specific to each commodity – corn, soybeans, wheat, rough rice, and oats were limited to 600 deliverable instruments, soybean oil was limited to 540 warehouse receipts, and soybean meal limited to 720 shipping certificates per speculator. This new amendment to the rules was designed to limit speculation in the delivery instruments market by non-commercial users and strengthen contract integrity as during this time CBOT contracts failed to converge properly to their cash counterparts. Before this rule was in place there were no limits to the amount a speculator could own of the deliverable instrument. However, speculators were limited to making and taking delivery based on the spot month allowance of futures contracts. For example, in soybean oil the spot month speculative limit is 540 futures contracts. In order to add/decrease inventory held, the speculator could only accept/deliver at a maximum of 540 receipts per contract expiration. This regulation limited the amount of inventory to change hands per futures expiration, which in turn raised the risk of financing receipts in the market.

In the case of an extremely leveraged speculator or hedge fund, there posed a liquidity risk in amassing deliverable instruments in a portfolio. During the 2007-2009 financial crisis, investor outflows of capital had impacted the functionality of many institutional funds. Figure 20 displays the interest rate environment from January 2000 to September 2011 for LIBOR, T-Bill rate, commercial paper rate, and the credit spread between commercial paper and T-Bill's. As the chart demonstrates there were several flights to quality to T-Bill's and other government debt that provided a safe haven for investment capital. This in turn created a larger than usual credit spread in the market measured as the difference between the commercial paper rate and the T-Bill rate. The LIBOR rate was also impacted as there was a liquidity scare amongst banking institutions in late 2008. These liquidity scares and flights to quality provoked investors to demand money from their investment institutional managers which forced many speculative funds to liquidate assets en masse on the spot market (many at a steep discount.) This liquidity risk could have forced large speculators in CBOT deliverable instruments to skip the delivery process and sell receipts in the over the counter (OTC) market to other market participants foregoing the arbitrage opportunity and possibly losing money on the trade. This was reason enough for most arbitrageurs to limit their speculative inventory of deliverable instruments prior to the 2009 amendment.

4.6 Inferring Market Activity

Looking back at the deliverable instrument data in Figures 17, 18, and 19 we see buildups of deliverable instruments at certain locations and others with little or no registered instruments. As Peck and Williams (1991) documented, deliveries would normally occur at locations where deliverable stocks were large and were also dependent on the basis and nearby futures spread. In Figures 21 and 22 deliverable stocks per location/territory for soybeans and soybean oil are displayed. Starting with soybeans we can see buildup of stocks at the Chicago deliverable location. This coincided with deliveries being made at that facility (Figure 17.) Soybean oil also shared a similar pattern as stocks at the Iowa and Northern region were the largest and received the bulk of the deliveries (Figure 18.)

Observing soybean shipping certificates per location (Figure 17), soybean deliverable stocks (Figure 21), and the soybean basis and carry on first delivery day (Figure 15), it is apparent that several relationships develop in the market when the basis fails to converge. From early 2005 to late 2008, the soybean basis failed to converged, deliverable stocks at Chicago and other locations began being accumulated, and large carries in the market enticed speculators to accept delivery of shipping certificates. The reasoning behind this accumulation of inventories and certificates was thought to have been due to storage rates in the CBOT contract specifications being too low compared to the physical market rate thus it became cheaper to store in the facilities registered with the CBOT. In November 2008, the CBOT amended contract specifications on soybeans and raised the contract storage rate to 4.95 cents/bushel/month from 4.5 cents/bushel/month. This increase in storage rates resulted in the liquidation of deliverable instruments for soybeans and soybean deliverable stocks, decreased the carry in the market, and re-established basis convergence in the market. Simply increasing the storage rate in late 2008 returned price transparency in the marketplace. Irwin et al (2009, 2011) found the same observations for CBOT corn, soybeans, and wheat when the contract storage rates were raised. However, wheat continued to have convergence problems until the variable storage rate system was introduced in July 2010 (Seamon, 2009.)

Using the same graphical evidence for soybean oil, we can infer a similar story, but with a different ending. Observing soybean oil warehouse receipts per territory (Figure 18), soybean oil stocks (Figure 22), and soybean oil basis and carry (Figure 15), the same relationships emerge. Beginning in 2005 when the basis became positive for soybean oil, the accumulation of stocks resulted in a large positive basis and a large carry in the market. Inventories in the receipt market reached their highest point in late 2011 before rapidly decreasing. This was caused by several locations observing an inverted basis (Figure 12) which caused users to liquidate receipts as the receipts were more valuable selling on the spot market than carrying them forward. Compared to soybeans, contract storage rates never changed which made a non-converging basis the norm for soybean oil. This could predominantly be the reason why there still exist such large carries in the market for soybean oil.

Soybean meal compared to soybean oil and soybeans had a less dramatic history, but the same patterns emerged. In 2007 the soybean meal basis became strong which followed with a large carry priced into the market (Figure 15.) Shipping certificates (Figure 19) were accumulated and carried forward until the basis inverted in 2008 (Figure 13.) Like soybean oil, the reasoning for accumulation of receipts was a large lucrative carry in the market which subsided when there was a demand for the cash commodity that inverted the basis.

4.7 Summary

This chapter examined the market during the selected time frame and observed the linkages between the different markets from January 2000 to September 2011. It was found that many of the same instances of basis non-convergence that occurred in the soybean market had also occurred in the soybean meal and soybean oil markets. Likewise, many of the same patterns in the market became apparent with convergence failure – a large carry priced into the market, large deliverable stocks at deliverable locations, and a buildup of delivery instruments held by market participants. These patterns also were noticed by market participants who entered the marketplace to arbitrage grain futures contracts through the deliverable instrument market. After repeated episodes of a non-converging basis the CBOT amended the rules to the maximum allowance of delivery receipts held by for non-commercial use by any one participant. The CBOT also increased storage rates in the soybean, wheat, and corn futures contract to help restore convergence in the market. Convergence was restored in the market followed by a weaker basis, a smaller carry, a decrease in deliverable stocks, and liquidation of deliverable instruments. This change in the marketplace was responsible for unwinding many of the patterns described earlier with a non-converging basis. Although the linkages of the market are related, further analysis of what drives this non-convergence needs to be analyzed. In the following chapter an analysis is presented along with statistical evidence explaining what causes non-convergence.

5. MODELS & EMPIRICAL RESULTS

5.1. Introduction

The analysis in this section draws from the model developed by Garcia, Irwin, and Smith (2011) to explain basis behavior in the presence of the futures, cash, and delivery instrument market. This section introduces the dynamic infinite horizon model used to measure and explain the wedge between the physical rate of storage and the cost of storage in the delivery instrument market. Thereafter linear regression models are introduced and used to test explanatory variables that may impact the wedge. Graphical evidence of the wedge over time is then provided which can then establish a link to the basis, carry, and inventories at deliverable locations as suggested in Chapter 4. Lastly, graphical results are presented that demonstrate basis predictability of the basis under perfect foresight.

5.2 Dynamic Infinite Horizon Model

Garcia, Irwin, and Smith (2011) first conceived a rational expectations model to measure the difference between the physical rate of storage in the market and the cost of holding shipping certificates. Based on their research convergence failure arises from one of two scenarios:

1. An imbalance between the price of storage in the physical market relative to the cost of holding delivery instruments.
2. The differences in capital costs between holders of grain inventory (commercial firms) and holders of delivery instruments (financial firms[3].)

[3] A key assumption is made that financial firms are the holders of delivery instruments

The imbalance or difference in storage rates is called the "wedge" and will be referenced as such for the remainder of the thesis. The wedge as defined by Garcia, Irwin, and Smith (2011) can be expressed by the following equation,

$$W_1 \equiv \delta - y(I) - \gamma + (r - r^f)(P + \delta - y(I))/(1 + r^f) \quad (1)$$

Where δ is the cost of physical storage, $y(I)$ is the convenience yield as a function of stocks, γ is the cost of holding delivery instruments (CBOT maximum daily storage rate), P is the cash commodity price, r is the interest rate facing commercial firms, and the interest rate facing financial firms is r^f. Notice that this wedge calculation incorporates three markets – the cash market, the futures market, and the delivery instrument market.

As mentioned earlier, the first scenario that basis non-convergence can occur is when the storage rate in the physical market exceeds the cost of holding delivery instruments. This is modeled as the first part of the wedge equation, $\delta - y(I) - \gamma$. Graphically this is presented in Figure 23. It can be seen that the cost of storage in the physical market, $\delta \quad - y(I \quad)$, is determined by the supplies at any giving point on the curve. However, since the cost of holding delivery instruments is fixed, γ, the cost of physical storage ($\delta - y(I)$) could be greater and thus a positive wedge term will be observed resulting in non-convergence as is the case . The second scenario that causes non-convergence is the difference of capital costs, $\left(r \quad - r^f\right)$. If firms have access to cheap credit, this term can cause an imbalance and cause the wedge term to become positive. This credit spread can largely impact the wedge when a low interest rate environment exists, coupled with high cash prices.

Garcia, Irwin, and Smith (2011) also show that wedge term can also be written as,

$$W_t = B_t - \frac{E_t[B_{t+1}]}{1+r_t^f} + S_t \,. \qquad (2)$$

In this formulation, the wedge is determined by the difference between current basis (B_t) and the discounted expected basis ($E_t[B_{t+1}]$) and added to the excess spread (S_t). The spread S_t , is simply the excess spread in the futures market that exists after taking into account storage costs embedded into the contract, as the following equation demonstrates,

$$S_t = \frac{F_{t,t+1}}{1+r_t^f} - F_{t,t} - \gamma_t. \qquad (3)$$

When $S > 0$, there is a riskless arbitrage opportunity in the market. This is also where the cost of carrying the instruments implied by the futures spreads departs from maximum full carry (100 %.) The following two definitions also explain conditions for convergence and non-convergence, which were used in creating equation (2)

$$B_t = \max\left(\frac{E_t[B_{t+1}]}{1+r_t^f} + W_t, 0\right) \qquad (4)$$

$$S_t = \max\left(\frac{E_t[B_{t+1}]}{1+r_t^f} + W_t, 0\right) \qquad (5)$$

As we can see, when $\frac{E_t[B_{t+1}]}{1+r_t^f} + W_t > 0$ we have basis non-convergence and the futures market is at full carry ($S_t = 0$). If $\frac{E_t[B_{t+1}]}{1+r_t^f} + W_t < 0$ then we have basis convergence market and the futures market is less than full carry ($S_t < 0$).

Furthermore Equation (4) shows that the basis at time period t is dependent on the expected basis in $t+1$. This relationship could loop infinitely as long as we expect subsequent bases to remain positive. Garcia, Irwin, and Smith (2011) simplify writing this equation by first defining $D_{t+i} \equiv 1(B_{t+i} > 0)$ as the conditional function for whether the basis is positive in period $t+i$. Now the basis can be written as,

$$B_t = \max\left(\frac{1}{1+r_t^f} E_t\left[\frac{D_{t+1}}{1+r_{t+1}^f} E_{t+1}[B_{t+2}] + D_{t+1}W_{t+1}\right] + W_t, 0\right)$$

$$= \max\left(W_t + \sum_{i=1}^{\infty} E_t\left[D_{t+i}W_{t+i}\left(\prod_{j=0}^{i-1} \frac{D_{t+j}}{1+r_{t+j}^f}\right)\right], 0\right) \quad . \qquad (6)$$

This equation simply states that the basis is made up of the expected present value of future wedges as long as the basis is expected to be positive.

5.3 Regression Model & Results

Like Garcia, Irwin, and Smith (2011) we want to explain the wedge by a set of explanatory variables, Z_t . To do this we would want to estimate the following regression,

$$W_t = \beta' Z_t + u_t \,, \qquad (7)$$

where $E[u_t | Z_t] = 0$. However, this equation cannot be estimated directly as W_t is unobservable. Instead the following equation is used,

$$S_t + B_t - \frac{B_{t+1}}{1+r_t^f} = \beta' Z_t + v_{t+1} \,, \qquad (8)$$

where $v_{t+1} = u_t + \varepsilon_{t+1}$ and $E[v_{t+1}| Z_t] = 0$. Equation (8) comes from combining equation (7) and the following equation,

$$B_t + S_t - \frac{B_{t+1}}{1+r_t^f} = W_t + \varepsilon_{t+1} \text{ ,} \tag{9}$$

where the error term, $\varepsilon_{t+1} \equiv \frac{(E_t[B_{t+1}]-B_{t+1})}{(1+r_t^f)}$. Equation (9) provides a way to calculate a noisy version of the wedge which then can then be estimated in equation (8).

The next step is to normalize W_t to a per month basis. The reason for normalization is to be able to compare one wedge against another adjusting for differences of duration between contracts. The following equation normalizes the wedge to a per month basis.

$$\widetilde{W}_t = \frac{1}{m_t}\left(B_t - \frac{B_{t+1}}{1+r_t^f} + S_t\right) \tag{10}$$

All the terms are defined as before in (2) except now scaled by m_t which can be 1, 2, or 3 depending on the contract and the commodity being surveyed. Having this wedge term now normalized, we can test the regression equation against an array of variables that are likely to explain the wedge.

Garcia, Irwin, and Smith (2011) selected the following explanatory variables for their regression models: the CBOT storage rate on delivery instruments, credit spreads between commercial paper and treasury bill rates, open interest of commodity index traders, the inventory-sales ratio for food manufacturing firms, a trend variable to capture seasonality, and inventory at deliverable locations (log form.) Dummy variables were also chosen for outliers.

These values were chosen as extremely negative values that were 4 standard deviations below the wedge sample mean. Garcia, Irwin, and Smith found that of the variables just mentioned, inventory was a significant variable in explaining the wedge in CBOT corn (Toledo/Illinois River), CBOT soybeans (Toledo, Illinois River), CBOT wheat (Toledo), and KCBOT wheat (Kansas City.)

Garcia, Irwin, and Smith (2011) found little evidence of statistical significance for the inventory/sales ratio and commodity index trader positions, so these variables were dropped from the models. The following variables were tested: the difference between the non-financial commercial paper rate and the T-Bill rate as the credit spread, the inventory/stocks at deliverable locations (log form), and each contract month (for seasonal purposes). Dummy variables were used for outliers in the sample just as Garcia, Irwin, and Smith had included. The CBOT storage rate was also included for soybeans but not for soybean meal and oil since there was no change in the storage rate for those specific markets during the duration of this study. Inventory data at deliverable locations for soybeans was direct from the CBOT. Soybean oil inventory was produced by the National Oilseed Processors Association (NOPA.) Soybean meal inventory is not kept, so deliverable commodities under registration served as a proxy for inventory.

As the wedge can result from an imbalance in capital costs or from a storage rate imbalance, we should expect positive coefficients for the credit spread and the inventory variables. It is also expected there may be some seasonality present with the largest coefficient being after the harvest window for soybeans. This would largely affect the November and January contracts. Later into the year the coefficients decrease and possibly contribute negatively when the supply of stocks is the lowest before harvest (August and September contracts.) Soybean oil and soybean meal should expect positive coefficients for the contract months, but possibly not as much of a seasonal variation compared to soybeans.

Tables 6, 7, and 8 display the results of the regression. Starting with Table 6, soybean regression results are examined. In comparison to the study by Garcia, Irwin, and Smith (2011), signs on the coefficients are the same – storage rate negative, inventory positive, and credit spread positive. However, inventory did not show up as significant in explaining the wedge at the cheapest to deliver location. The difference is most likely due to this study focusing on a different time period and only on the deliverable locations of the Illinois Waterway System. Garcia, Irwin, and Smith used the 1986-2010 time period and tested for the Toledo/Illinois River location. At a location level, the only significant location was Chicago. Going back to Figure 23, we can see the heavy buildup of stocks at Chicago in comparison to the other locations surveyed. Another interesting observation was the credit spread was significant in explaining the wedge for two locations, the Illinois River, South of Peoria territory and the St. Louis location. These two locations did not show an abundance of deliverable stocks at the location in comparison to Chicago. We can infer to some degree that that Chicago is more of a storage location and the other locations are more concerned with merchandising operations on the river. Seasonality showed up in the coefficients with large negative coefficients around harvest time (August and September contracts.) The least negative coefficient on a per month basis was the January and November contracts. During those contract months the new crop is usually harvested and the largest amount of supplies are available, therefore a positive coefficient or weakly negative coefficient is logical. Lastly, the storage rate coefficient was negative for all locations except the Illinois River, North of Peoria. Testing if the the storage rate is statistically different from -1 for each location yields an acceptance of that hypothesis. This is reasonable since the storage rate impacts the wedge negatively in the model.

Table 7 details the regression results for soybean oil per location. Inventory at the cheapest-to-deliver location and the Central territory tested positive for significance. Going back to Figure 24, we can see stocks started to accumulate in 2006 which helped explain the wedge in the regression model. Credit entered in as a positive coefficient but was extremely small for all locations (less than .01). Lastly from a seasonal aspect there does not seem to be any noticeable pattern in the contract months.

Finally, Table 8 displays the results of the soybean meal regression. The same observations are made in comparison to soybeans and soybean oil the coefficients for inventories are positive and large on average and credit being small and positive on average. However, no variables tested positive for significance in the linear regressions for soybean meal. From a seasonal aspect there did seem to be a pattern of large negative coefficients for July and September contracts. Thereafter positive coefficients were observed for the remaining contract months.

Aggregating the results for the three commodities we can see that two variables were significant in explaining the wedge – inventory and the credit spread. Inventory is the larger driver of the wedge, for example for soybean oil in the Central territory, the coefficient is .60. A 10% increase in inventory (log terms) leads to a .060 cents/pound increase in the wedge. Following this methodology, the large accumulation of inventories of soybean oil from 2005 to

2011 produced a wedge of .384 (.60*.64) using this model. This is extremely significant as the maximum storage rate on soybean oil receipts is .09 cents/pound per month.

As mentioned credit spreads were significant, but only for soybeans at two locations – St. Louis and Illinois River, South of Peoria. Both locations have stronger positive coefficients associated with them compared to the Chicago and Illinois River, North of Peoria locations. Although the coefficients are small (.13 for Illinois River, South of Peoria, and .18 for St. Louis) they could have a significant impact on the wedge. For example, take into consideration credit spreads during the 2007-2008 financial crisis – credit spreads averaged 56 basis points during those two years which could increase the St. Louis wedge by 10.08 cents using the model. Before the financial crises the sample mean of the credit spread from 2000-2011 was 23 basis points which strengthens the wedge by 4.14 cents at St. Louis. Large credit spreads can be a decisive factor in contributing to large wedge values, however, they are not as pronounced as inventory at deliverable locations.

5.4 Graphical Evidence of the Wedge

Since many of the episodes of a non-converging basis began to occur in 2006, it would be worthwhile to present graphically how the wedge behaved over time as the market changed for all three commodities. The wedge is also presented for comparative purposes between the three markets as well as against each underlying storage rate to determine the magnitude of the imbalance.

Using equation (9) the wedge is computed for each contract. Figures 25, 26, 27 display the average wedge per contract per location as well as a separate graph of the average wedge at the cheapest to deliver location for soybeans, soybean oil, and soybean meal. The average is taken by averaging each contracts wedge per day of the delivery cycle. So from equation (9), we start by computing the wedge from on the first day of delivery of the expiring futures contract to the next first day of delivery on the next contract then compute the wedge of on the second day of delivery to the second day of delivery of the next futures contract and so forth and finally averaging those values. This averaging process was chosen to smoothen out the estimation of the wedge term for each contract and also to take into account the possibility of the basis converging during expiration. From the figures we can see that the average wedge per contract has episodes of large positive values in soybeans and soybean oil. In soybeans at the cheapest to deliver location there were periods of large average wedges starting in 2005 and ending in 2008 that reached 10 to 20 cents/bushel per month. Soybean oil also exhibited patterns of large average wedges in the beginning of the sample from 2000 to 2002 and then from 2005 to 2011 ranging from .50 to .90 cents/pound. Soybean meal was less dramatic compared to soybeans and soybean oil, but still was observed as having large average wedges in 2003 and 2007 ranging from 5 to 15 dollars/ton.

The wedge can also be used to estimate the monthly price of physical storage. This estimate is used for comparative purposes to observe the actual cost of storage in relation to the maximum storage rate set by the CBOT for agricultural futures contracts. Figures 28, 29, 30 display an estimate of the monthly price of physical storage against the CBOT storage rate for soybeans, soybean oil, and soybean meal. For brevity we will label this as, W_+ and is computed with the following equation.

$$W_{+} = \frac{W_t}{m_t} + \gamma_t + \varepsilon_{t+1} \qquad (11)$$

The three month centered moving average of this wedge term is used to smooth out the error term, ε_{t+1}. Starting with soybeans (Figure 28) we can see that the storage rate has been changed three times during the period surveyed (see Table 5.) Early in the period when the physical rate of storage became greater than the contract storage rate (2001), the contract storage rate increased from 3.6 cents/bushel to 4.5 cents/bushel per month and this decreased the wedge. From 2005 to 2008 the physical rate of storage was greater than the contract storage rate and in 2008 was increased to 5 cents/bushel per month and the physical rate of storage coincidentally decreased immediately. The effect of increasing the contract storage rate can be seen in the basis and carry. Going to Figure 17 we can see how the basis at the cheapest to deliver location on first delivery day for soybeans decreased significantly from 2008. Likewise, the carry in the market decreased significantly during the same time frame. However the increase solved some of the problem, there were two episodes since the last increase in storage rates when the physical rate of storage was above the contract storage rate in both January 2010 and January 2011. Garcia, Irwin, and Smith (2011) found similar results of the physical rate of storage being above the contract storage rate from 2000-2002, 2006-2008, and later from late 2009 to mid-2010.

Moving to soybean oil (Figure 9), which has not had any changes to the embedded contract storage rate in the futures we can see the physical storage rate being above the contract storage rate starting in 2001 and ending in 2003. The contract rate is .09 cents/pound per month and during this time it was 2-3 times higher in the physical storage market. Thereafter a long inversion in the marketplace took place which forced the market price of physical storage below the contract storage rate. However, starting in 2006 the inversion in the market stopped and the physical storage rate immediately overtook the contract storage rate. For most of the years from 2006 to 2011 when the physical price of storage was greater than the CBOT contract rate, it was 3 times larger, and at times in 2011 it was 10 times larger standing at .93 cents/pound per month. Lastly in soybean meal (Figure 30), we can see a few observations of the physical price of storage being greater than the contract storage rate in 2003, 2007, 2008, and 2011. Although these physical storage rates did not persist as long as in the soybean oil and soybean markets, they are important for the reason that the physical price of storage was up to 50% higher than the contract storage rate of 2.1 $/ton per month.

As the many violations became apparent, it became important to explain the cause for increased prices. Using Working's supply of storage model (Figure 1), it can be reasoned that the price of storage can be increased in one of two ways, either a supply shift to the left or a demand shift to the right as illustrated in Figure's 24 and 25, respectively. Although capacities either decreased or demand to store grain increased, it is not possible to tell from this study. However, shifts in either or both have happened during this time frame which resulted in the cost to store physical grain to increase.

5.5 Perfect Foresight Basis

Like Garcia, Irwin, and Smith (2011), we want to test to see if Equation (6) predicts the current basis. The intuition behind this is that the basis is made up of the present value of expected future wedges as long as the basis is expected to be positive. Therefore, there should be some prediction power embedded in the wedge that determines the basis. To test for this prediction, we would like to test this under the assumption of perfect foresight. Using the last basis observation in the sample we can solve backwards for the previous basis under perfect foresight by using the following equation,

$$B_t^{PF} = \max\left(\frac{B_{t+1}^{PF}}{1+r_t^f} + \widehat{W_t}, 0\right) \tag{12}$$

Where $\widehat{W_t}$ is a proxy for the wedge. Two wedge proxies were used – the three period centered moving average of equation (10) and the predicted values from regression equation (8).

Modeling the basis against the predicted results is demonstrated in Figures 31-35 for soybeans, Figure 36-39 for soybean oil, and Figure 40-43 for soybean meal. Each location is surveyed along with the cheapest to deliver location. Starting with Figures 31-34 for soybeans we can see the two measures – the regression prediction and smoothed proxy prediction – track the movements of the basis well, but have difficulty of tracking the magnitude of the basis. The Illinois River, South of Peoria and St. Louis location's predictions were the best of the series in both tracking the magnitude and basis movement. Similar results to these were found for the Illinois River, North of Peoria location as Garcia, Irwin, and Smith (2011) first documented.

Figures 36-39 display the results for soybean oil. Observing the results for the cheapest to deliver location and the central territory we can see that the smoothed proxy prediction and the regression prediction give us mixed results in tracking the basis. From January 2000 to January 2003, the basis predictions in terms of movement resembled the actual pattern of the basis during that time period but not the magnitude. Thereafter starting in 2006 to early 2007 the regression prediction tracked the movement of the basis well, but overestimated the magnitude of the basis.

Later, from 2007 to 2011 the regression predictions understate the magnitude of the basis. During that same period the smoothed proxy prediction tracked the basis better but overestimated the basis from 2009-2011. This also explains why the coefficient of determination was so low (.22 at cheapest to deliver) compared to the other commodities tested.

Figures 40-43 display the results for soybean meal. Like soybeans and soybean oil, soybean meal predictions track the basis well, but not to the magnitude of the observed basis at the cheapest to deliver location. For the central territory there is a noticeable improvement when the basis was large between 2007 and 2008 (Figure 41). The Missouri location does a poor job of tracking the basis in 2006, but thereafter improves. This could possibly be due to the weak basis at this location during the sample period. Lastly, for the amount of data points available for the Eastern Iowa Territory, the predicted basis does a good job of tracking the changes in the basis both in movement and magnitude for out sample.

5.6 Summary

The model used in this paper is a rational expectations model originally developed by Garcia, Irwin, and Smith (2011.) The model captures the wedge term by linking the cash, futures, and delivery instrument market. The wedge term as presented in the model is the difference between the physical price of storage and cost of holding the delivery instruments.

Several explanatory variables were chosen to test what influences the wedge. Inventory at deliverable locations, storage rate (soybeans only), a credit spread, and each contract month were tested. It was expected that inventory would positively influence the wedge as well as credit spreads and specific contract months for a seasonal measure. It was found that inventory tested significant in explaining the wedge for the soybean futures contract at the Chicago location. Inventory was also significant in explaining the wedge for soybean oil at the Central Illinois territory as well as the cheapest to deliver location. Credit spreads tested significant for soybeans at two locations – the Illinois River, South of Peoria territory and the St. Louis Location and were positively related to the wedge. Although not significant the model did pick up a seasonal component for soybeans in which case the largest positive coefficient being present after the soybean harvest and the lowest coefficient present before the soybean harvest.

Graphical evidence was then provided to explain the magnitude of the wedge. Large wedge values were observed for both the soybean oil and the soybean futures market starting in 2005 and 2006. Further evidence was provided of an estimate of the physical price of storage. This was used in comparison to the CBOT storage rate and found to be largely above the contract storage rate for soybeans and soybean oil.

Tracking the basis under perfect basis foresight was also examined. It was found that the basis was predicted well for the Illinois River, South of Peoria and St. Louis location for soybeans. Tracking the soybean oil basis proved problematic and gave mixed results due to the observed large carry in the market. Soybean meal had similar results compared to soybean oil and meal, but still did not carry as good of a fit in predicting the basis.

From the descriptive analysis in Chapter 4 and the thorough analysis done in this chapter, basis non-convergence can be largely attributed to inventories and credit spreads. Although the model did not pick up significance in all locations for all variables tested, the variables are important in determining and estimating the magnitude of the wedge when non-convergence is present.

6. CONCLUSION

6.1 Summary and Review

This thesis examined basis convergence in the soybean futures complex from January 2000 to September 2011. During this time period several agricultural futures contracts that trade on the CBOT exhibited episodes of a non-converging basis. Specifically, soybean, corn, and wheat markets experienced failures to converge. As non-convergence continued in the market, price transparency, hedging decisions, and contract integrity became an issue. Contract specifications and trading rules were amended for agricultural futures that trade on the CBOT to help alleviate this problem, but only for the flagship contracts – corn, wheat, and soybeans. This thesis sought to investigate if other agricultural futures contracts shared a similar fate.

The soybean futures complex, which includes soybeans, soybean oil, and soybean meal, was chosen because of the close relation of the byproducts (oil, meal) of soybean crushing. Each of these commodities also has a different economic use – soybeans are typically crushed for the oil and meal component, soybean oil is used as vegetable oil and in biodiesel production, and soybean meal is used as a feed in livestock production. The soybean futures complex also has differences in perishability amongst its components as both soybeans and soybean oil can be stored for long periods of time compared to a shortened shelf life for soybean meal. These differences among the three markets provided an opportunity to analyze each commodity in relation to one another.

As explained in Chapter 4, the soybean futures complex experienced basis convergence problems as early as 2005. Repeatedly the price of the futures would expire above the cash price for each component of the soybean futures complex. These episodes of a non-converging basis presented lucrative opportunities for non-commercial users to arbitrage grain through the delivery market. Several other patterns were discovered when a basis failed to converge. Upon expiration, the failure of the basis priced in a large carry for holding the instrument and delivering it into the next contract, deliverable stocks at deliverable territories were large, and lastly a buildup of CBOT deliverable instruments outstanding.

These linkages in the market between the cash, futures, and deliverable instrument market were further analyzed to uncover what drove the failure of the basis to converge. In Chapter 5 a model created by Garcia, Irwin, and Smith (2011) was used to explain non-convergence. According to the model basis non-convergence arises either from an imbalance of the price of storage in the physical market relative to the cost of holding deliverable instruments on the CBOT, or from a difference between capital costs between holders of grain inventory and the holders of delivery instruments. This difference or "wedge" in storage rates was hypothesized to be chiefly the reason for a non-converging basis to occur. To investigate what drove the wedge a linear regression model was used. In the regression model several explanatory variables were tested – a credit spread, inventory at deliverable locations, each contract months to see if seasonal tendencies affect the wedge, and the storage rate for holding deliverable instruments (soybeans only.) Based on the results of the regressions it was found that soybeans inventory was a significant explanatory variable in explaining the wedge at the Chicago deliverable location. Likewise for soybean oil, inventory in the central territory tested significant in the linear regression models. All other locations for soybean oil and soybeans did not test significant, as did all locations for soybean meal. However, all the signs of the coefficients were the same for all regression explanatory variables. Credit spreads also tested significant in the regression model for two deliverable locations in soybeans – Illinois River South of Peoria, and St. Louis. Expected seasonal patterns were observed in the monthly coefficients where the wedge was the largest during the harvest period for soybeans. Seasonal patterns were not as recognizable for soybean oil and meal.

Graphical evidence was also presented in Chapter 5 to observe how the wedge over time had changed. During the study it was found that the average contract wedge increased as well as the magnitude of the wedge when basis non-convergence problems began in 2005 and 2006. Graphical evidence also was presented comparing the maximum CBOT storage rate on deliverable receipts/certificates against the estimated physical price of storage. It was found that for soybeans when the rate on storage increased for CBOT futures contracts, coincidentally convergence was re-established and the cost of physical storage dropped. Unfortunately for soybean oil and meal, this was not observable since the CBOT contract storage rate for each commodity was unchanged during the sample period. This had caused the estimated physical price of storage to remain elevated, upwards of 10 times the official posted rate (soybean oil.)

Further graphical results were also examined to test the predictability of the basis. Using the last basis quote in the data sample (September 2011), under perfect basis foresight, a smoothed proxy prediction and a prediction from the residuals from the regression equation were estimated to track the basis. Using these proxies for the wedge, the basis was tracked starting from the latest basis quote in September 2011 and then solved backwards per basis quote all the way to the January 2000 contract. Graphical evidence from the predicted results of the linear regression fit well in determining the movement of past bases in soybeans (St. Louis and Illinois River, South of Peoria locations) and in Soybean Meal (Illinois and Eastern Iowa territories.) Soybean oil had mixed results in tracking the basis under perfect foresight. However, the magnitude of the basis was tracked better for soybean oil compared to soybeans or soybean meal.

From the results of the regression models and the graphical evidence presented, it is clear that there are problems looming around the contract design for CBOT agricultural futures contracts. Basis non-convergence is a result from one of them and from this thesis it is clear it is hindering the soybean futures complex (namely soybean oil.) Although this thesis examined three agricultural futures contracts, it has implications for all agricultural futures contracts that use the CBOT delivery system and have fixed storage rates for deliverable instruments.

6.2 Suggestions and Future Work

In light of the evidence provided in this thesis on basis non-convergence, a re-assessment of storage rates should be sought for commodities that trade on the Chicago Board of Trade. From the graphical evidence it is clear that storage rates are too low for soybeans and soybean oil. This is reflected in the large outstanding delivery instruments in the past and present (soybean oil only.)

Several options can be implemented to help remedy basis non-convergence. One way would be simply to raise the rates on holding delivery instruments as has been done in the past. Another way would be to introduce the variable storage rate system for other commodities which would allow the futures market to discover the market price for storage. Cash settlement is another option, but the problem associated with cash settlement has always been finding a reference price to settle the contracts to, therefore making cash settlement not possible. One final way would be by forcing load out on cash settled commodities instead of delivery of a delivery instrument. The main problem with this is that the long contract holders, who receive deliveries, would have to find a home for the commodity immediately. This could be extremely burdensome for end users if they do not own any storage capacity or cannot find an end user to resell the commodity to. Of all the options, the easiest option would be to increase storage rates. Judging from the results of this study all three commodities would benefit from increased contract storage rates. Increasing the storage rates would benefit the trade and bring transparency to prices and help bona fide hedgers with rational storage making decisions.

Still on the topic of convergence, more work needs to be done on what caused physical storage rates to increase. Similar convergence problems hardly ever arose based on the research presented by Working (1953), Peck and Williams (1991), and Pirrong (1993.) The bigger question is what had happened to the market since then. As much of the convergence failure started in the mid-2000's for CBOT agricultural futures, the question underlying was what caused the price of physical storage to increase. This shift in supply or demand (or both) for storage is an important topic to look further in as it has impacted the functionality of the market, contract integrity, hedging decisions, and market participants reactions to pricing anomalies.

Lastly, in the delivery market, further work could be examined for other commodities such as rough rice or oats. Although this study has focused on the Chicago Board of Trade delivery market, there are other exchanges that handle delivery differently such as the London Metals Exchange (LME) and the Intercontinental Exchange (ICE) for commodities. Besides delivery studies, it is worthwhile to test for the same results using other locations when they become available and by utilizing other data sources for cash quotations other than the USDA.

6.3 Concluding Remarks

The grain futures complex at the Chicago Board of Trade is unique as in some commodities are cash settled, some have physical delivery, and others have delivery receipt/shipping certificates. Simple and complex changes to the delivery process can be made, as has been evident with changes in fixed storage rates for corn, wheat and soybeans as well as variable storage rates introduced in 2010 for the CBOT wheat contract. These ‘problems’ if one were to call them problems, have given rise to institutional investors entering the arena although not as bona fide hedgers/users of the commodity, but as arbitrageurs and speculators capitalizing on market inefficiencies within the delivery market. Changes to contract storage rates should be assessed by the Chicago Board of Trade to improve the transparency in the futures market and re-establish a link between the cash and futures price going forward.

TABLES

State	City	Firm	State	City	Firm
Alabama	Decatur	Bunge Corporation	Kentucky	Owensboro	Owensboro Grain Company
	Guntersville	Cargill	Louisiana	Delphos	Bunge Corporation
Arkansas	Helena	ADM		Destreham	Bunge Corporation
	Little Rock	ADM		Lafayette	Marion Dale
	Stuttgart	Riceland Foods	Marylaand	Salisbury	Perdue Farms
Georgia	Valdosta	ADM	Michigan	Grand Rapids	National Select
	Gainsville	Cargill		Midland	Wysong Corporation
Illinois	Bloomington	Cargill		Ulby	Thumb Oilseed Producers Coop
	Danville	Bunge Corporation		Zeeland	Zeeland Farm Soya
	Decatur	ADM	Minnesota	Brewster	Minnesota Soybean Processors
	Cairo	Bunge Corporation		Dawson	Ag Processing
	Galesburg	ADM		Fairmont	CHS
	Gibson City	Solae		Grove City	Midwest Protein
	Gilman	Incobrasa		Mankato	ADM
	Mattoon	US Soy		Mankato	CHS
	Quincy	ADM		Minneapolis	Cargill
Indiana	Claypool	Louis Dreyfus	Mississippii	Clarksdale	ADM
	Decatur	Bunge Corporation		Marks	Bunge Corporation
	Fort Wayne	Bunge Corporation		Vicksburg	Bunge Corporation
	Frankfurt	ADM	Missouri	Gallatin	Gallatin Soy Products
	Indianapolis	Bunge Corporation		Kansas City	ADM
	Logansport	Bunge Corporation		Kansas City	Cargill
	Lafayette	Cargill		Mexico	ADM
	Morristown	Bunge Corporation		St. Joseph	Ag Processing
	Mt. Vernon	CGB	Nebraska	Axtell	Roberts Seed
	Portage	Zeeland Farm Services		Crete	Lauhoff Grain Company
	Seymour	Rose Acres		Hastings	Ag Processing
	Waterloo	Bunge Corporation		Fremont	ADM
Iowa	Ackley	Cargill		Lincoln	ADM
	Buffalo	Cargill		Omaha	Ag Processing
	Cedar Rapids	Cargill		West Point	Grain States Soya Inc.
	Creston	CF Processing	New York	Fort Plain	Logan Farms
	Clinton	ADM		Homer	Homer Oil Co.
	Council Bluffs	Bunge Corporation		Massena	Ag-Pro

Table 1. List of U.S. Soybean Crushing Facilities

State	City	Firm	State	City	Firm
Iowa (continued)	Des Moines	ADM	North Carolina	Fayetteville	Cargill
	Des Moines	Cargill		Raleigh	Cargill
	Eagle Grove	Ag Processing		Teachey	Bunge Corporation
	Emmetsburg	Ag Processing		Warsaw	Carolina Soy Products
	Iowa Falls	Cargill	North Dakota	Enderlin	ADM
	Manning	Ag Processing	Ohio	Fostoria	ADM
	Mason City	Ag Processing		Bellevue	Bunge Corporation
	Ralston	West Central Cooperative		Delphos	Bunge Corporation
	Sergeant Bluff	Ag Processing		Marion	Central soya Company
Kansas	Sioux City	Cargill		Sidney	Cargill
	Sheldon	Ag Processing	Oklahoma	Ada	Southern Proteins
	West Bend	West Bend Elevator Company	South Carolina	Yankton	Frontier Mills
	Delavan	Grain States Soya Inc.		Volga	South Dakota Soybean Processors
	Emporia	Bunge Corporation	Tennessee	Memphis	ADM
	Fredonia	ADM	Texas	Bedfort	Schmitt & Kern
	Lawrence	Central Soyfoods	Wisconsin	Adams	Soy-Co
	Topeka	Soy King		Cambria	College Grove Cooperative
	Wichita	Cargill		Cambria	Didion Milling
	Wright	The Right Cooperative		Rothschild	Ligno Tech, USA

Table 1. List of U.S. Soybean Crushing Facilities (continued)

Territory						
Year	Chicago & Burns Harbor	Lockport-Seneca	Ottawa-Chillicothe	Peoria-Pekin	Havana-Grafton	St. Louis & Alton
2011	PAR	2	2.5	3	3.5	6
2010	PAR	2	2.5	3	3.5	6
2009	PAR	2	2.5	3	3.5	6
2008	PAR	2	2.5	3	3.5	6
2007	PAR	2	2.5	3	3.5	6
2006	PAR	2	2.5	3	3.5	6
2005	PAR	2	2.5	3	3.5	6
2004	PAR	2	2.5	3	3.5	6
2003	PAR	2	2.5	3	3.5	6
2002	PAR	2	2.5	3	3.5	6
2001	PAR	2	2.5	3	3.5	6
2000	PAR	2	2.5	3	3.5	6

Table 2. Soybean Futures Delivery Differentials (Cents/Bushel)

Territory						
Year	Illinois	Eastern	Eastern Iowa	Southwest	Northern	Western
2011	PAR	-.40	-1.00	.55	-1.25	-.05
2010	PAR	-.40	-.90	.45	-1.15	-.15
2009	PAR	-.30	-.70	.45	-.95	-.15
2008	PAR	-.20	-.50	.45	-.75	-.15
2007	PAR	-.10	-.30	.45	-.55	-.15
2006	PAR	-.10	-.10	.45	-.35	-.15
2005	PAR	-.20	0	.45	-.45	-.35
2004	PAR	-.30	.10	.35	-.55	-.35
2003	PAR	-.40	-.10	.15	-.55	-.55
2002	PAR	N/A	N/A	N/A	N/A	N/A
2001	PAR	N/A	N/A	N/A	N/A	N/A
2000	PAR	N/A	N/A	N/A	N/A	N/A

Table 3. Soybean Oil Futures Delivery Differentials (Cents/Pound)

Territory						
Year	Central	Northeast	Midsouth	Missouri	Eastern Iowa	Northern
2011	PAR	1.5	8.5	2	-2.5	-3.5
2010	PAR	1.5	8.5	2	-3.5	-3.5
2009	PAR	1.5	8.5	2	-3.5	-3.5
2008	PAR	1.5	8	1.5	-3.5	-3.5
2007	PAR	2	8	2.5	-3	-3
2006	PAR	3	8	2.5	-3	-2
2005	PAR	3	8	2.5	-3.5	-2
2004	PAR	2	7	1.5	-4	-3
2003	PAR	1.5	6.5	1	-4.5	-4
2002	PAR	N/A	N/A	N/A	N/A	N/A
2001	PAR	N/A	N/A	N/A	N/A	N/A
2000	PAR	N/A	N/A	N/A	N/A	N/A

Table 4. Soybean Meal Futures Delivery Differentials (Dollars/Ton)

Chicago Board of Trade Contract Storage Rates					
		Daily		**Monthly**	
Soybeans	11/1/2008 - Present	0.165	Cents/Bushel	4.95	Cents/Bushel
	11/1/2001 - 10/31/2008	0.15	Cents/Bushel	4.5	Cents/Bushel
	1/3/2000 - 10/31/2001	0.12	Cents/Bushel	3.6	Cents/Bushel
Soybean Oil	1/3/2000 - Present	0.003	Cents/Pound	0.09	Cents/Pound
Soybean Meal	1/3/2000 - Present	7	Cents/Ton	210	Cents/Ton

Table 5. Chicago Board of Trade Contract Storage Rates

CBOT Soybeans										
	CTD		Chicago		Illinois River, North of Peoria		Illinois River, South of Peoria		St. Louis	
Variable	**Coefficient**	**T-Stat**	**Coefficient**	**T-Stat**	**Coefficient**	**T-Stat**	**Coefficient**	**T-Stat**	**Coefficient**	**T-Stat**
Constant	-13.72	-0.41	-2.27	-0.20	2.95	0.07	16.33	0.91	11.51	0.52
Storage Rate	-3.64	-0.98	-3.47	-1.49	0.25	0.06	-4.61	-1.36	-4.45	-1.05
Inventory	8.40	1.21	4.44	**2.02**	-0.71	-0.06	-1.46	-0.47	-0.73	-0.18
Credit Spread	0.08	1.03	0.08	1.64	0.09	1.16	0.13	**2.13**	0.18	**2.17**
By Contract										
January	-6.87	-1.20	-2.24	-0.53	-9.30	-1.51	0.90	0.16	2.04	0.29
March	-5.94	-1.04	0.92	0.23	-8.03	-1.31	0.38	0.07	2.11	0.30
May	-8.55	-1.50	-3.64	-0.89	-10.98	-1.81	-1.00	-0.19	-0.20	-0.03
July	-14.04	-2.31	-15.43	-3.69	-7.52	-1.18	-3.07	-0.55	-7.21	-1.01
August	-32.11	-5.25	-15.71	-4.05	-24.72	-4.05	-24.77	-4.65	-21.02	-3.07
September	-2.42	-0.35			-9.94	-1.48				
November			-0.07	-0.02			9.81	1.70	12.02	1.61
Outlier/Dummy										
1-Jul-04	-139.36	-9.83	-123.20	-13.79	-140.81	-9.25	-149.00	-11.51	-150.09	-9.31
2-Sep-08			-22.28	-2.45						
1-Jul-09	-95.84	-6.67	-88.12	-9.68	-110.91	-7.21	-101.36	-7.73	-93.74	-5.75
1-Aug-09			-60.64	-6.72						
1-Sep-09	-33.71	-2.34	-33.74	-3.71	-91.15	-5.75	-44.69	-3.40	-24.14	-1.47
R-Square	0.77		0.89		0.74		0.80		0.73	
Sample Size	82		82		82		82		80	
T Test	**T-Stat**		**T-Stat**		**T-Stat**		**T-Stat**		**T-Stat**	
Storage Rate = -1	-0.98		-1.49		0.06		-1.36		-1.05	
Critical Value	+/-1.99		+/-1.99		+/-1.99		+/-1.99		+/-1.99	

Table 6. Soybean Wedge Regression Results

CBOT Soybean Oil								
	CTD		Central Territory		Northern Territory		Eastern Iowa Territory	
Variable	**Coefficient**	**T-Stat**	**Coefficient**	**T-Stat**	**Coefficient**	**T-Stat**	**Coefficient**	**T-Stat**
Intercept	-4.79	-2.45	-3.28	-2.72	-0.04	-0.01	2.48	0.30
Inventory	0.76	**2.43**	0.60	**2.66**	-0.01	-0.01	-0.41	-0.30
Credit Spread	0.00	-0.40	0.00	0.18	0.00	0.29	0.00	-0.26
By Contract								
Jan	-0.33	-1.80	-0.29	-1.69	0.03	0.08	-0.50	-1.53
March	0.23	1.26	0.19	1.13	0.51	1.38	0.64	2.03
May	-0.02	-0.12	-0.04	-0.22	0.00	-0.01	-0.08	-0.28
July	-0.23	-1.26	-0.21	-1.22	-0.35	-0.98	-0.10	-0.32
August	0.17	0.92	0.10	0.58	0.34	0.97	0.13	0.42
September					0.09	0.26	0.03	0.11
October	-0.04	-0.19	-0.04	-0.22	0.04	0.11	0.05	0.18
December	-0.16	-0.86	-0.16	-0.92				
R-Square	0.22		0.21		0.25		0.38	
Sample Size	85		85		35		35	

Table 7. Soybean Oil Wedge Regression Results

CBOT Soybean Meal								
	CTD		Illinois Territory		Missouri Territory		Eastern Iowa Territory	
Variable	**Coefficient**	**T-Stat**	**Coefficient**	**T-Stat**	**Coefficient**	**T-Stat**	**Coefficient**	**T-Stat**
Constant	-9.72	-2.38	-7.99	-1.91	-5.94	-1.09	-9.06	-1.26
Inventory	1.25	1.81	0.97	1.62	1.29	1.02	0.56	0.28
Credit Spread	0.03	0.48	0.02	0.49	0.06	0.85	6.76	0.95
By Contract								
January			0.89	0.18	1.50	0.23	3.63	0.41
March	2.34	0.52	3.22	0.68	1.39	0.21	5.29	0.61
May	3.52	0.79	4.88	1.04	2.81	0.44	6.85	0.75
July	-6.53	-1.45	-6.42	-1.37	-9.59	-1.49	-3.86	-0.45
August	5.41	1.19	3.11	0.66	7.22	1.13	12.78	1.55
September	-7.28	-1.47	-6.56	-1.32	-6.02	-0.90	-11.90	-1.31
October	1.23	0.25					3.79	0.46
December	2.53	0.52	1.38	0.29	1.50	0.23		
Outlier/Dummy								
1-Sep-09	-108.31	-11.02	-72.33	-7.52	-131.51	-10.18	-122.04	-8.88
R-Square	0.80		0.67		0.75		0.86	
Sample Size	61		61		61		35	

Table 8. Soybean Meal Wedge Regression Results

FIGURES

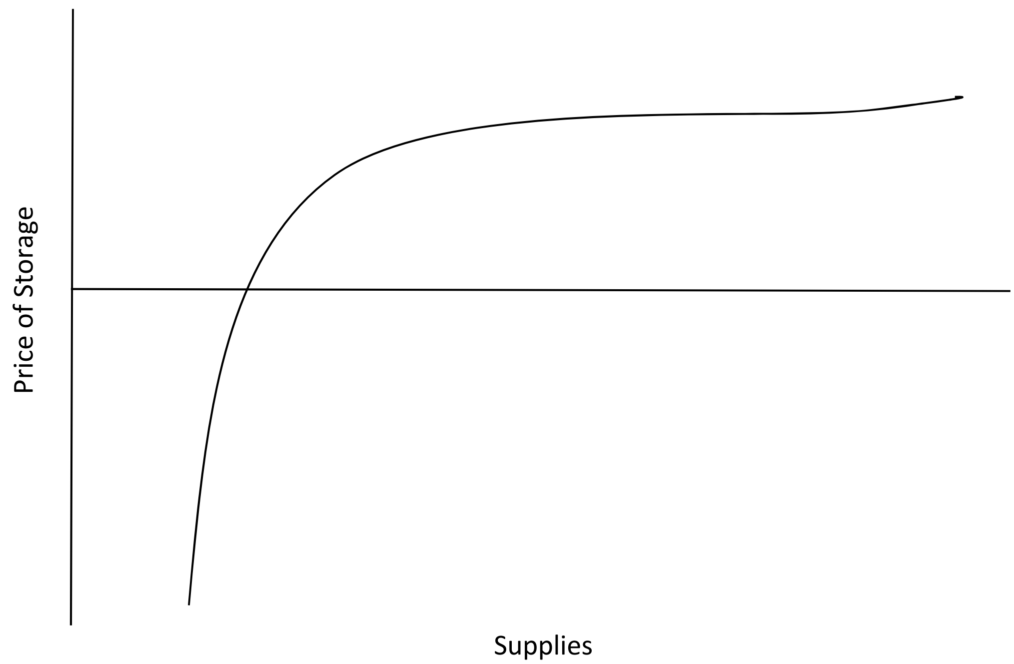


Figure 1. The Supply of Storage

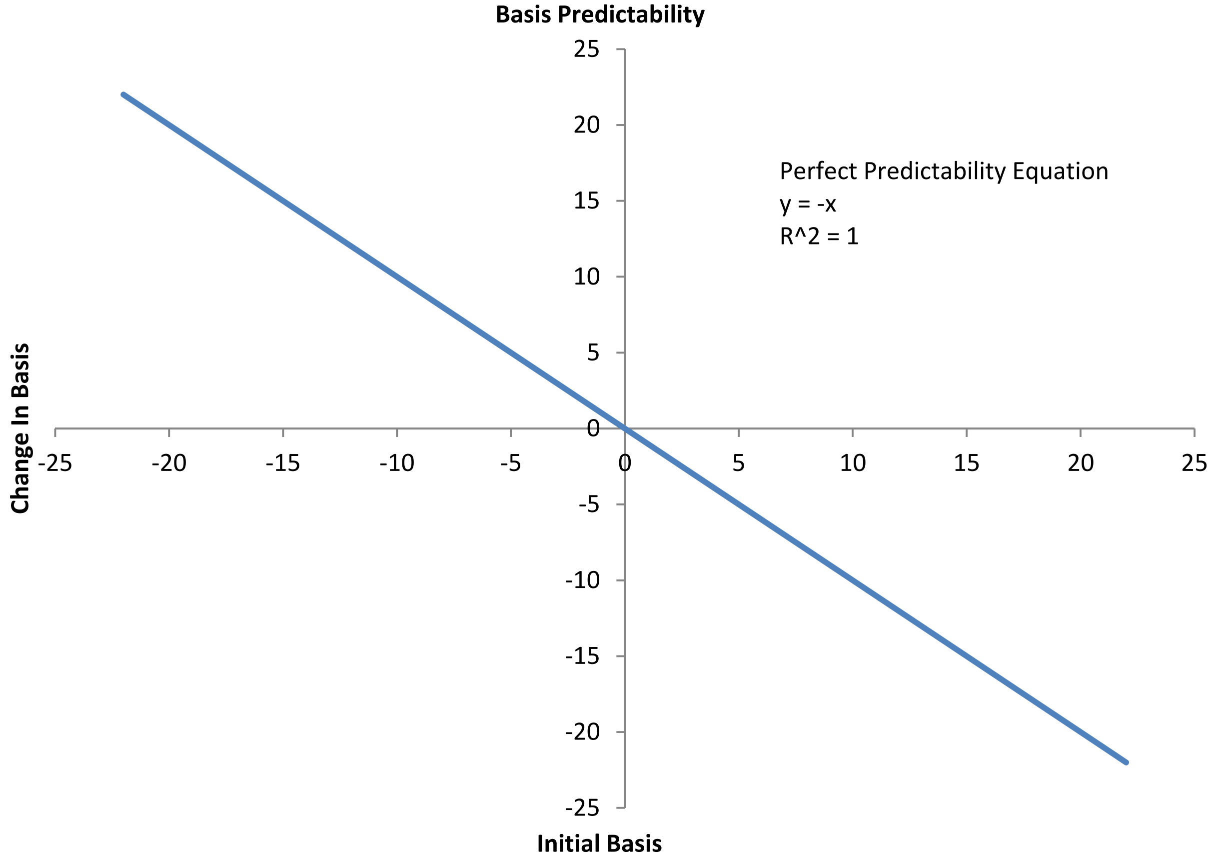


Figure 2. Perfect Predictability of the Basis

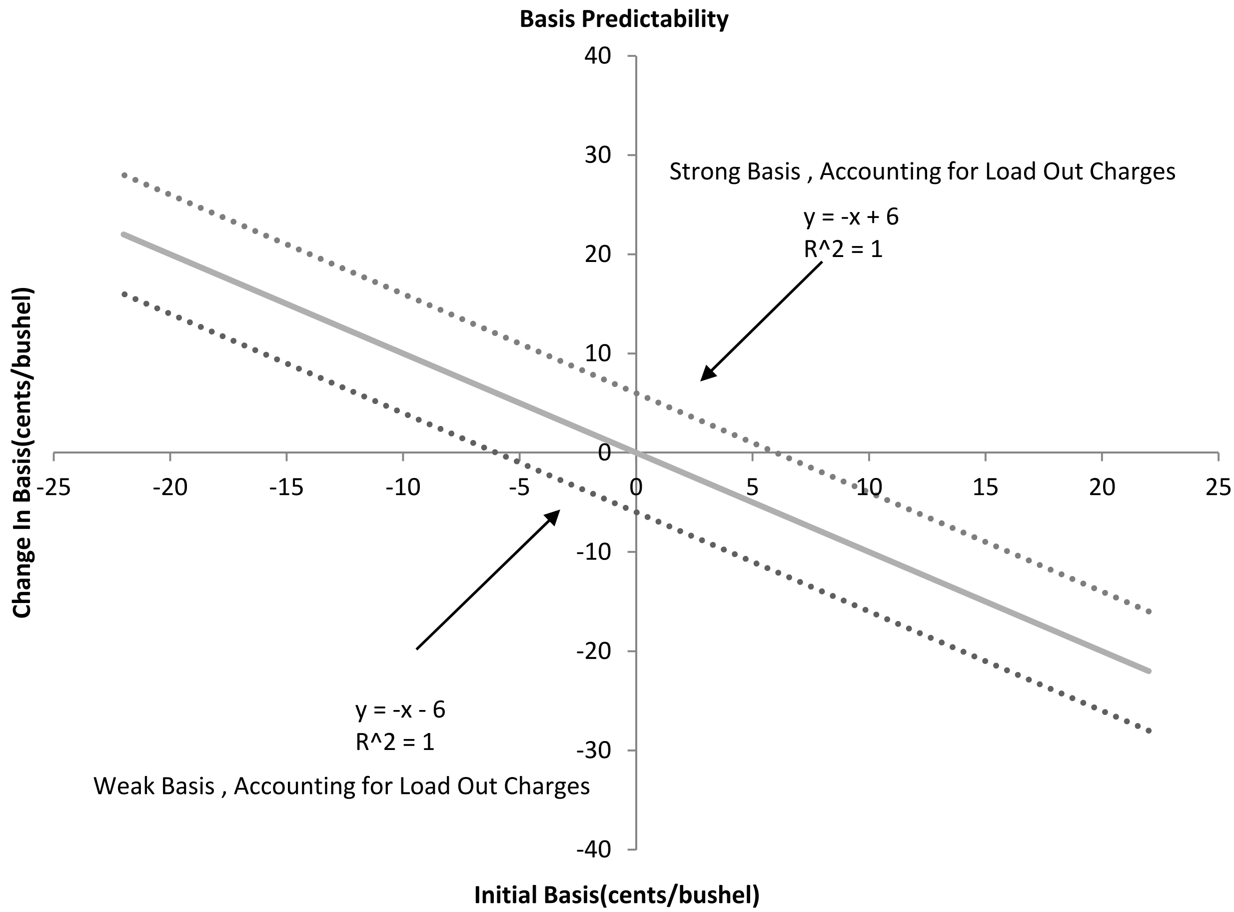


Figure 3. Perfect Predictability of the Basis With No-Arbitrage Bounds

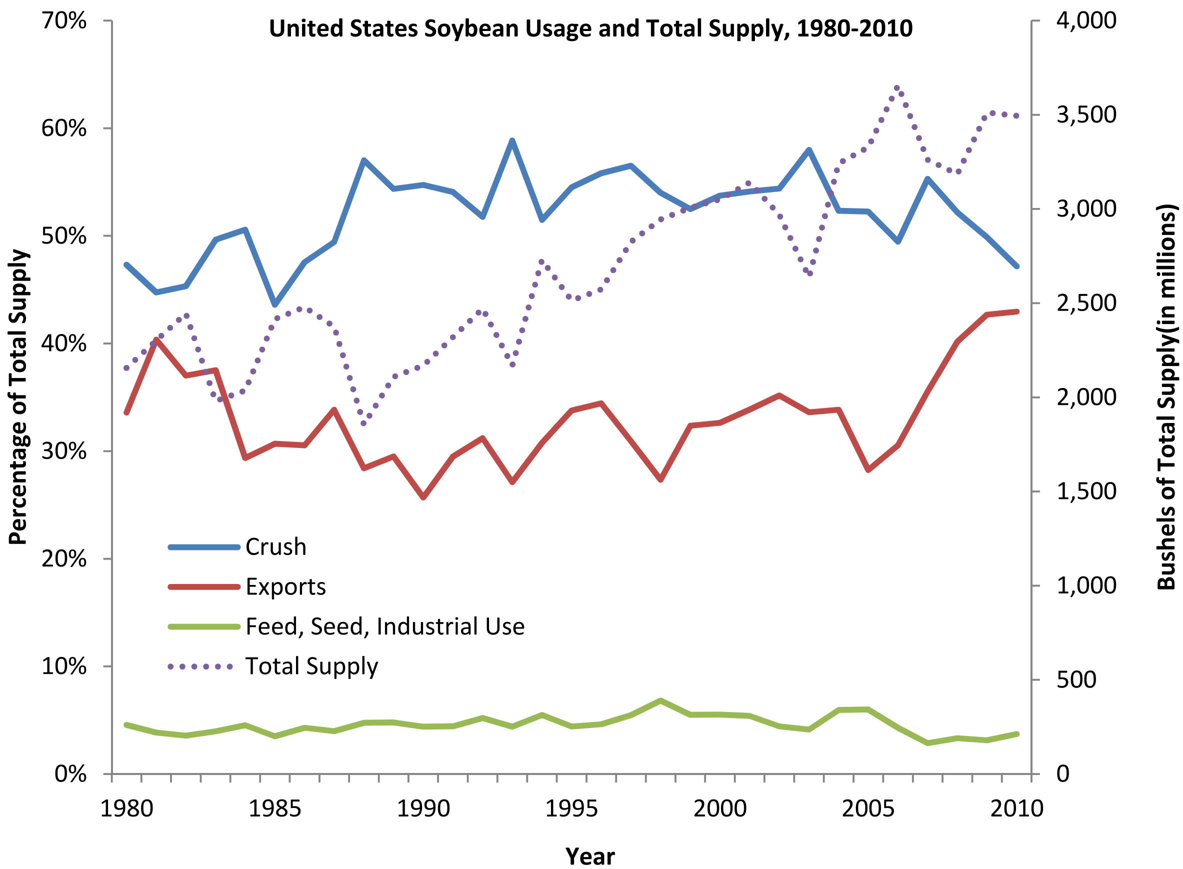


Figure 4. United States Soybean Usage and Total Supply, 1980-2010

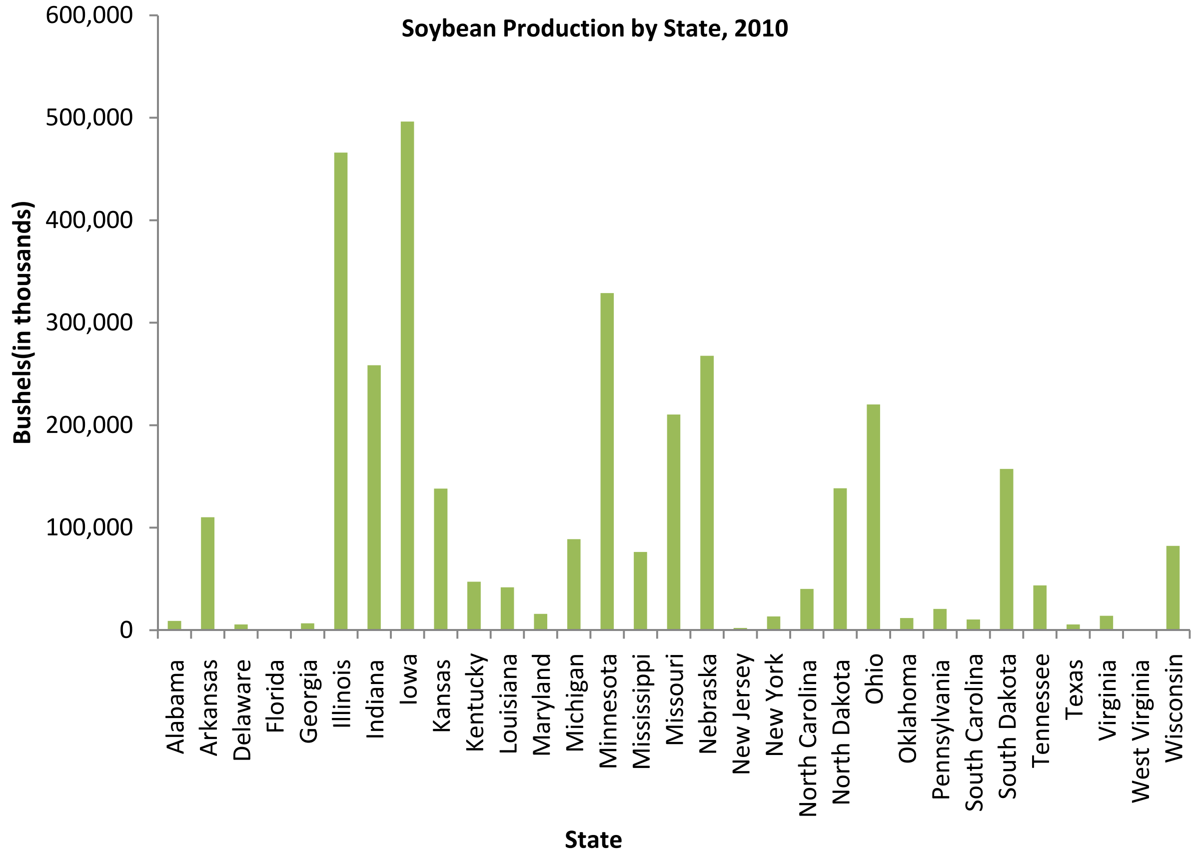


Figure 5. Soybean Production by State, 2010 Crop

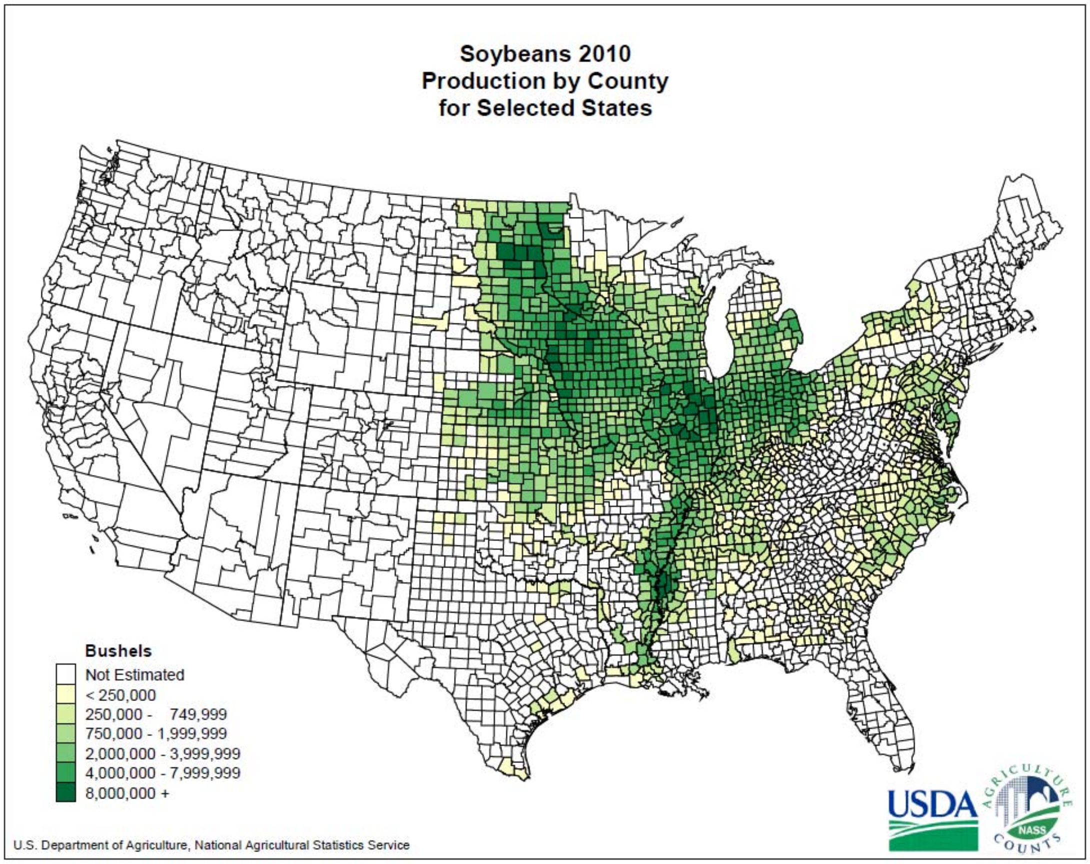


Figure 6. Soybean Production by County for Selected States, 2010 Crop

Source: United States Department of Agriculture

Soybean Oil

Illinois Territory
- Bloomington, Illinois
- Danville, Illinois
- Decatur, Illinois
- Galesburg, Illinois
- Gibson City, Illinois
- Quincy, Illinois

Eastern Territory
- Decatur, Indiana
- Frankfurt, Indiana
- Lafayette, Indiana
- Logansport, Indiana

Eastern Iowa Territory
- Ackley, Iowa
- Buffalo, Iowa
- Cedar Rapids, Iowa
- Cedar Rapids (East), Iowa
- Des Moines, Iowa
- Iowa Falls, Iowa
- Mason City, Iowa

Southwest Territory
- Kansas City, Missouri
- Mexico, Missouri
- St. Joseph, Missouri
- Emporia, Kansas

Northern Territory
- Dawson, Minnesota
- Mankato, Minnesota
- Volga, South Dakota

Western Territory
- Eagle Grove, Iowa
- Emmetsburg, Iowa
- Manning, Iowa
- Sergeant Bluff, Iowa
- Sheldon, Iowa
- Lincoln, Nebraska
- Omaha, Nebraska

Soybean Meal

Central Territory
- Bloomington, Illinois
- Cairo, Illinois
- Danville, Illinois
- Decatur, Illinois
- Galesburg, Illinois
- Gibson City, Illinois
- Quincy, Illinois
- Owensboro, Kentucky

Northeast Territory
- Bellevue, Ohio
- Claypool, Indiana
- Decatur, Indiana
- Fostoria, Ohio
- Frankfurt, Indiana
- Lafayette, Indiana
- Morristown, Indiana
- Mt. Vernon, Indiana
- Sidney, Ohio

Midsouth Territory
- Decatur, Alabama
- Guntersville, Alabama
- Little Rock, Arkansas
- Stuttgart, Arkansas

Missouri Territory
- Kansas City, Missouri
- Mexico, Missouri
- St. Joseph, Missouri

Eastern Iowa Territory
- Cedar Rapids (East), Iowa
- Des Moines, Iowa
- Iowa Falls, Iowa

Northern Territory
- Eagle Grove, Iowa
- Council Bluffs, Iowa
- Creston, Iowa
- Emmetsburg, Iowa
- Manning, Iowa
- Mason City, Iowa
- Sergeant Bluff, Iowa
- Sheldon, Iowa
- Sioux City, Iowa

Soybeans

- Chicago & Burns Harbor, Indiana Switching District
- Lockport-Seneca Shipping District
- Ottawa-Chillicothe Shipping District
- Peoria-Pekin Shipping District
- Havana-Grafton Shipping District
- St. Louis - E. St. Louis and Alton Shipping Districts

Figure 7. Soybean Futures Complex - Deliverable Locations

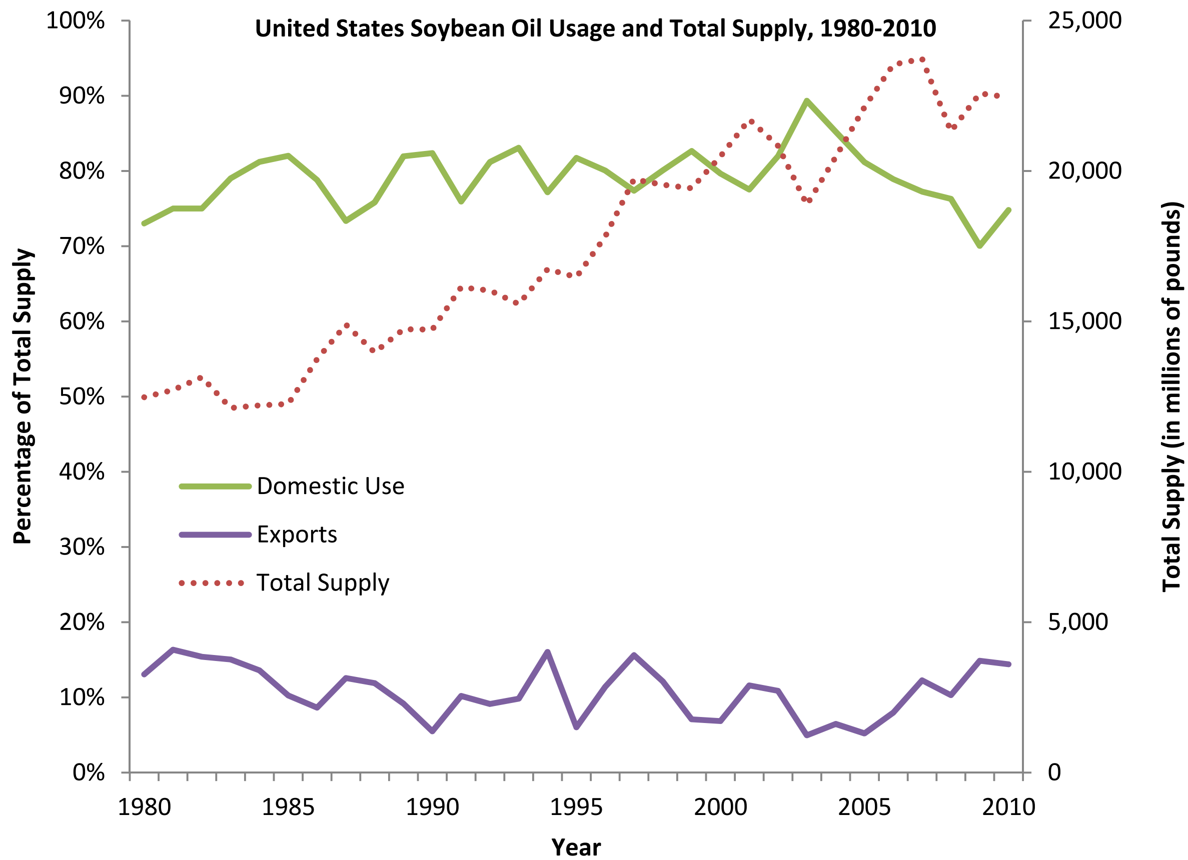


Figure 8. United States Soybean Oil Usage and Total Supply, 1980-2010

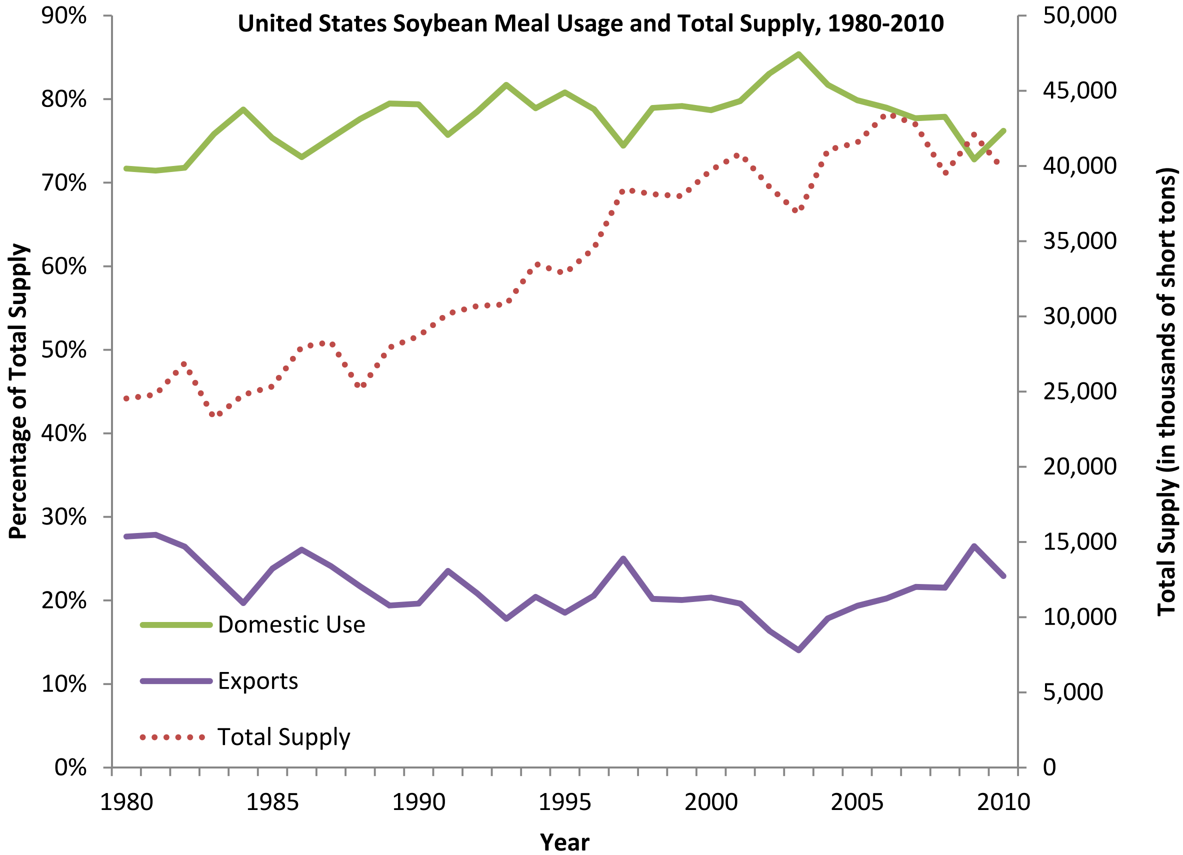
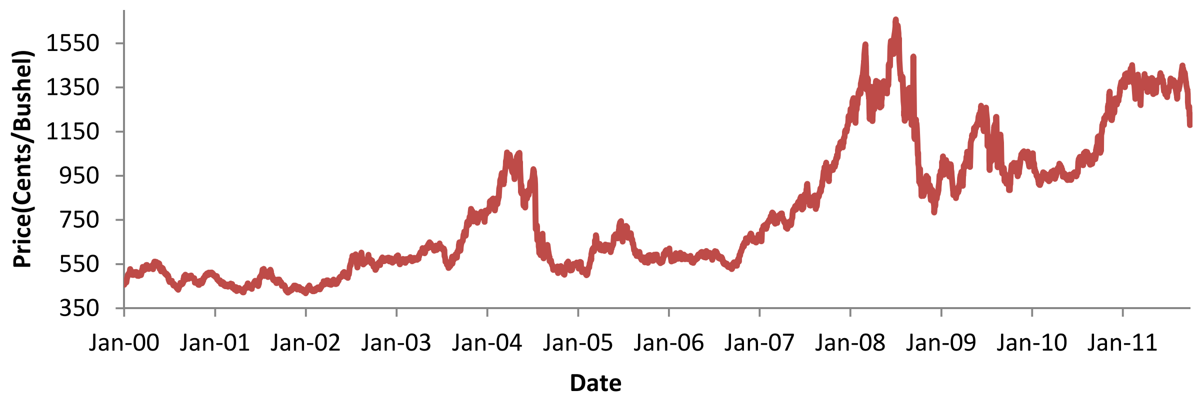
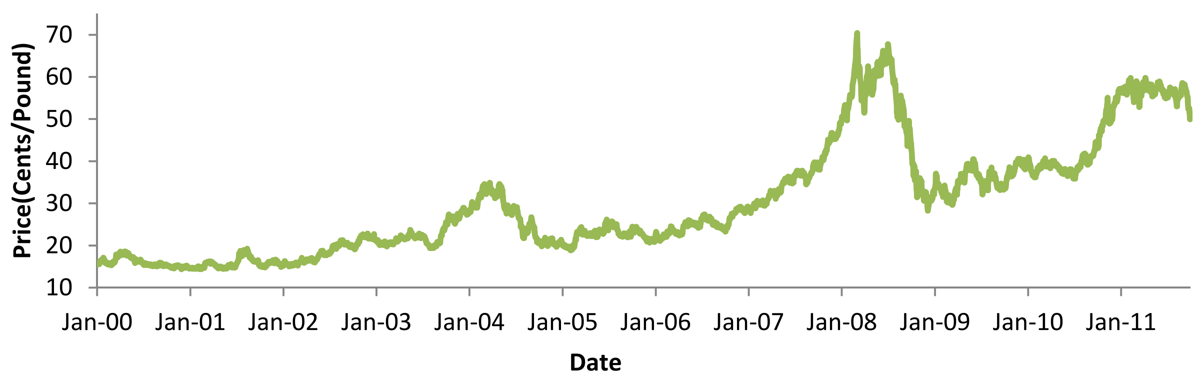


Figure 9. United States Soybean Meal Usage and Total Supply, 1980-2010

Soybean Futures Prices, January 2000 - September 2011



Soybean Oil Prices, January 2000 - September 2011



Soybean Meal Futures Price, January 2000 - September 2011

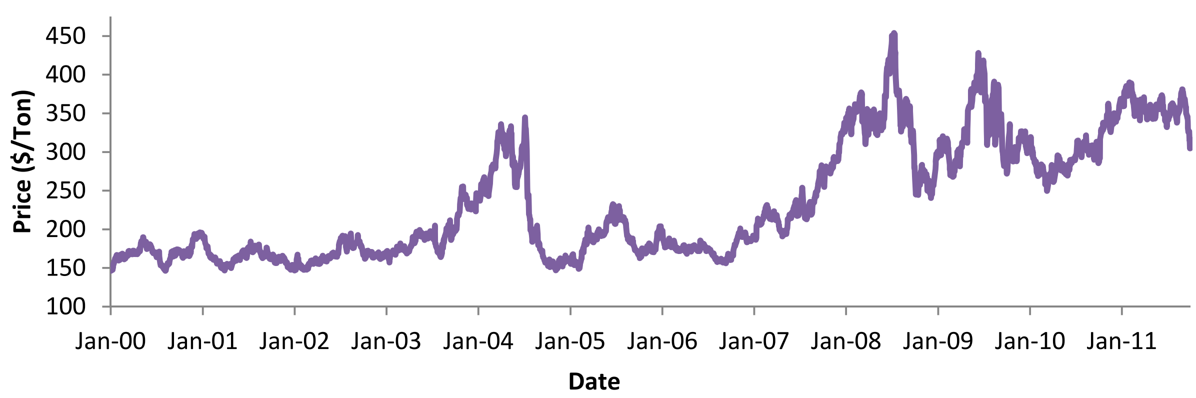
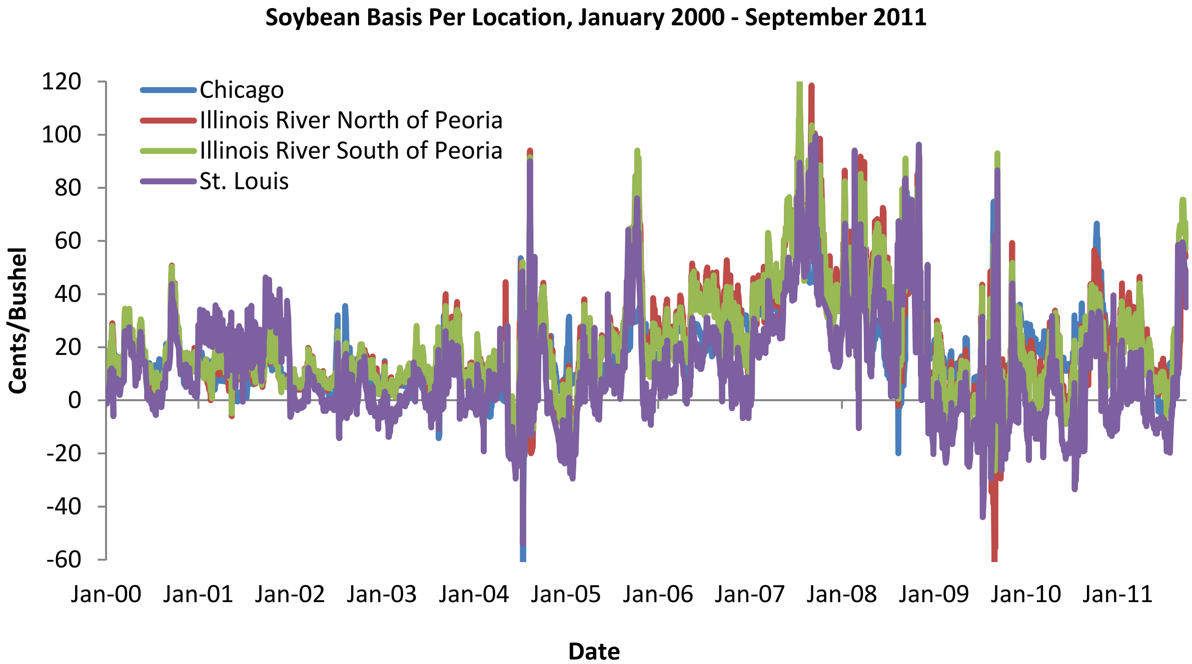


Figure 10. Price History, Soybean Futures Complex, January 2000 - September 2011



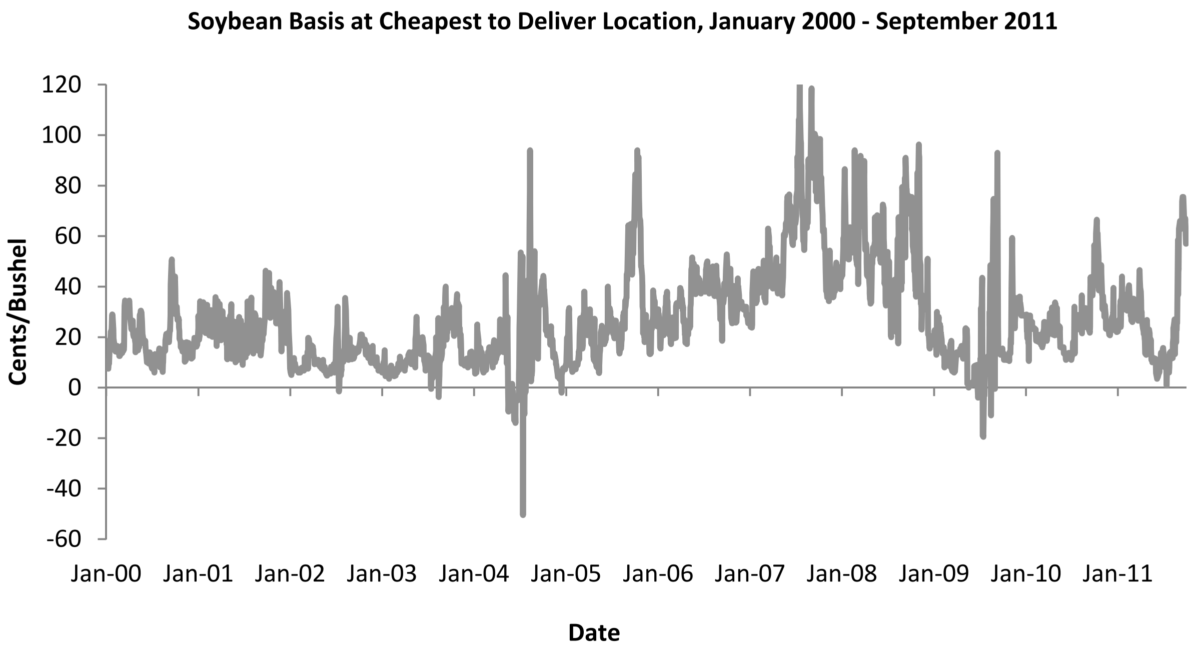
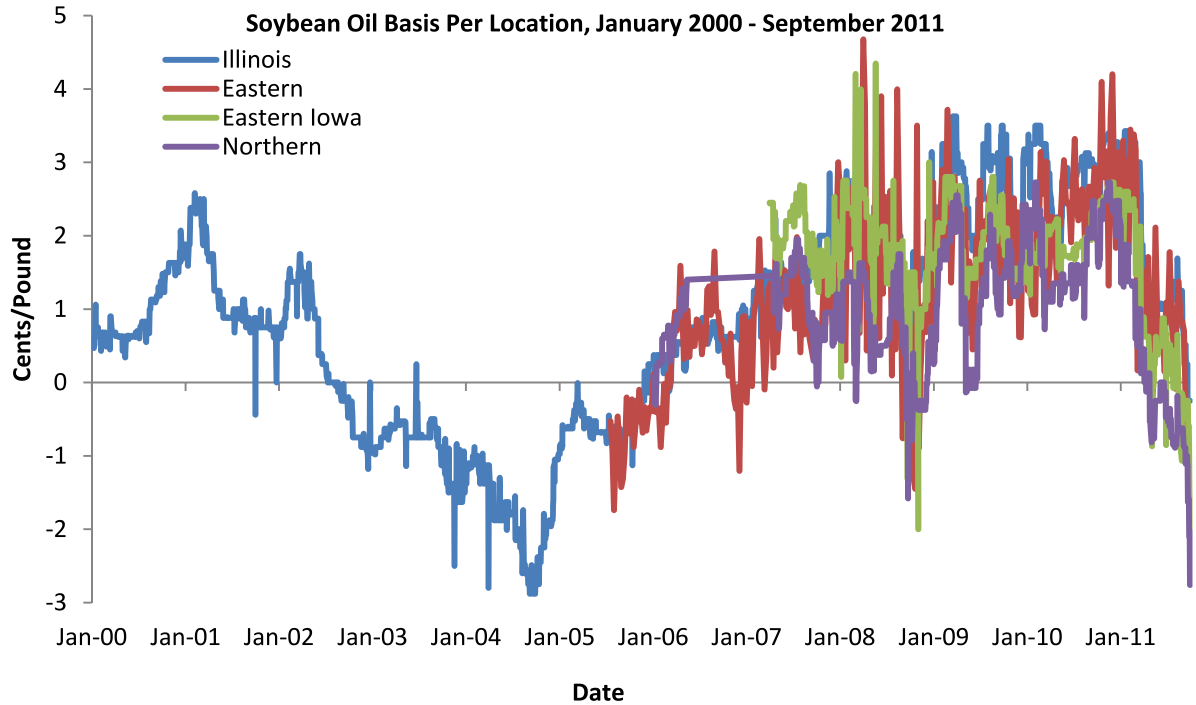


Figure 11. Soybean Basis, January 2000 – September 2011



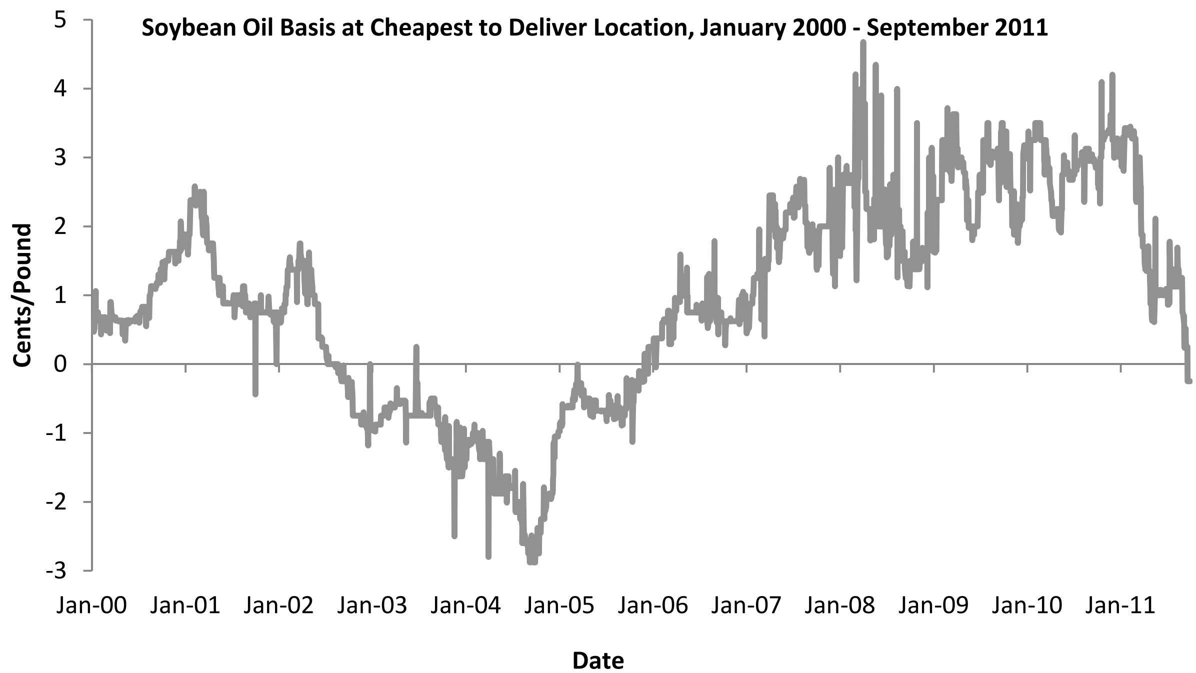
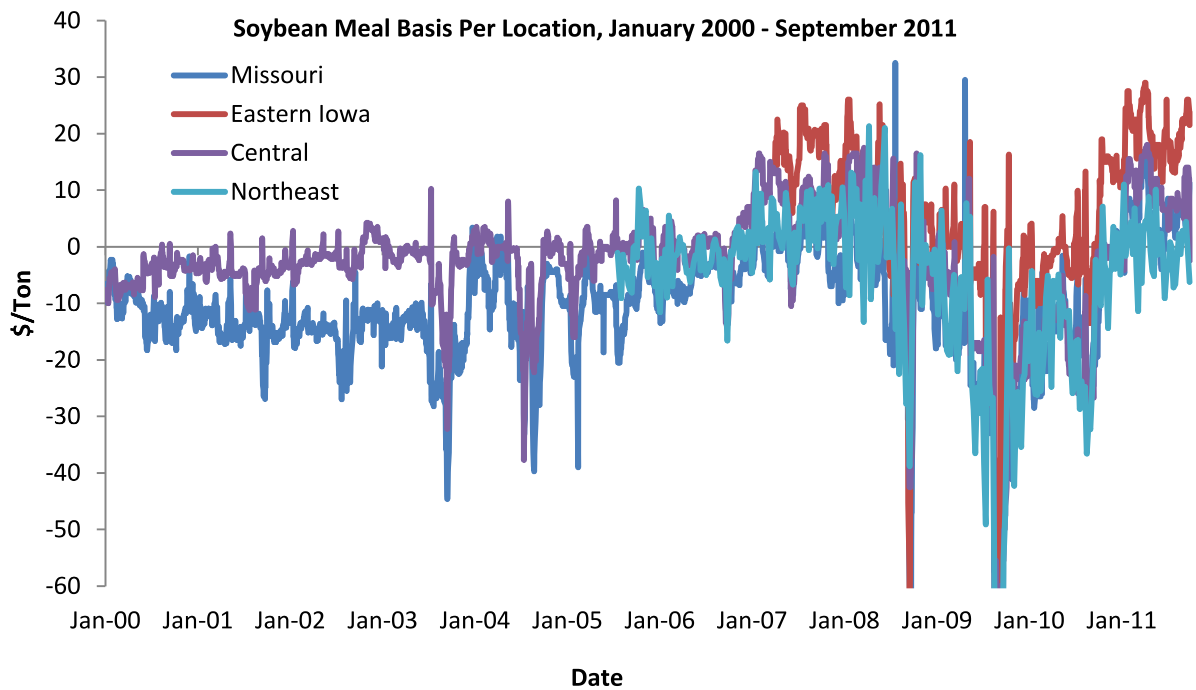


Figure 12. Soybean Oil Basis, January 2000 – September 2011



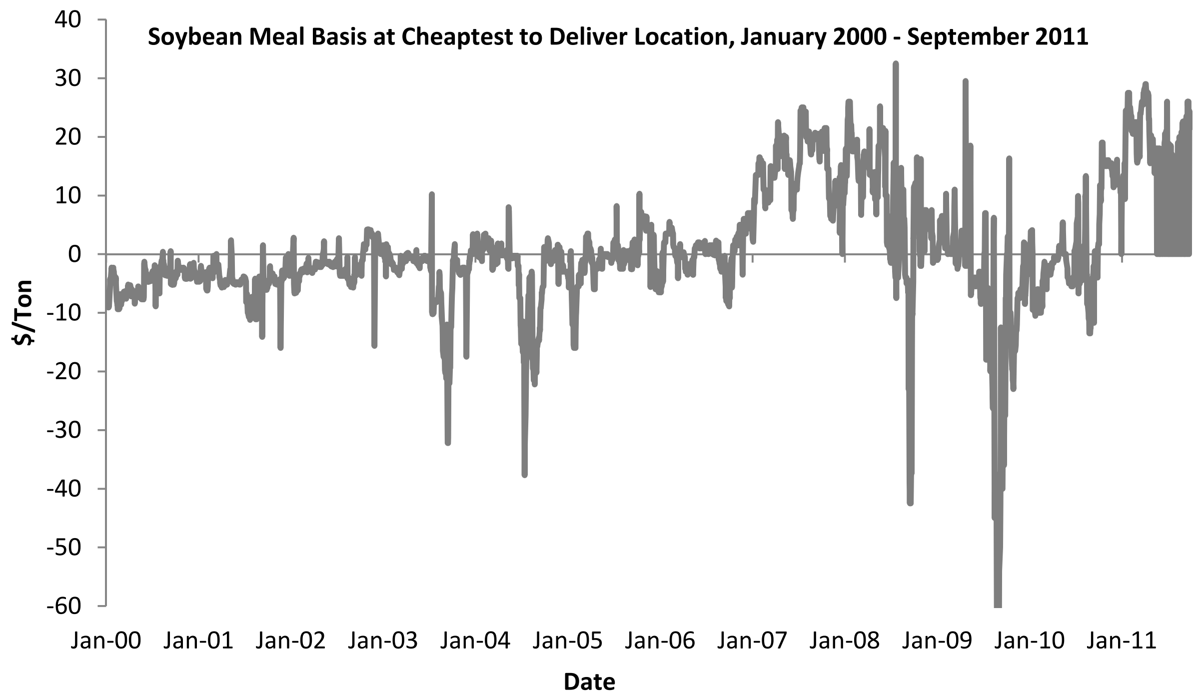


Figure 13. Soybean Meal Basis, January 2000 – September 2011

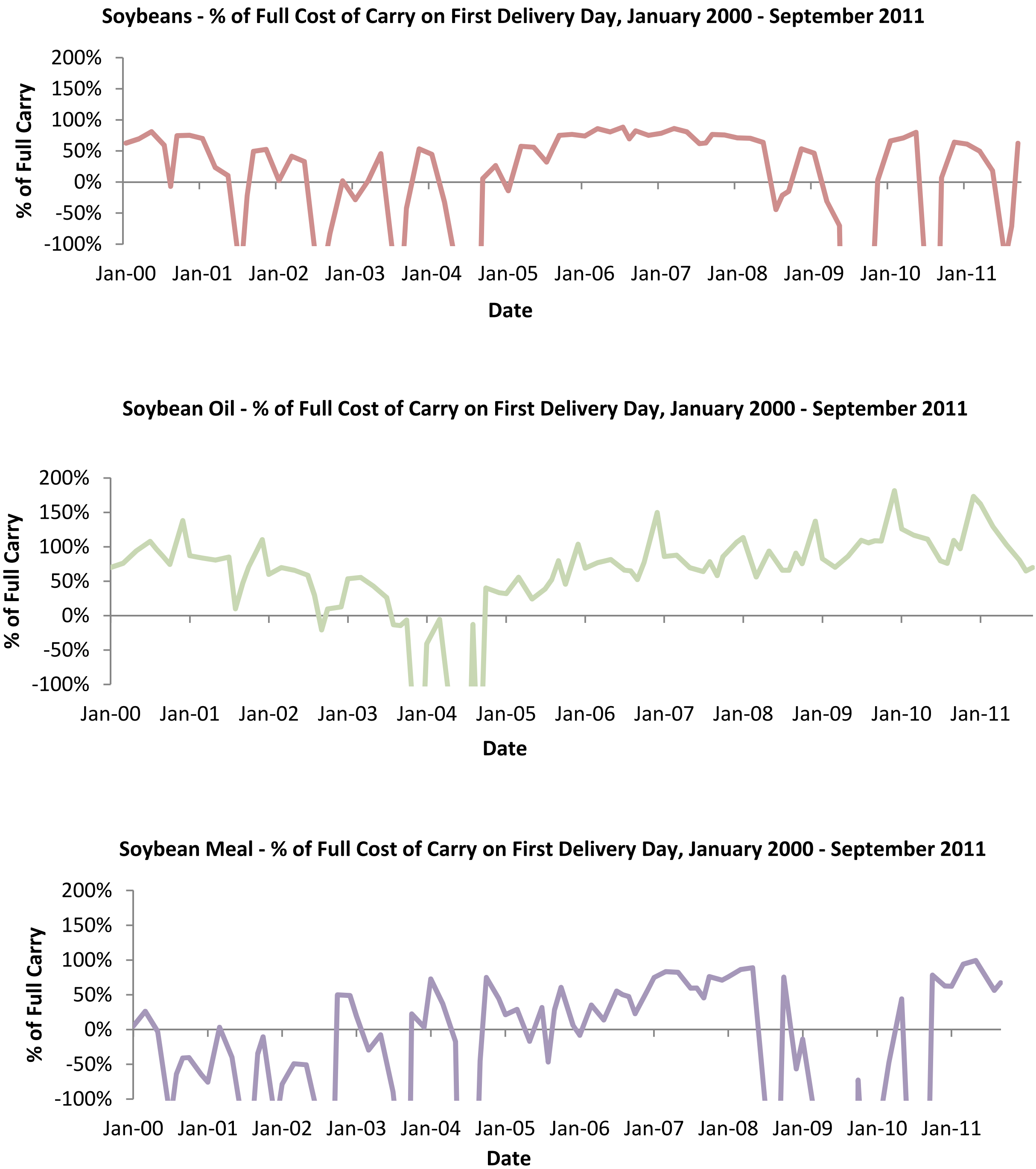


Figure 14. Soybean Futures Complex Cost of Carry, January 2000 – September 2011

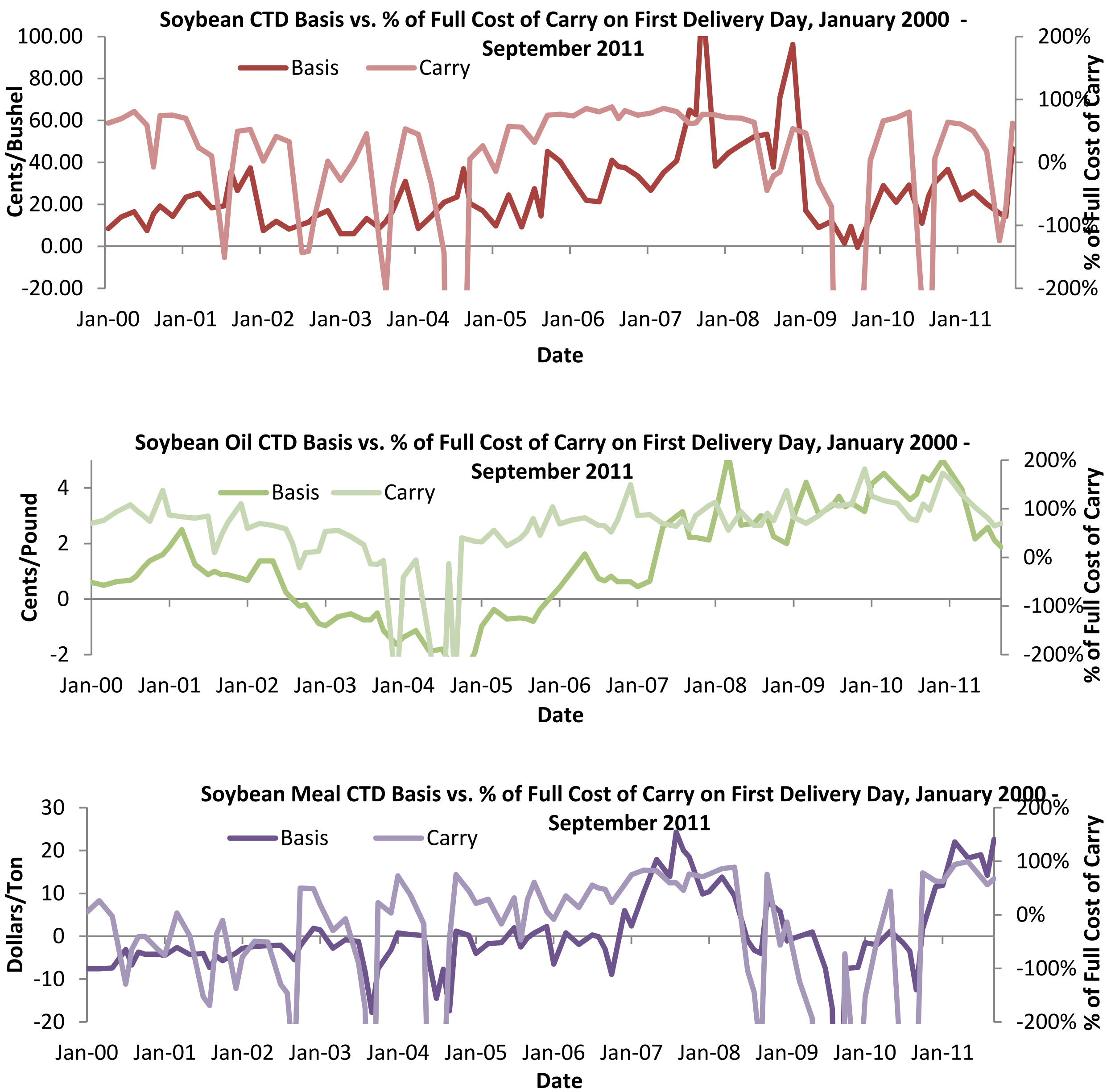


Figure 15. Cheapest to Deliver Basis vs. Carry on First Delivery Day, January 2000 – September 2011

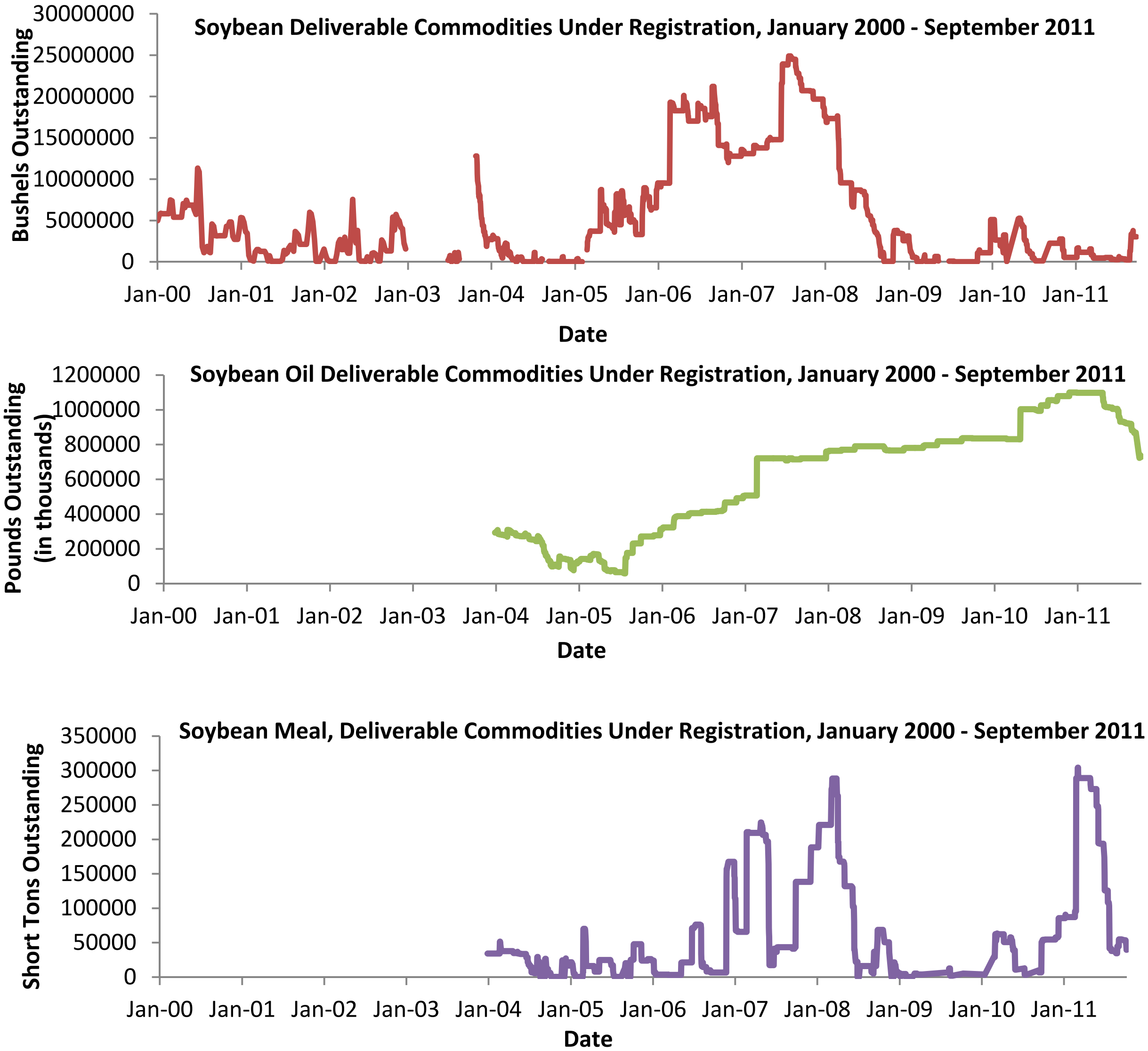


Figure 16. Deliverable Commodities Under Registration, January 2000 – September 2011

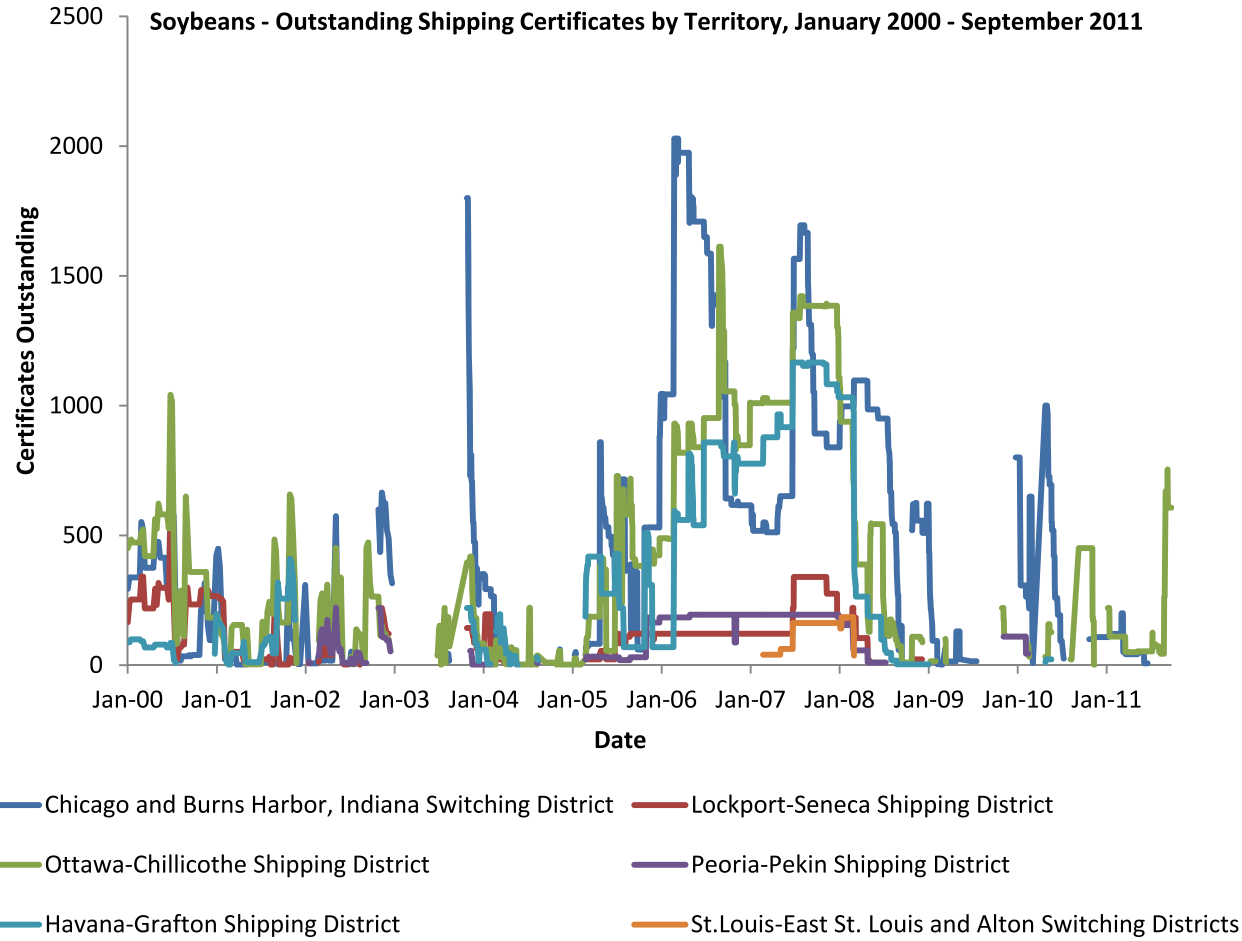


Figure 17. Soybean Shipping Certificates Outstanding by Territory, January 2000 – September 2011

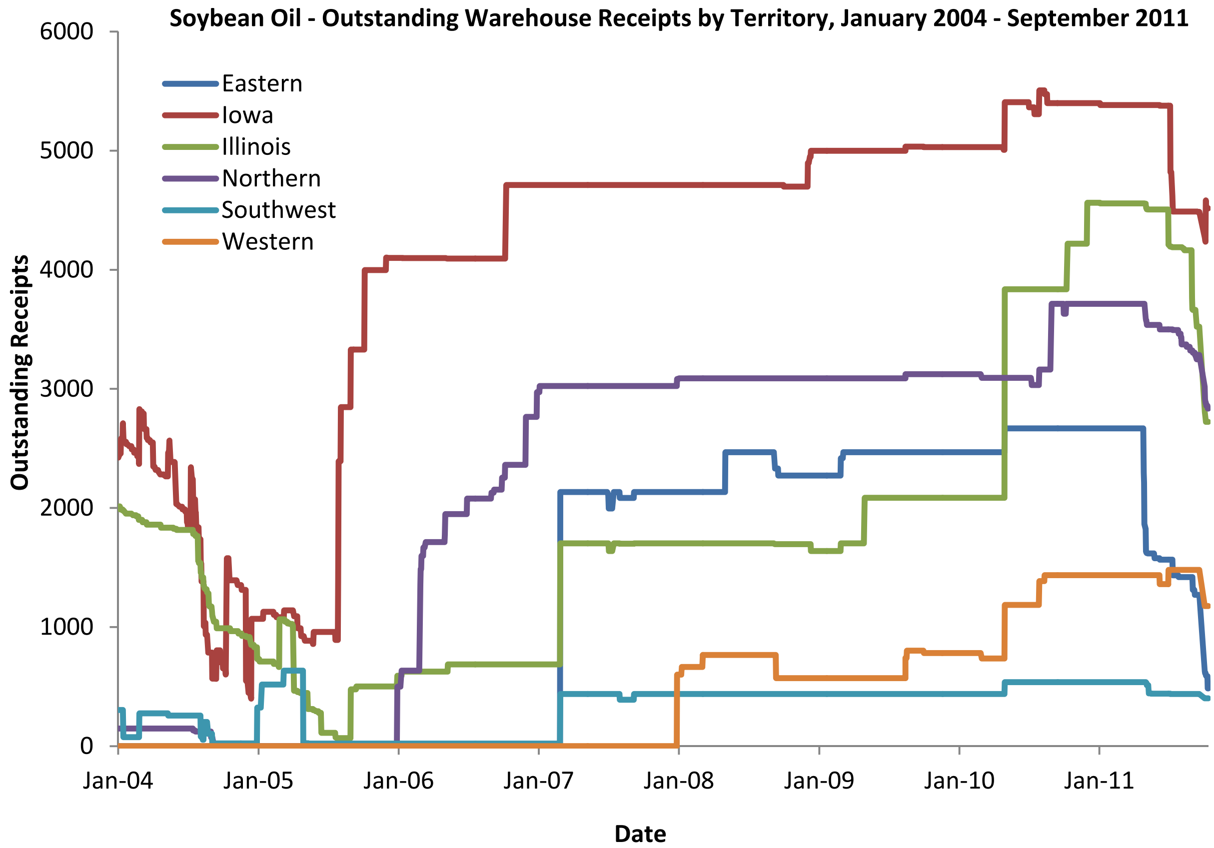


Figure 18. Soybean Oil Warehouse Receipts Outstanding by Territory, January 2004 – September 2011

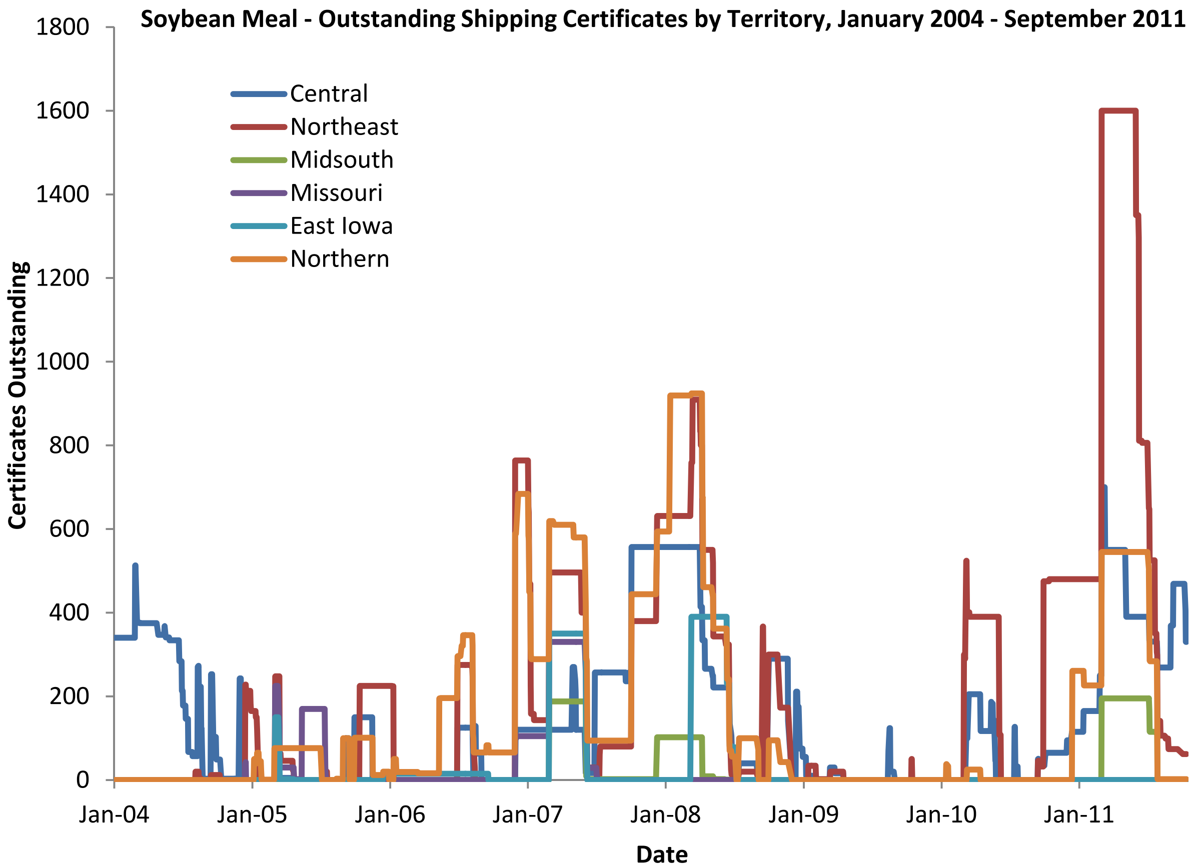


Figure 19. Soybean Meal Shipping Certificates Outstanding by Territory, January 2004 – September 2011

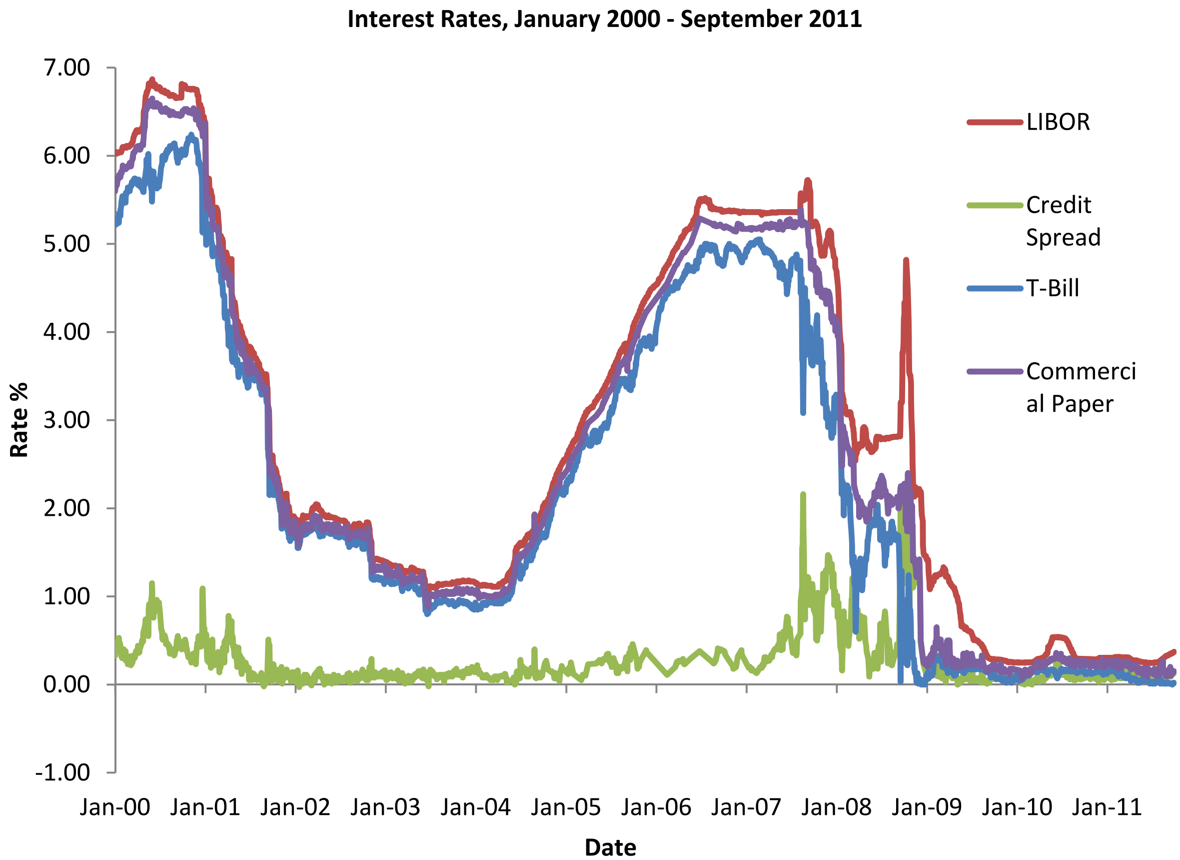


Figure 20. Interest Rates, January 2000 – September 2011

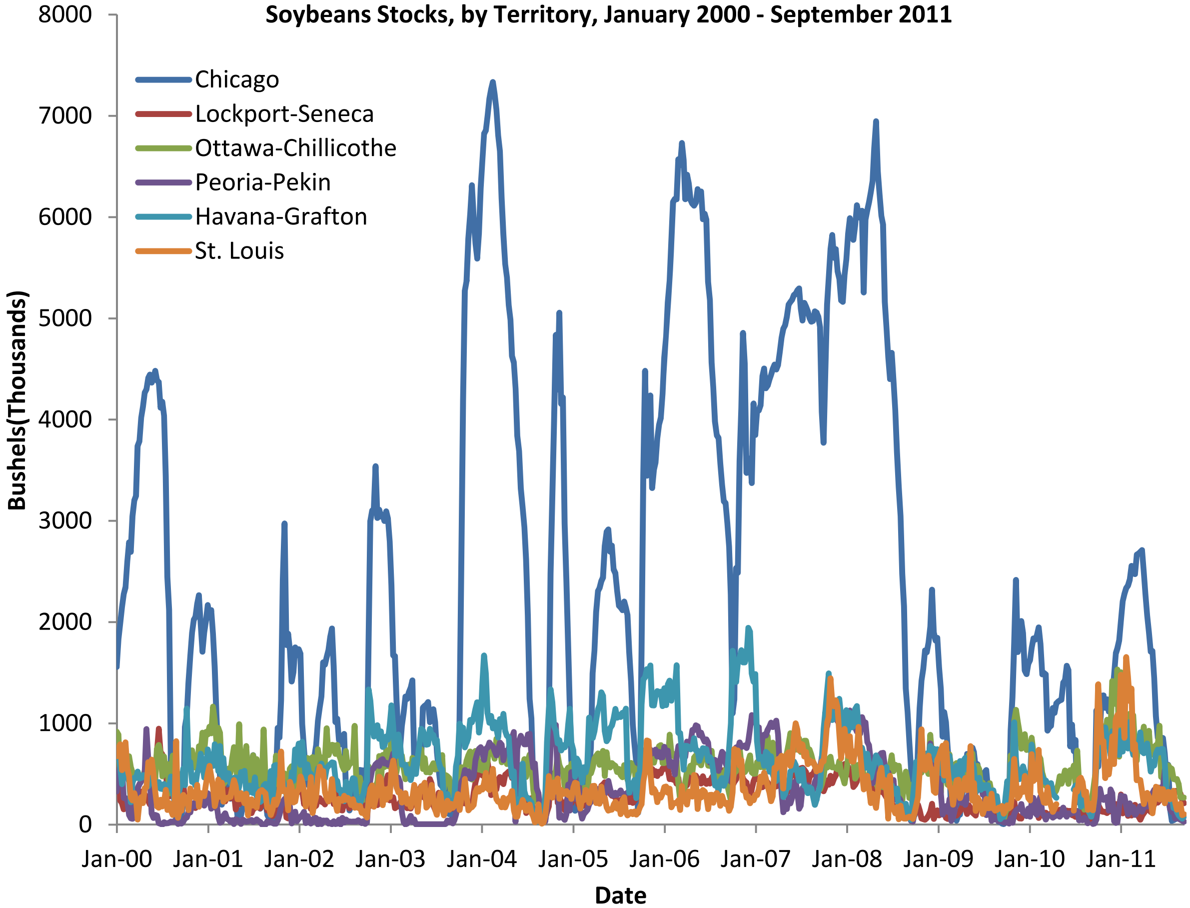


Figure 21. Soybean Deliverable Stocks by Territory, January 2000 – September 2011

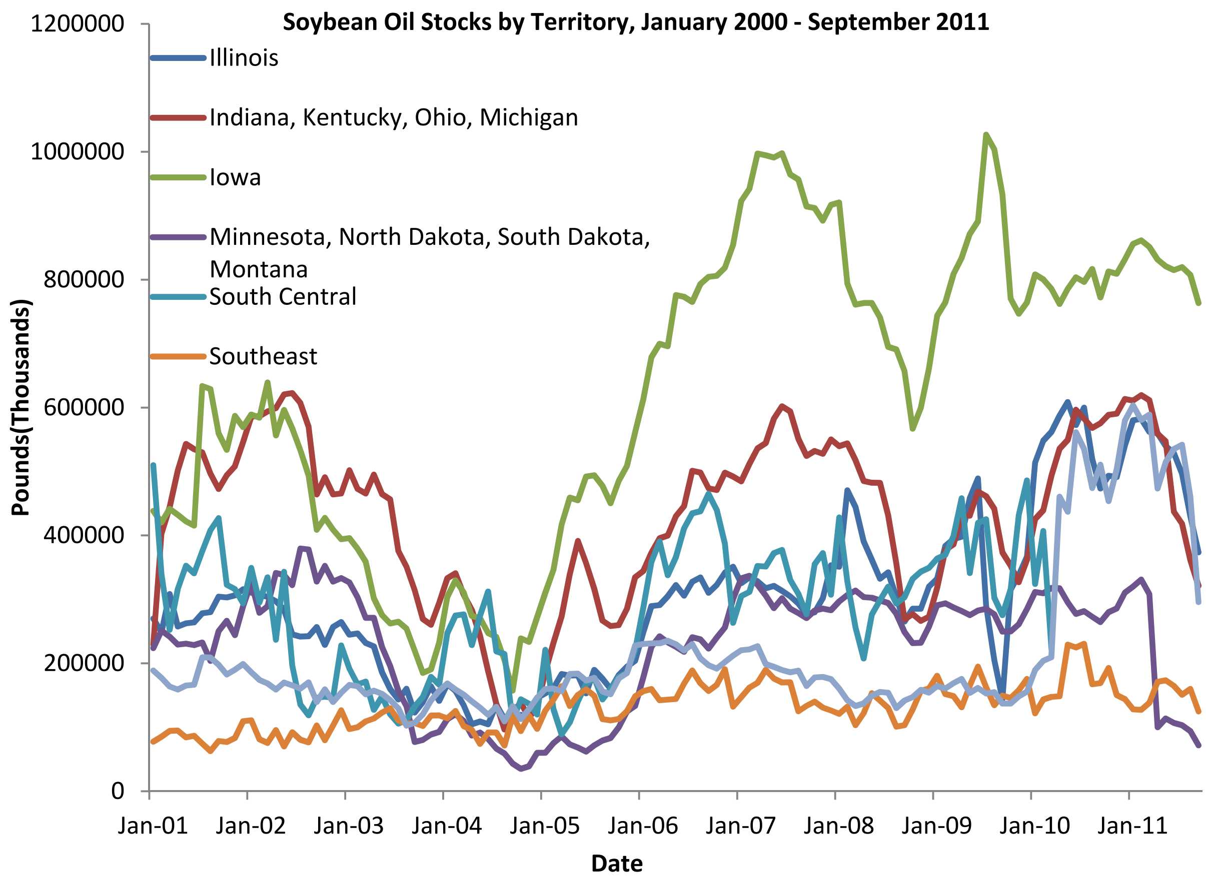


Figure 22. Soybean Oil Stocks by Territory, January 2001 – September 2011

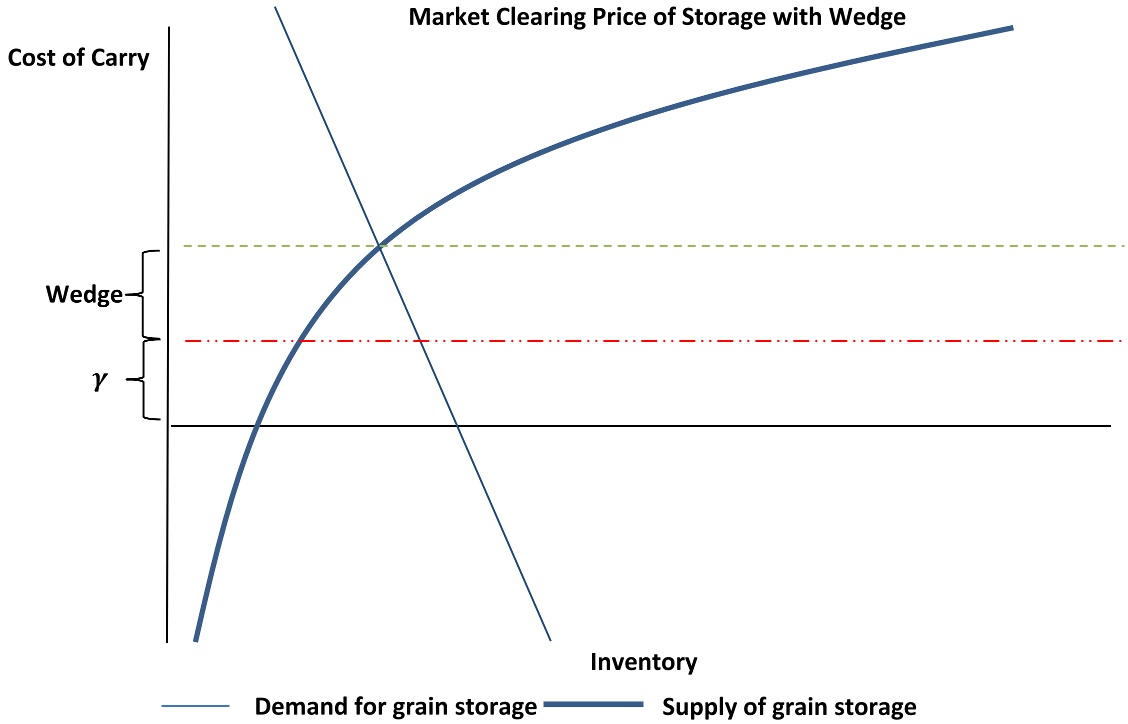


Figure 23. Market Clearing Price of Storage with Wedge

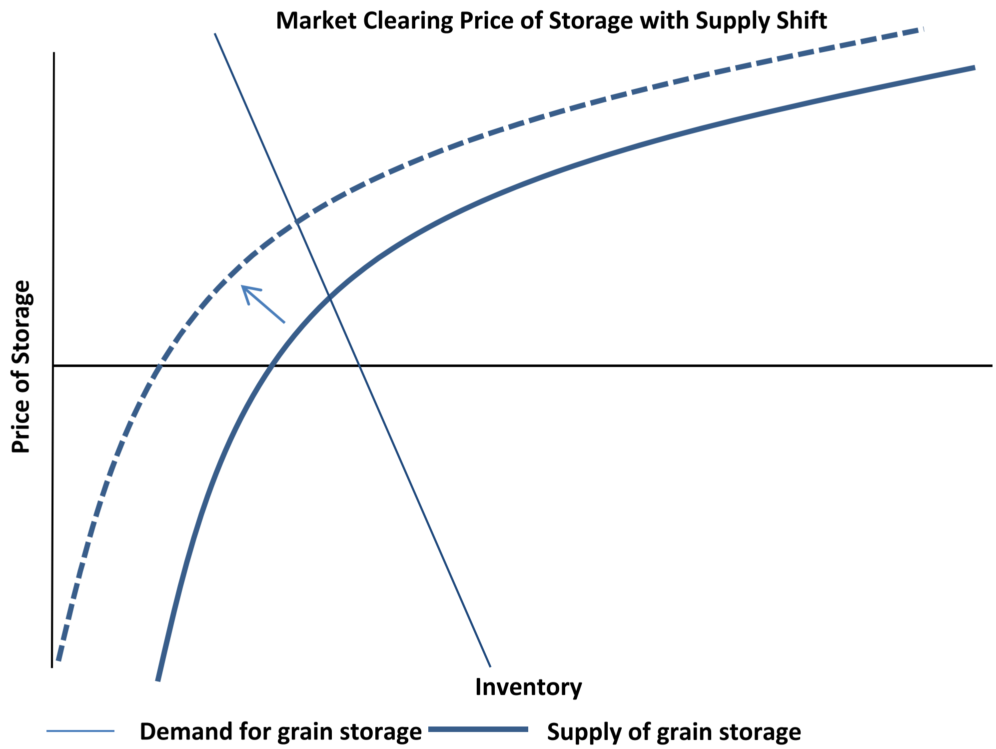


Figure 24. Market Clearing Price of Storage with Supply Shift

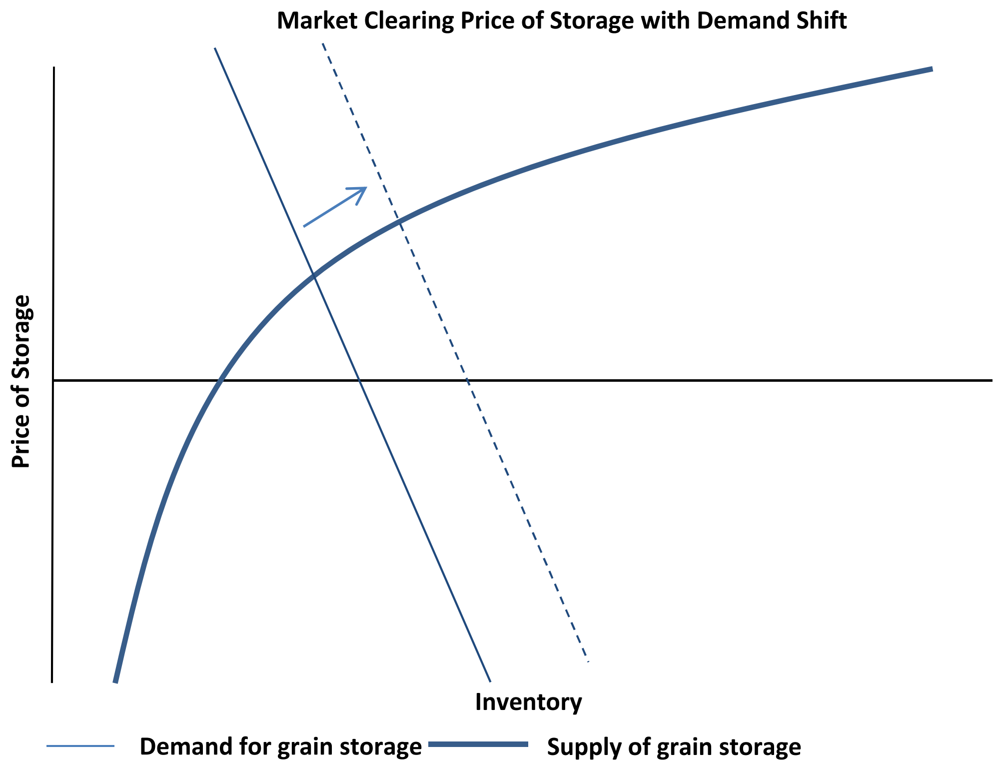
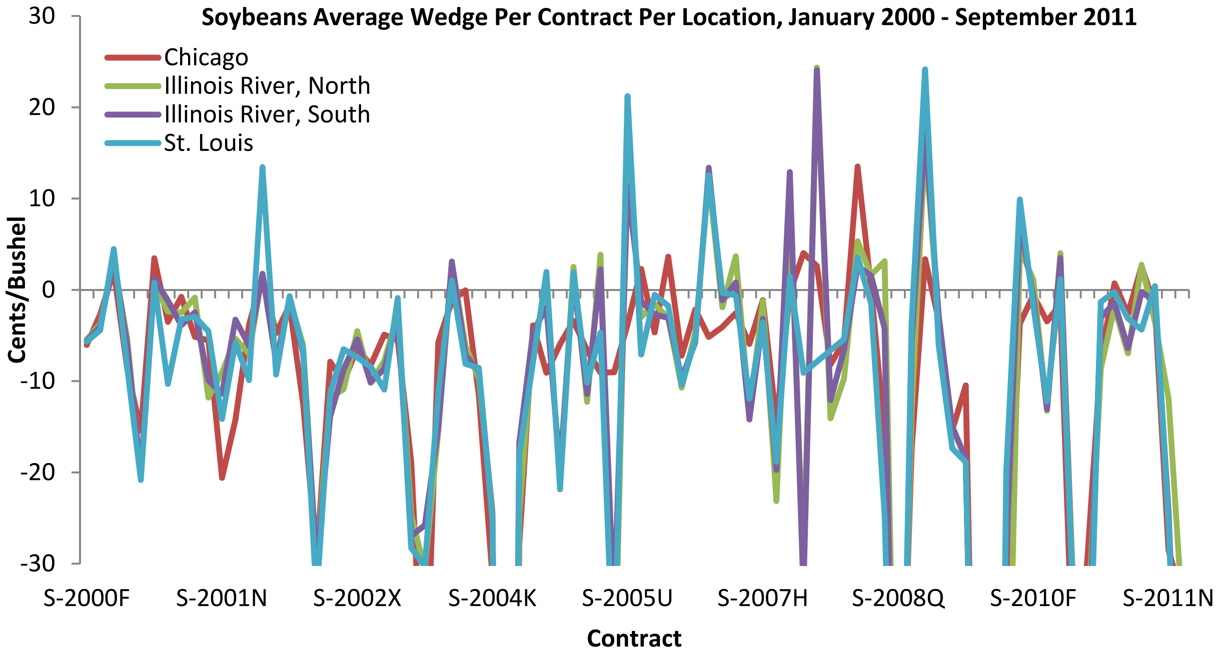


Figure 25. Market Clearing Price of Storage with Demand Shift



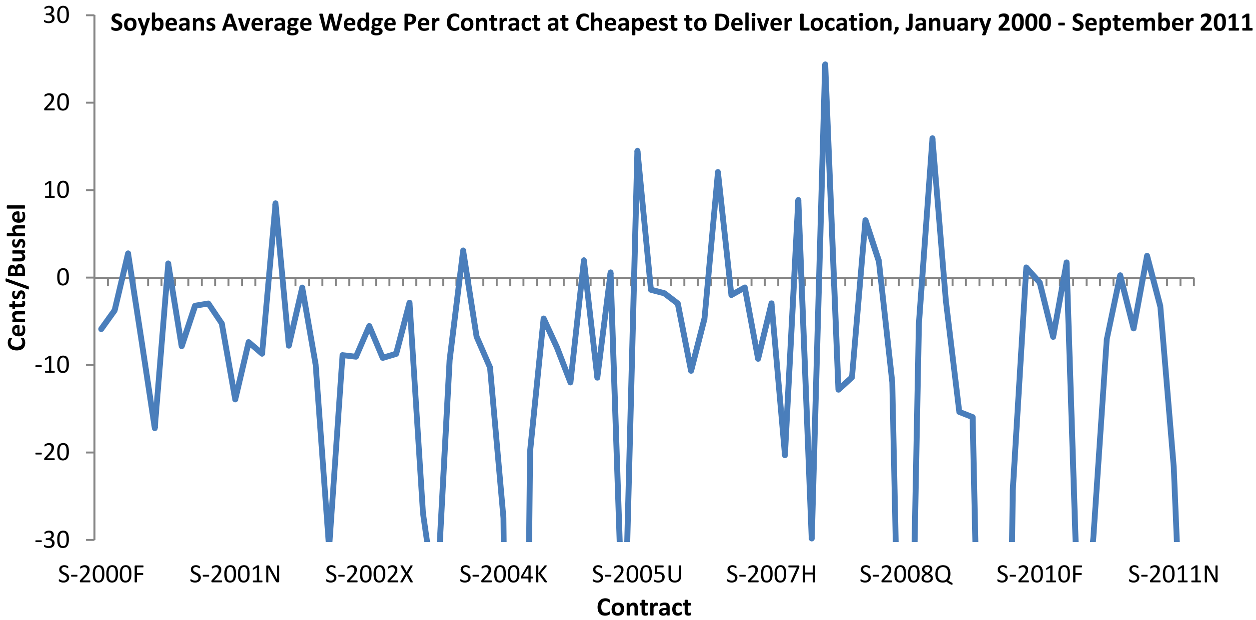
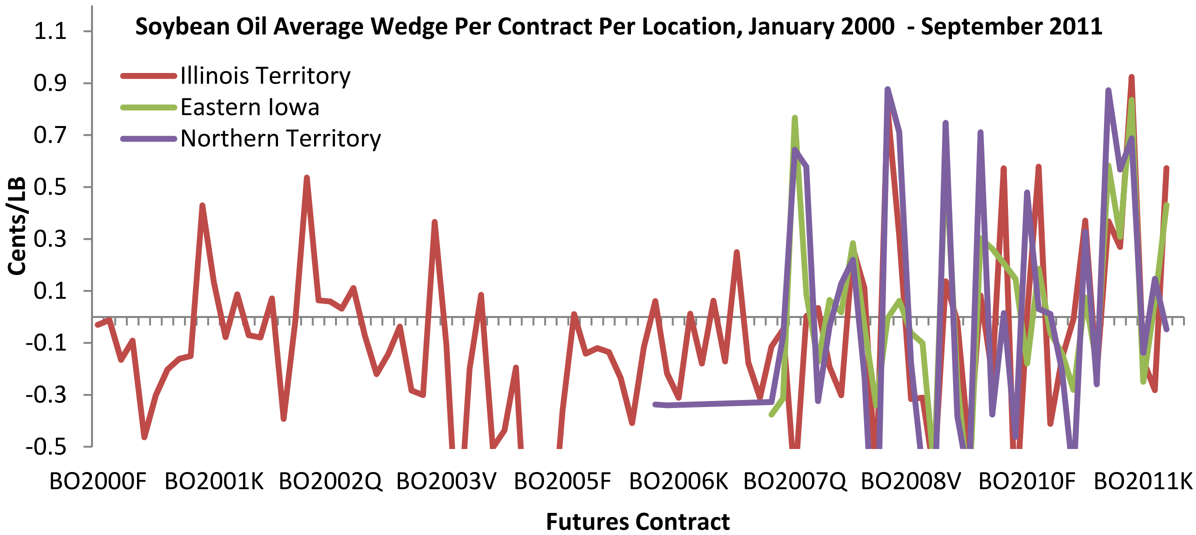


Figure 26. Soybean Average Wedge Per Contract, January 2000 – September 2011



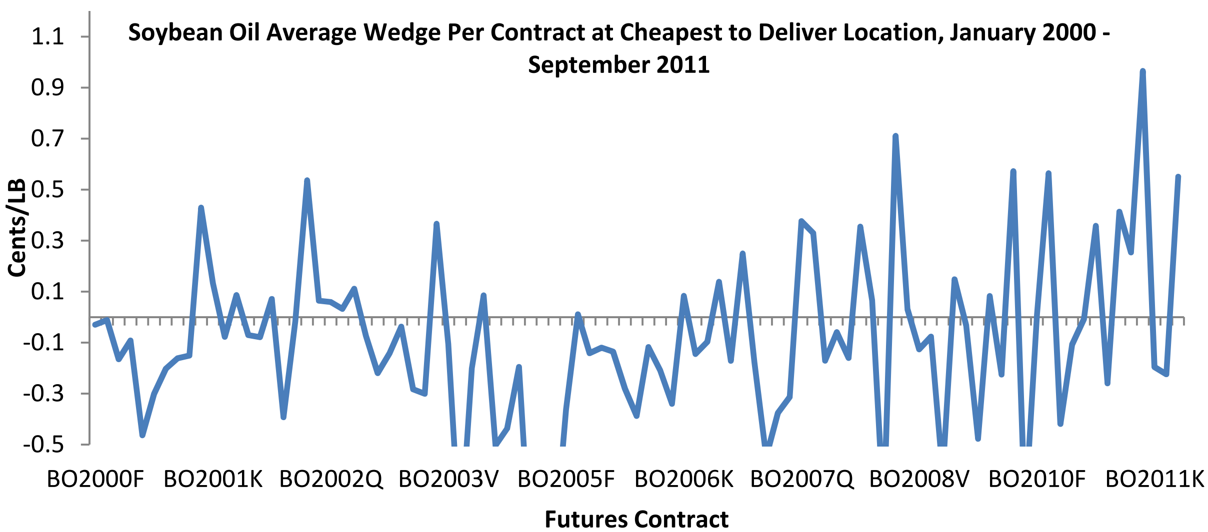
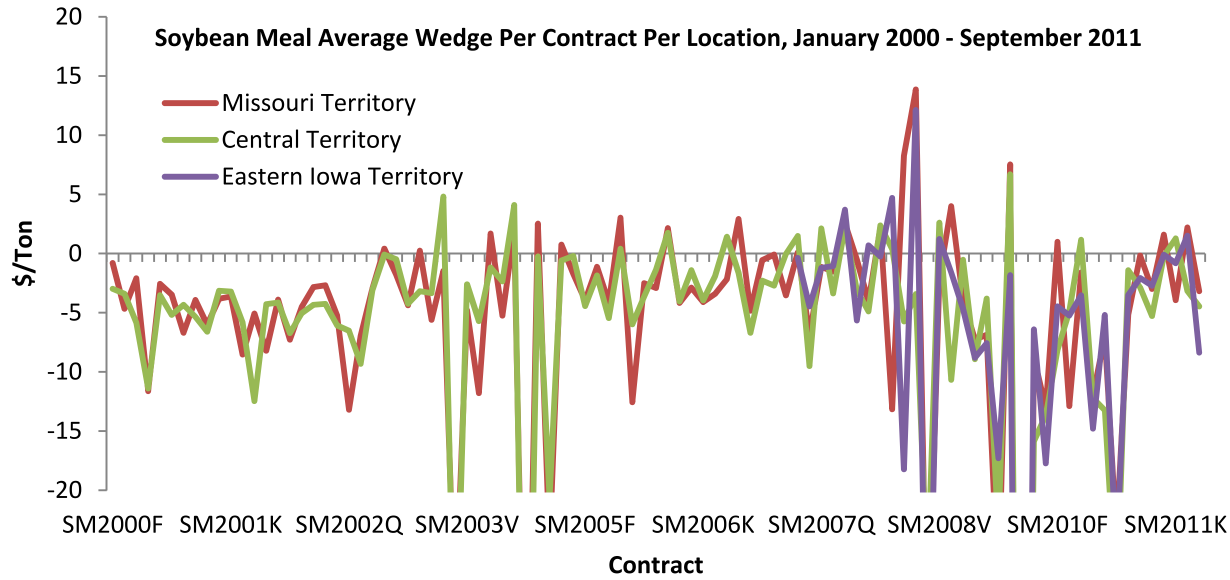


Figure 27. Soybean Oil Average Wedge Per Contract, January 2000 – September 2011



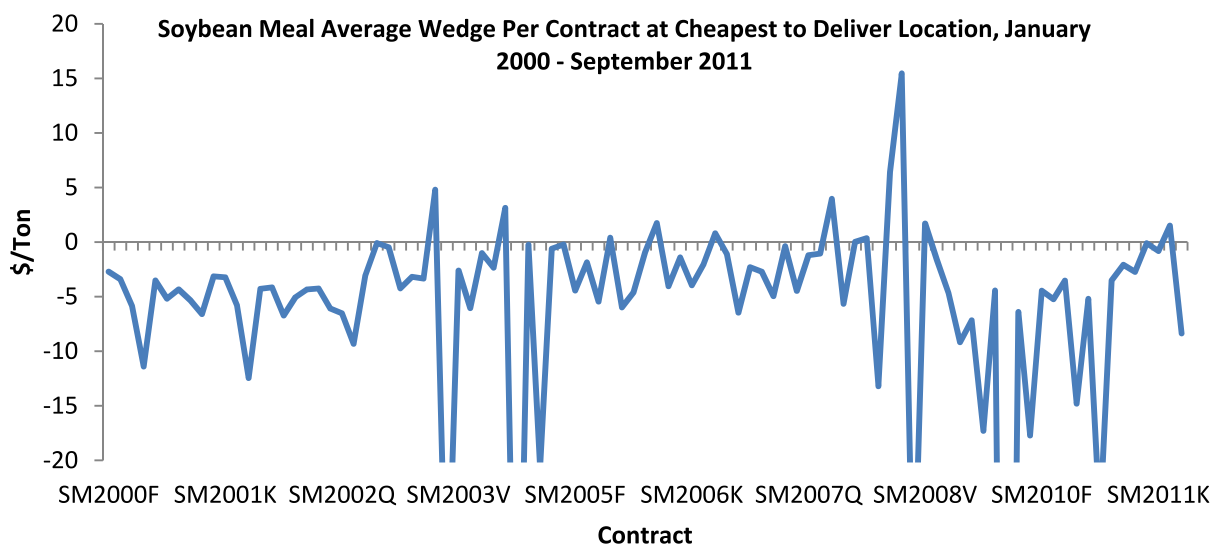
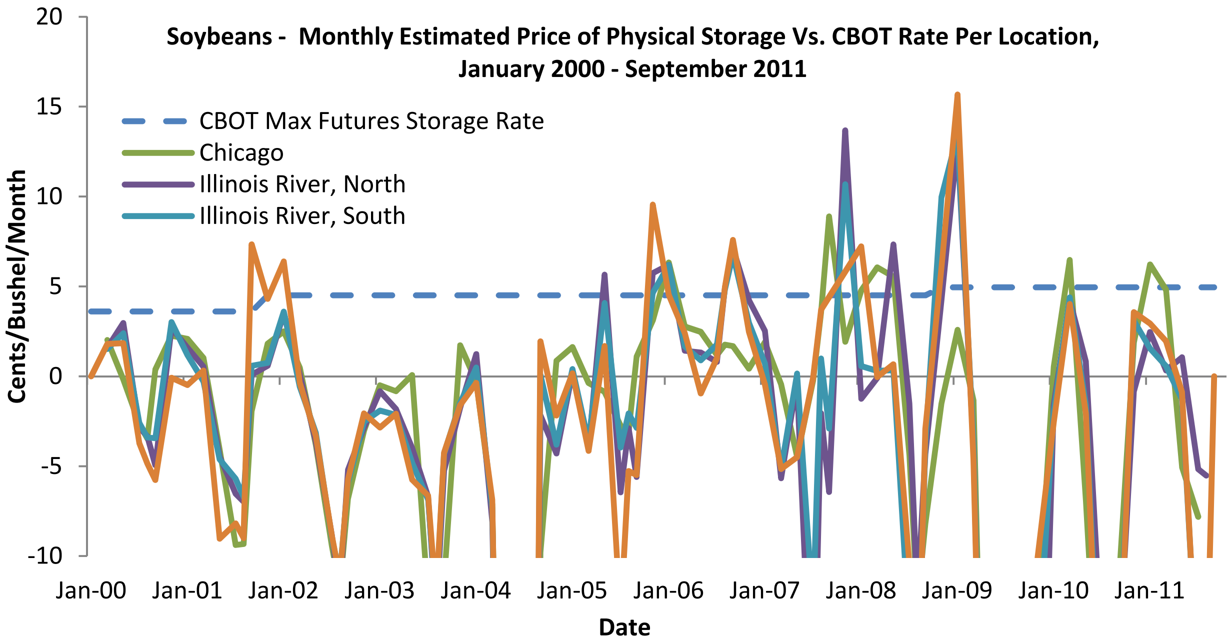


Figure 28. Soybean Meal Average Wedge Per Contract, January 2000 – September 2011



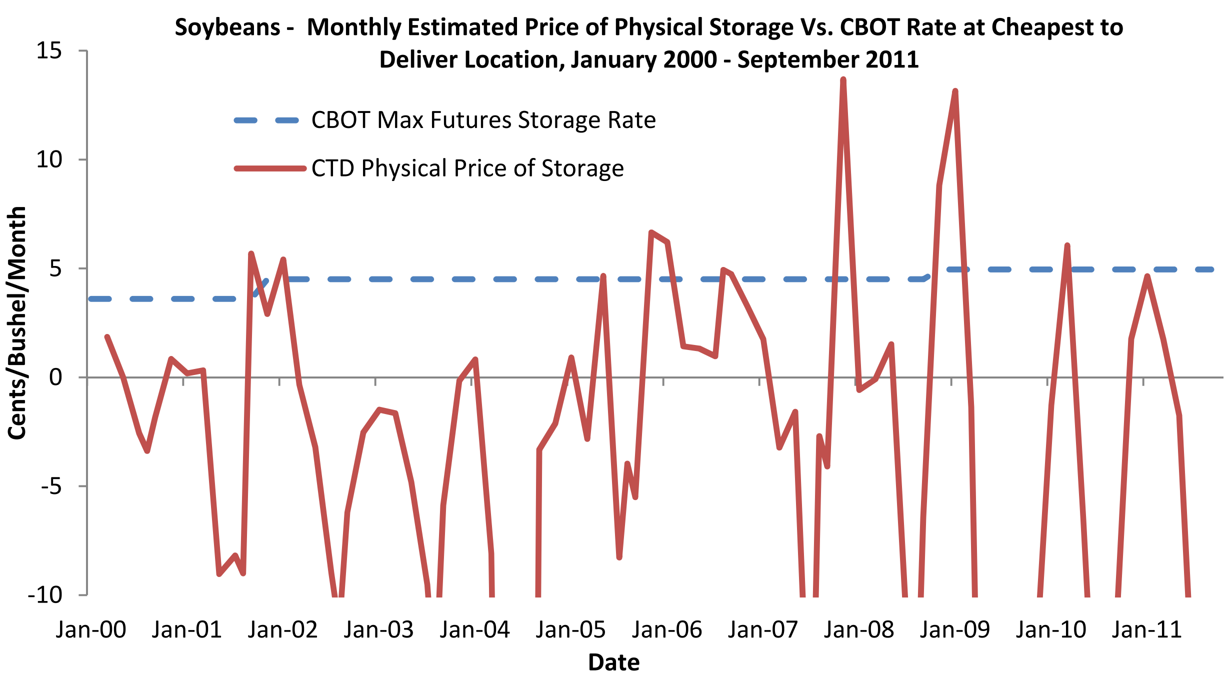
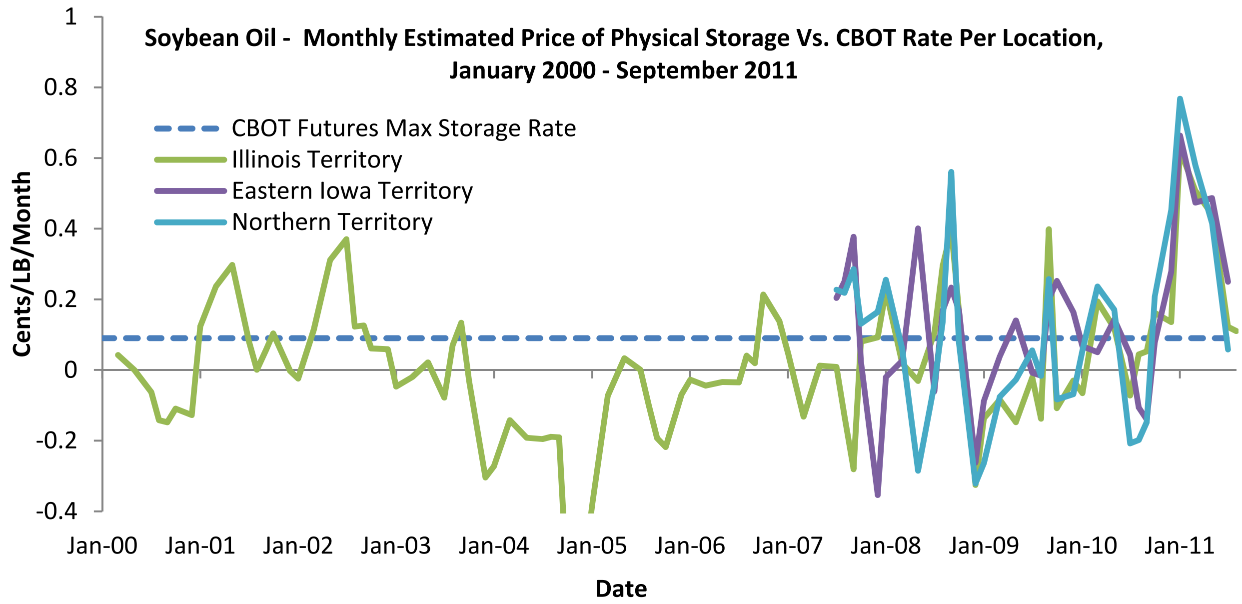


Figure 29. Soybean Monthly Estimated Physical Rate of Storage, January 2000 – September 2011



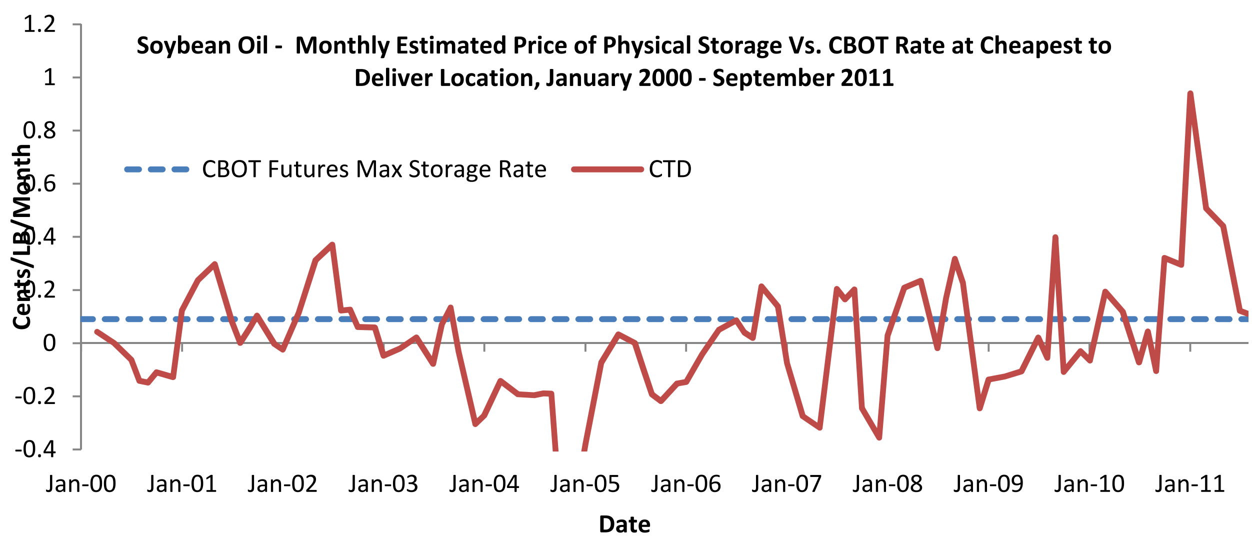
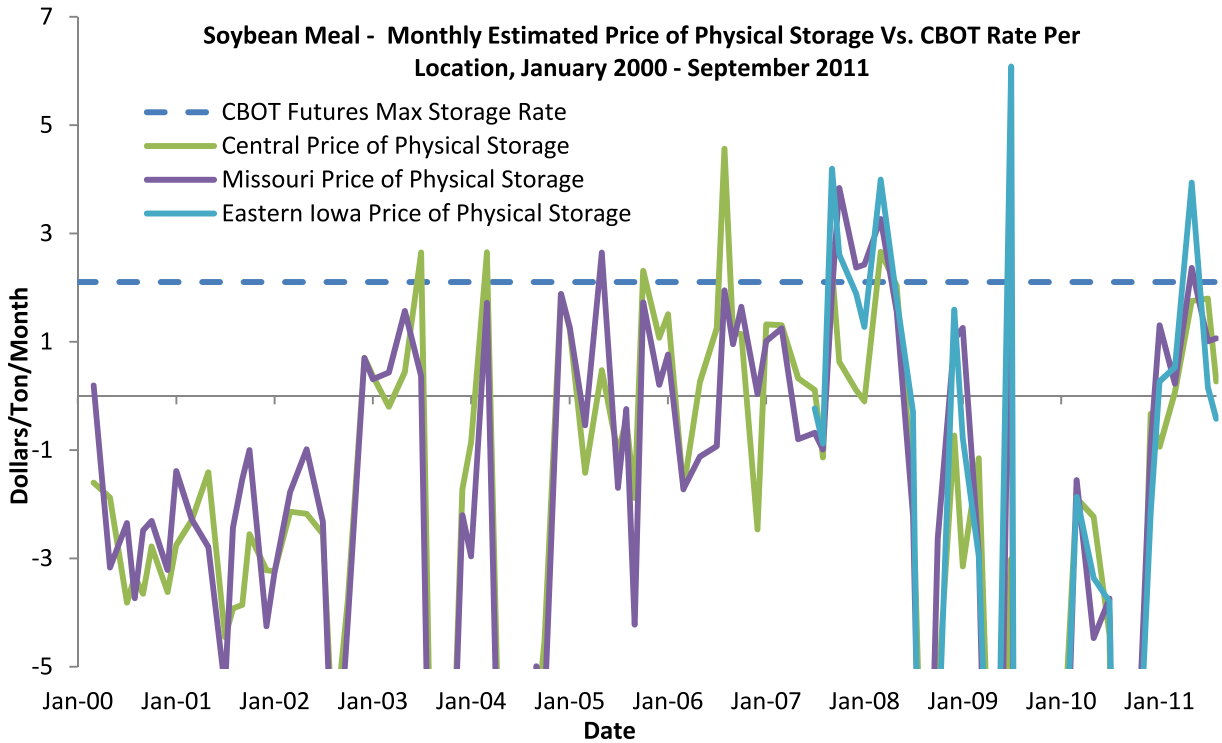


Figure 30. Soybean Oil Monthly Estimated Physical Rate of Storage, January 2000 – September 2011



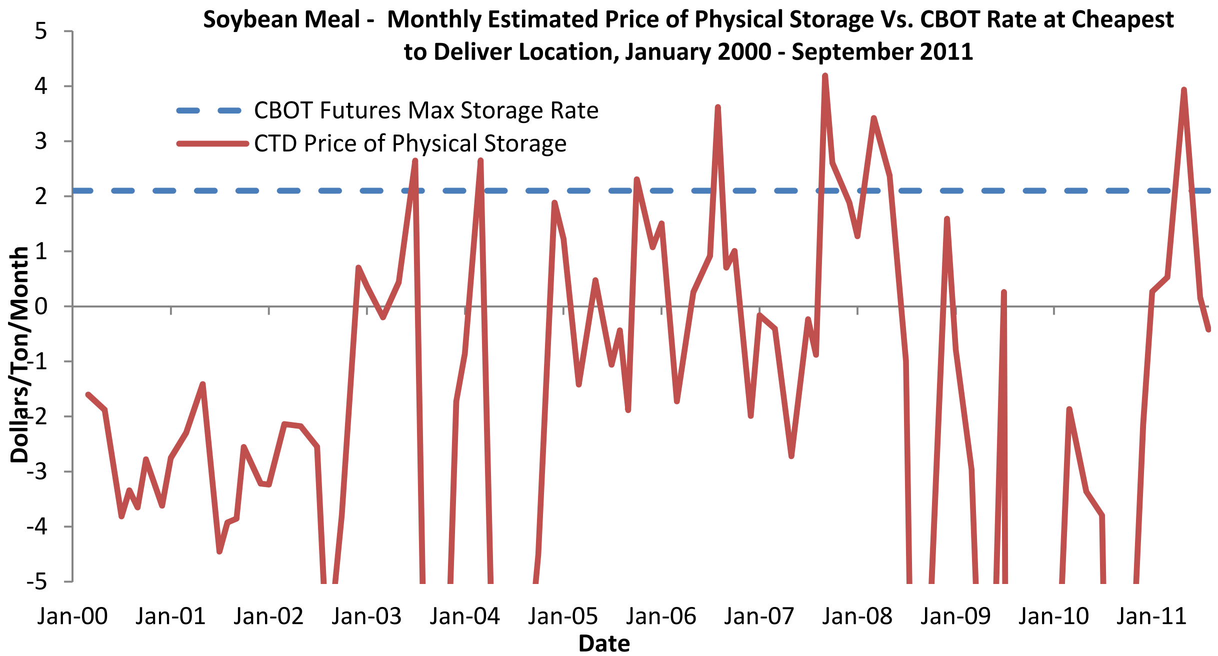


Figure 31. Soybean Meal Monthly Physical Rate of Storage, January 2000 – September 2011

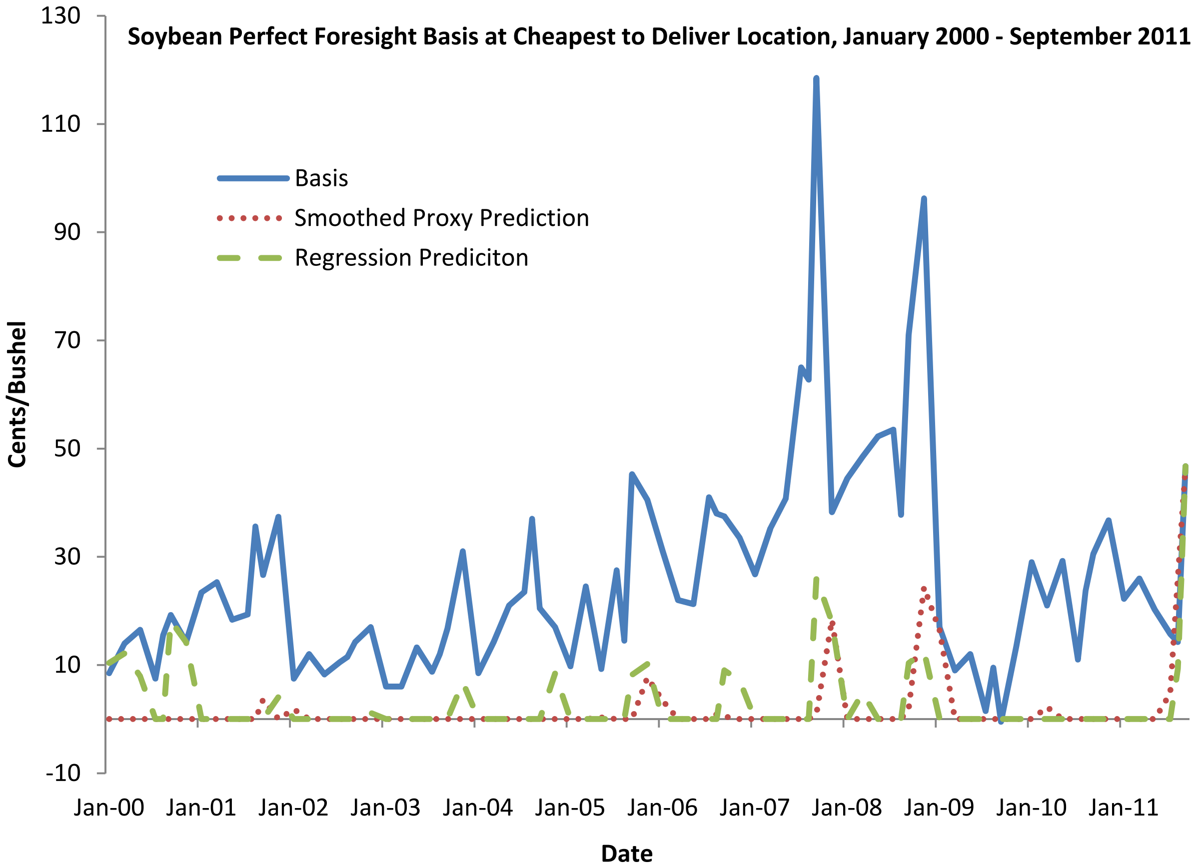


Figure 32. Soybean Perfect Foresight Basis at Cheapest to Deliver Location, January 2000 – September 2011

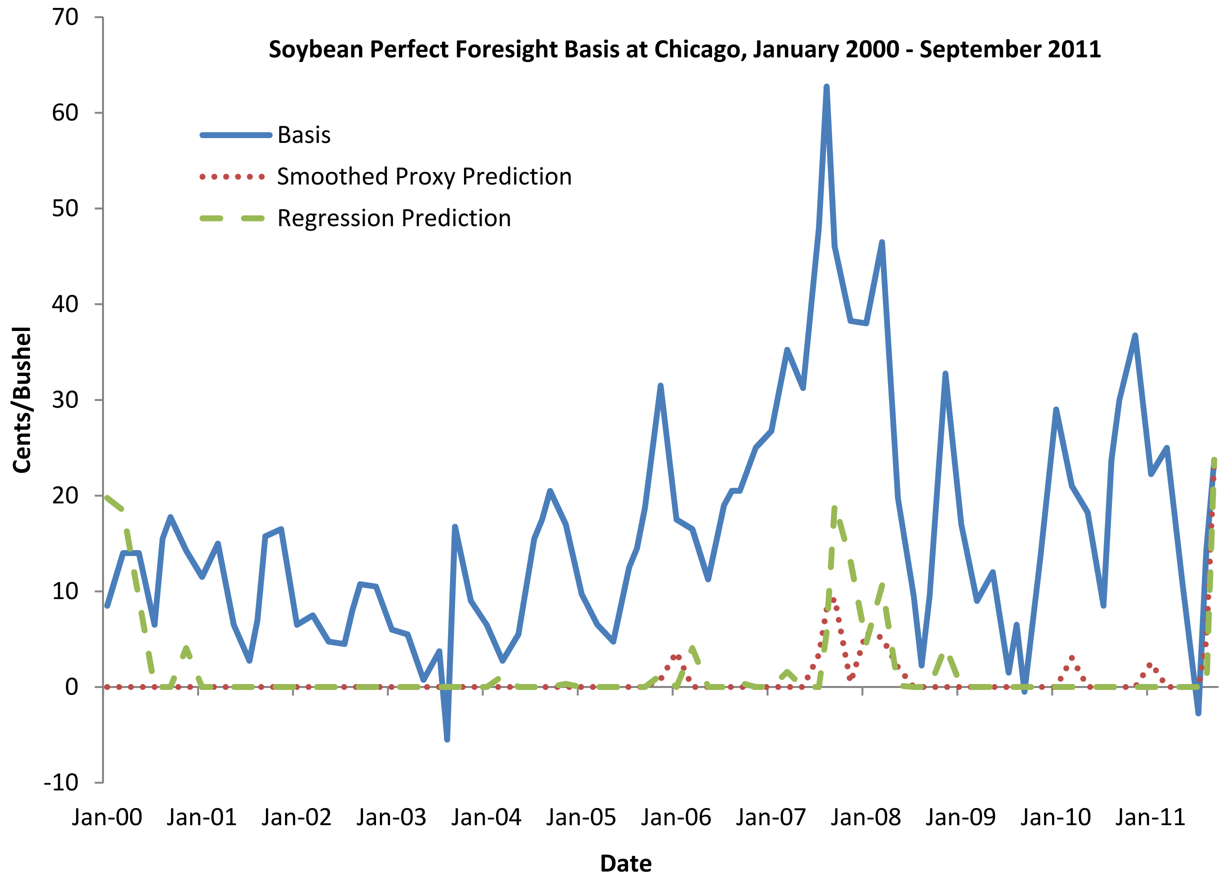


Figure 33. Soybean Perfect Foresight Basis at Chicago, January 2000 – September 2011

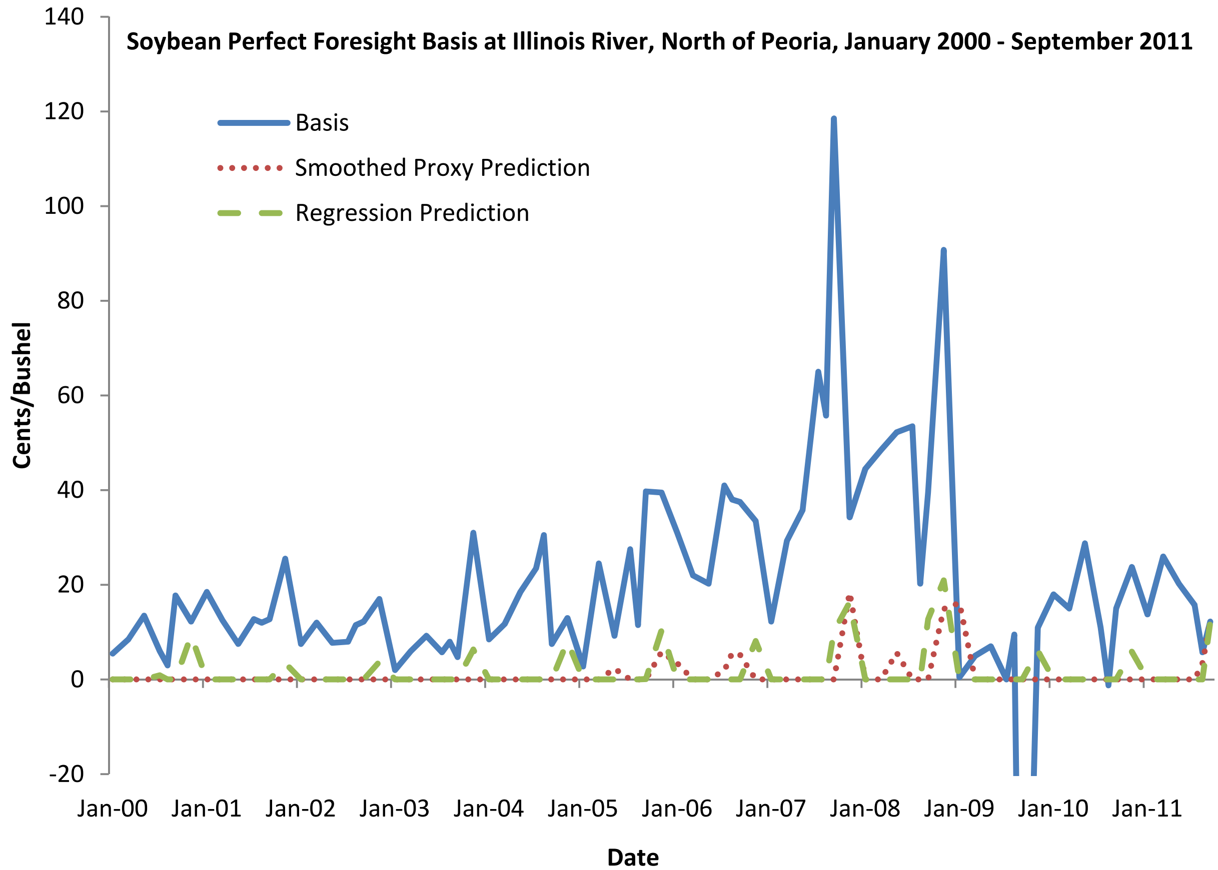


Figure 34. Soybean Perfect Foresight Basis at Illinois River, North of Peoria, January 2000 – September 2011

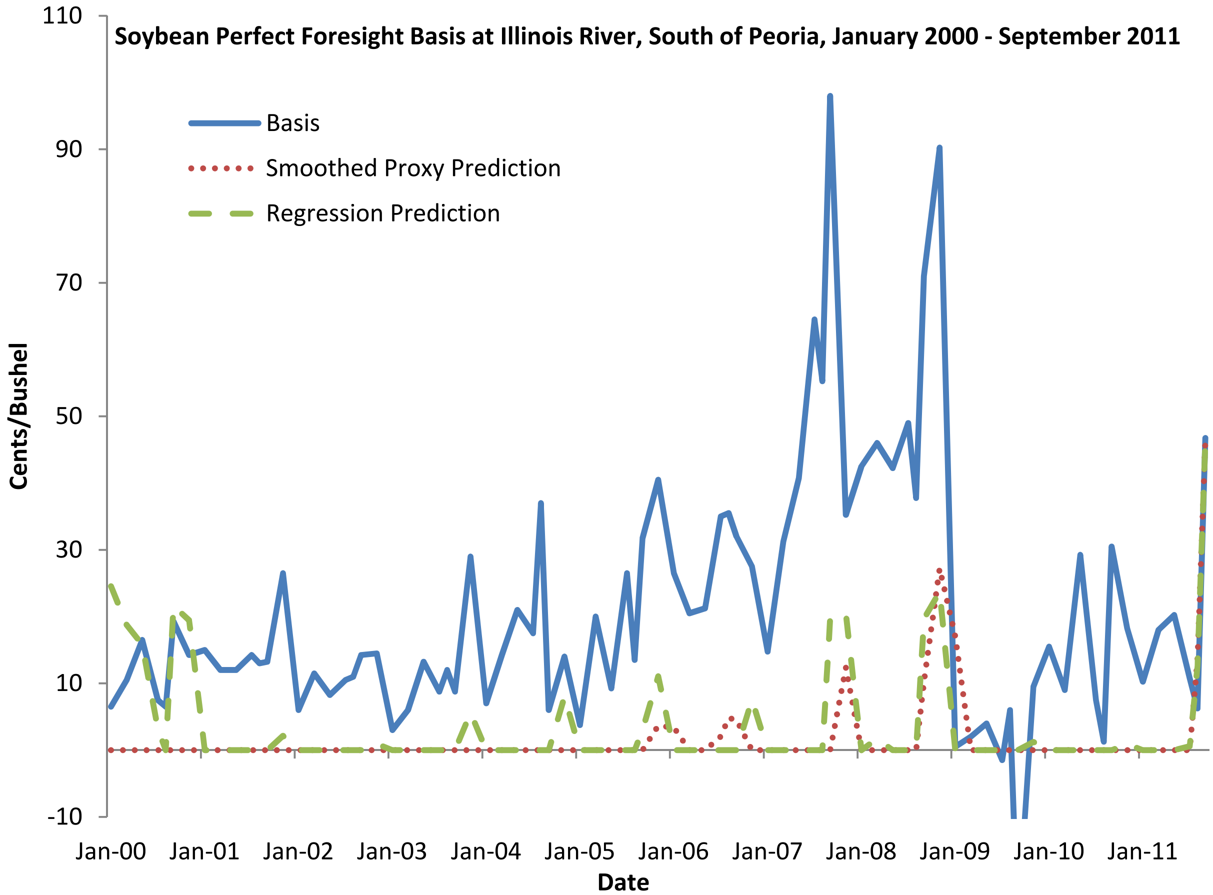


Figure 35. Soybean Perfect Foresight Basis at Illinois River, South of Peoria, January 2000 – September 2011

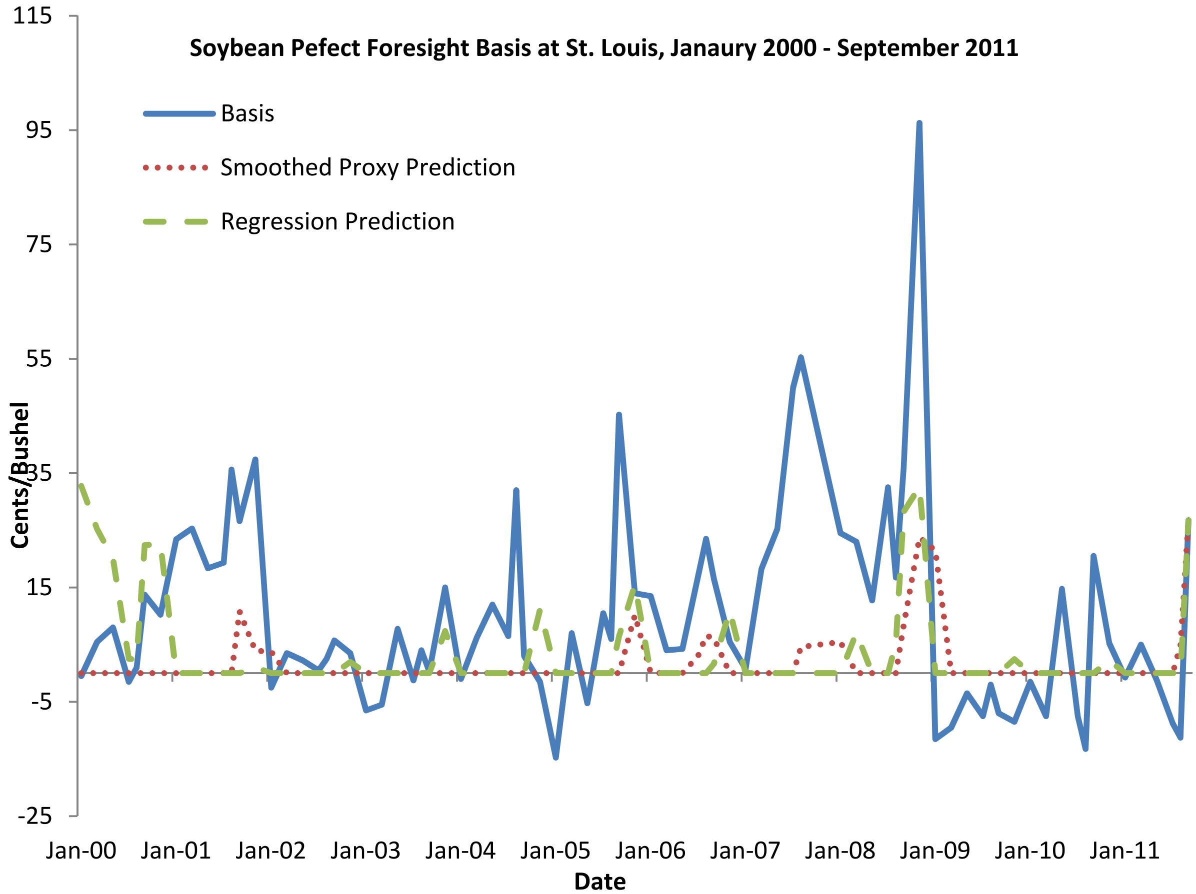


Figure 36. Soybean Perfect Foresight Basis at St. Louis, January 2000 – September 2011

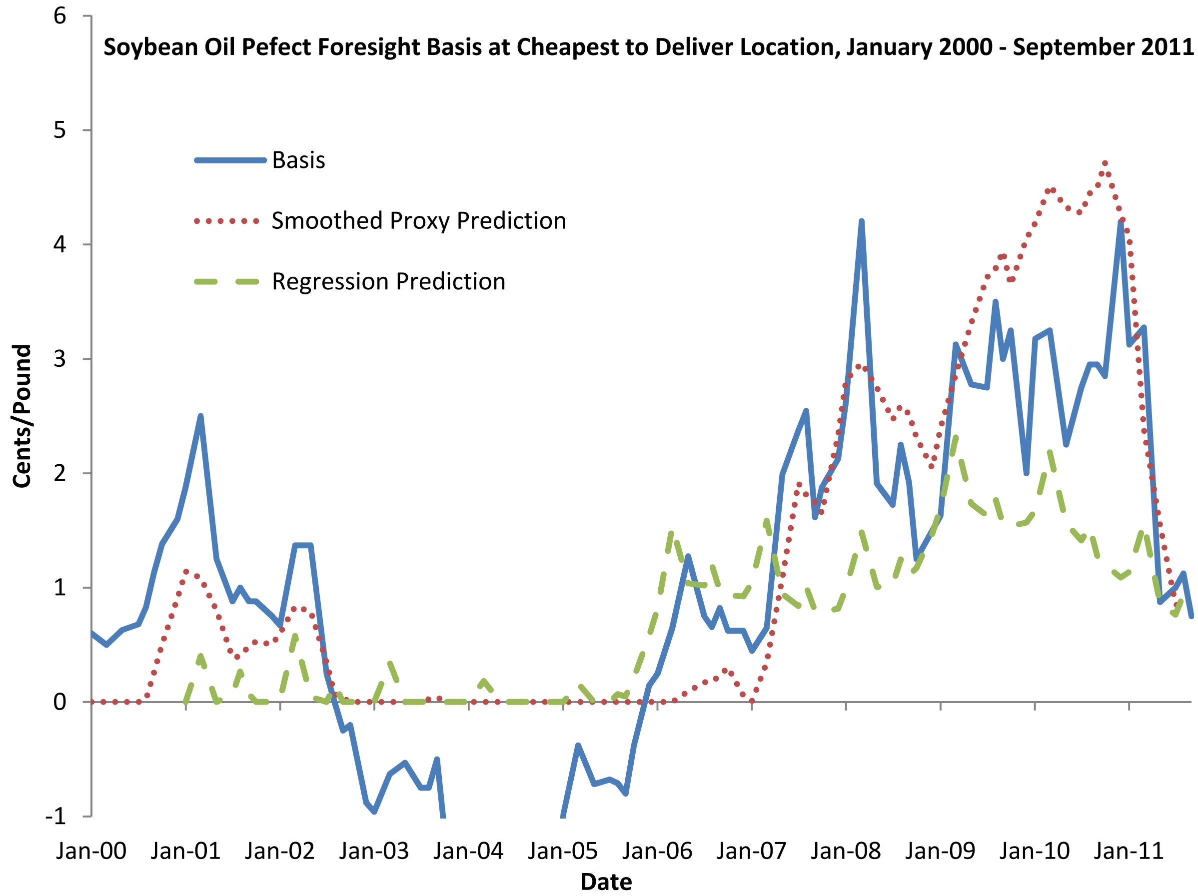


Figure 37. Soybean Oil Perfect Foresight Basis at Cheapest to Deliver Location, January 2000 – September 2011

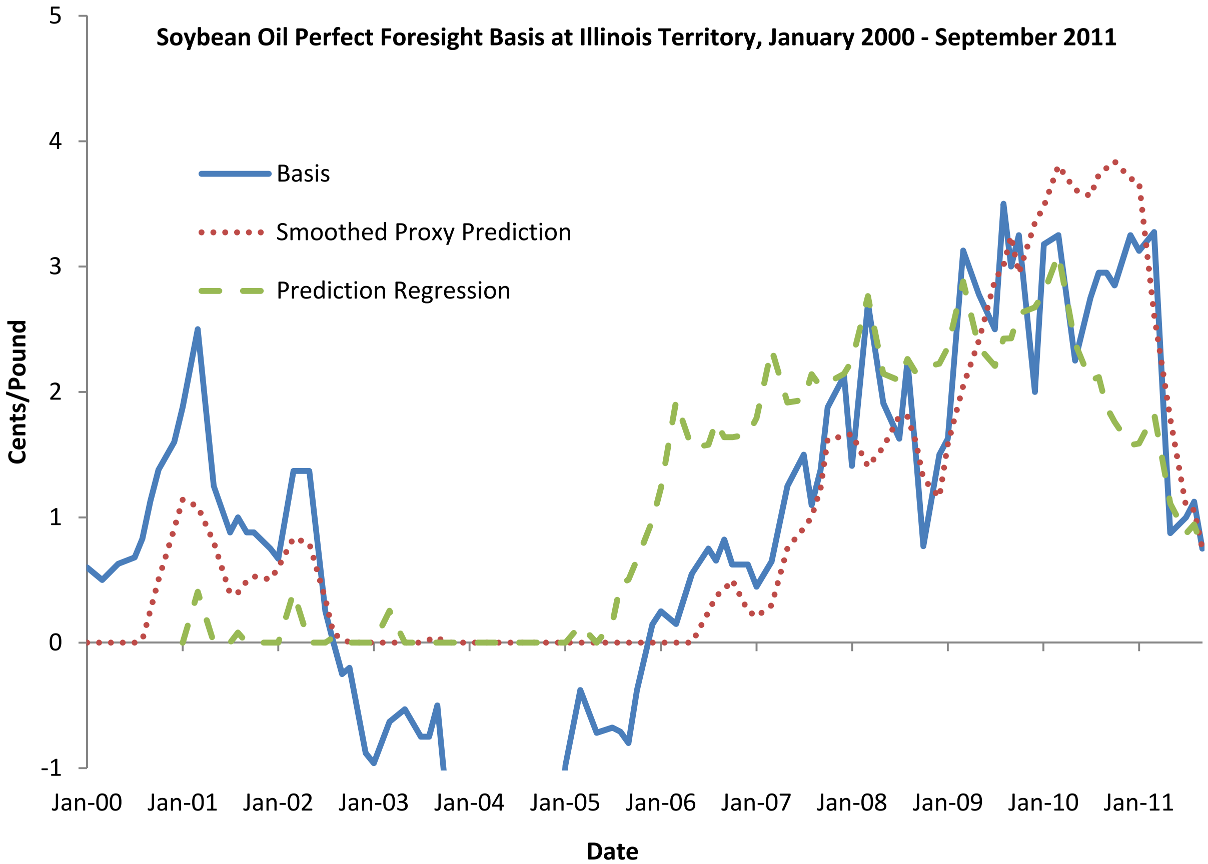


Figure 38. Soybean Oil Perfect Foresight Basis at Illinois Territory, January 2000 – September 2011

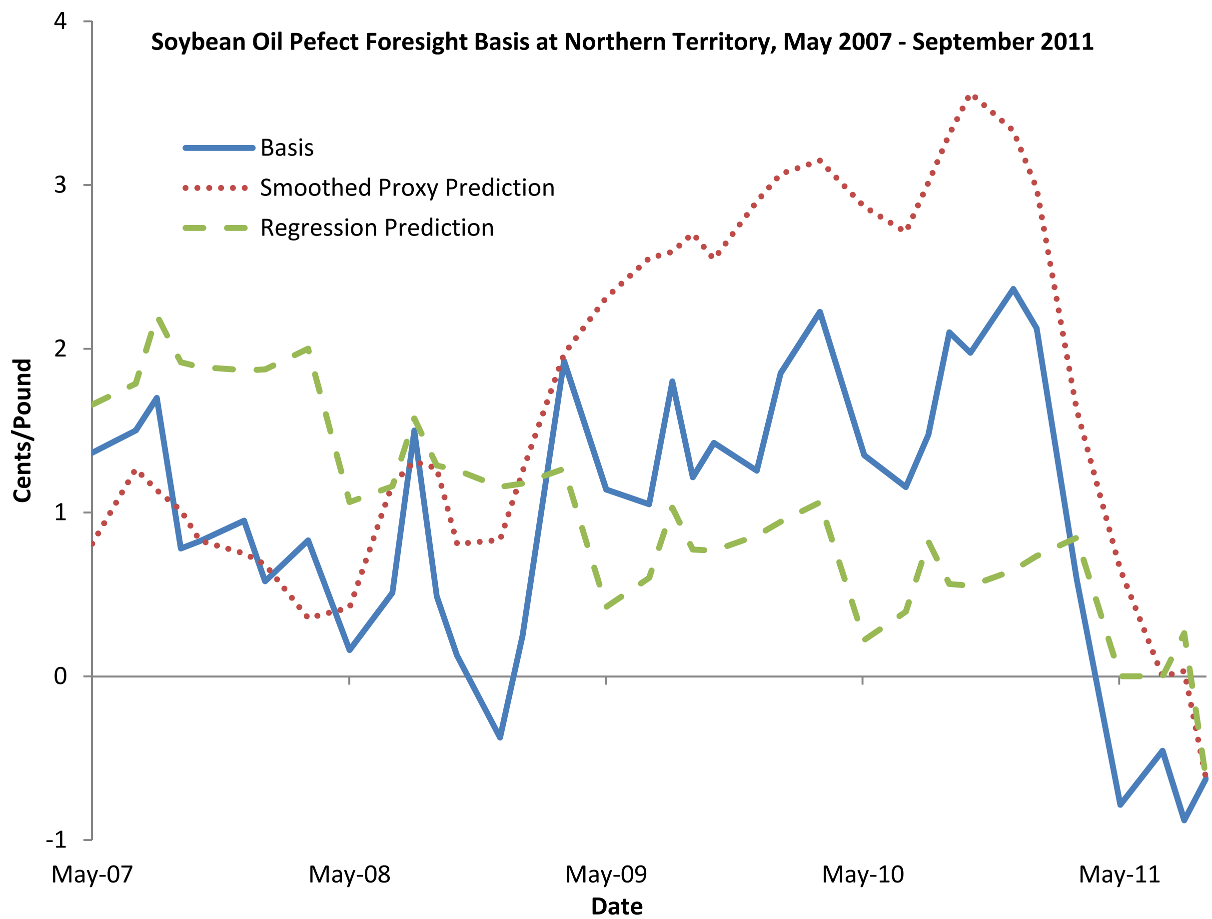


Figure 39. Soybean Oil Perfect Foresight Basis at Northern Territory, May 2007 – September 2011

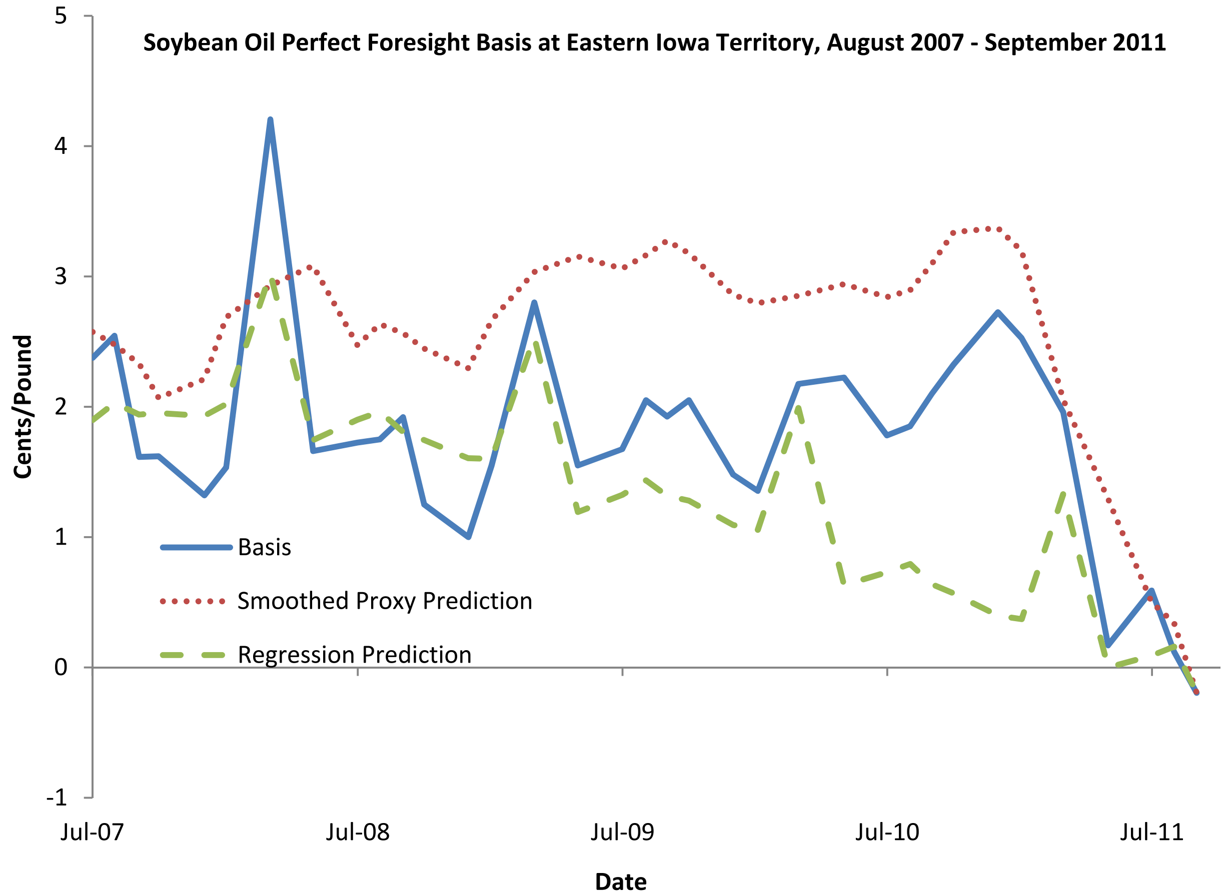


Figure 40. Soybean Oil Perfect Foresight Basis at Eastern Iowa Territory, August 2007 – September 2011

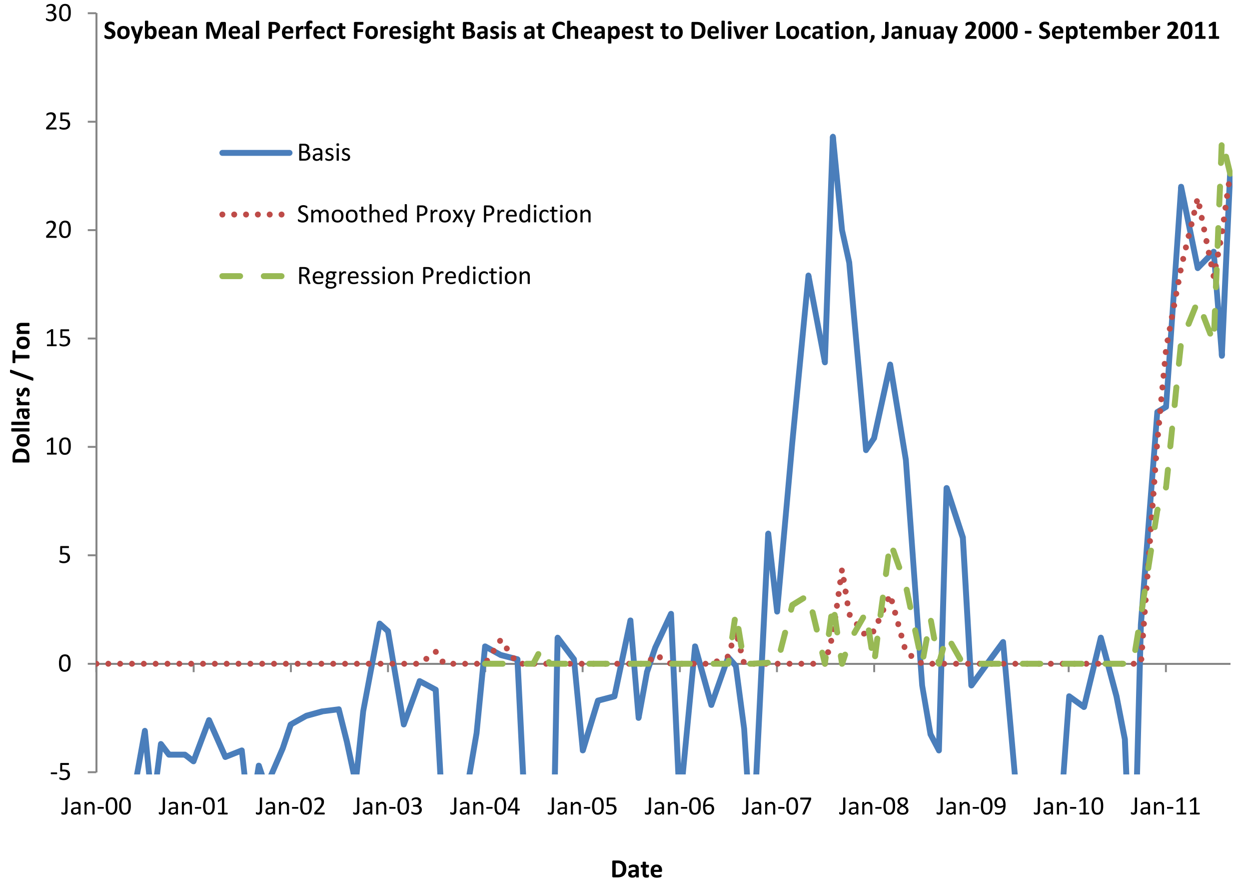


Figure 41. Soybean Meal Perfect Foresight Basis at Cheapest to Deliver Location, January 2000 – September 2011

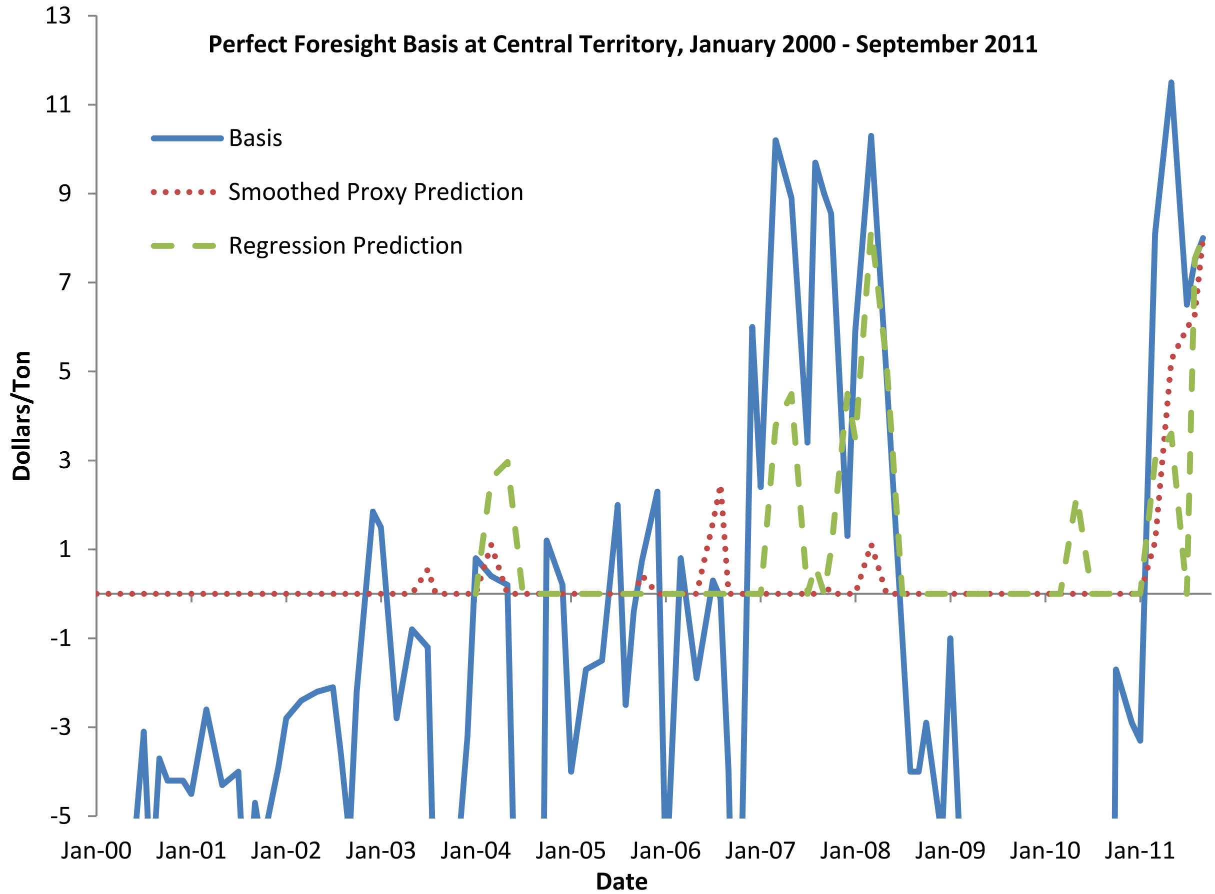


Figure 42. Soybean Meal Perfect Foresight Basis at Central Territory, January 2000 – September 2011

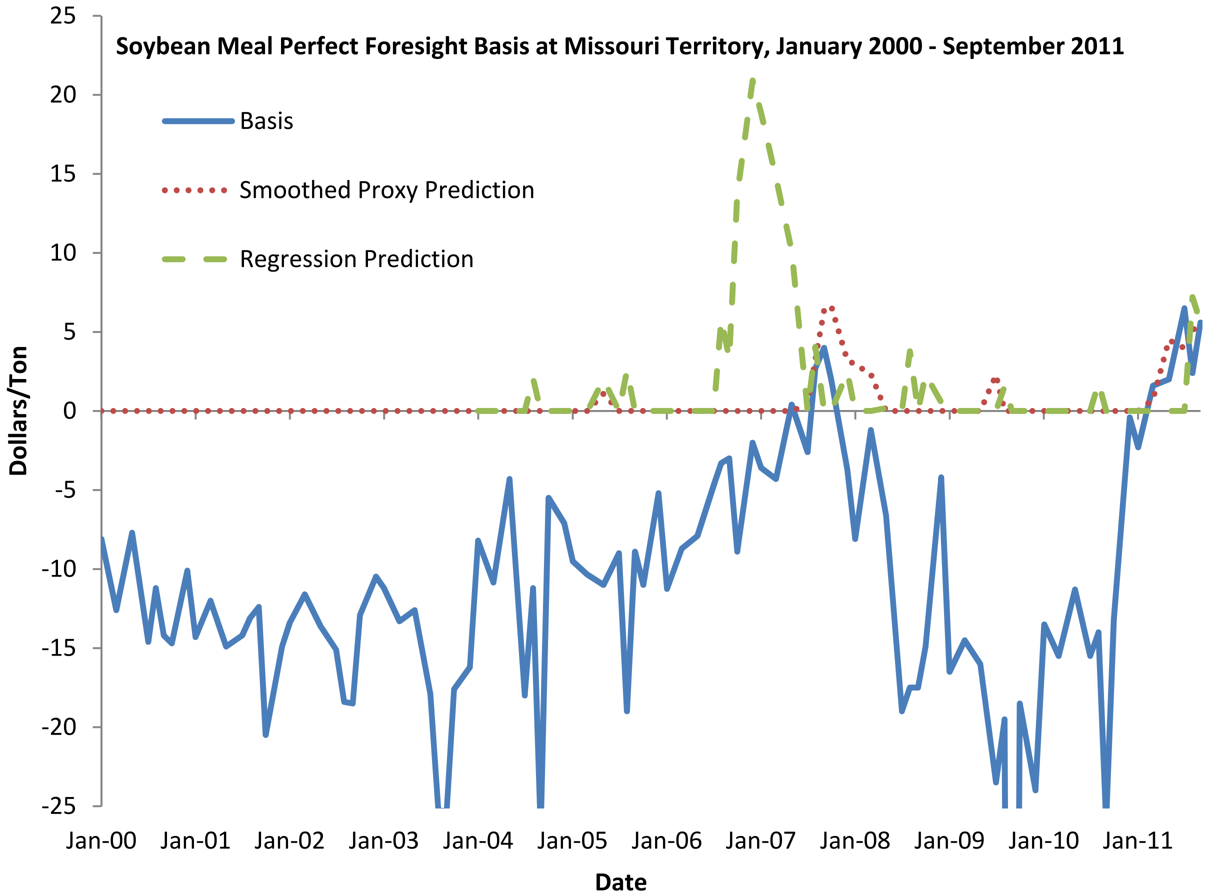


Figure 43. Soybean Meal Perfect Foresight Basis at Missouri Territory, January 2000 – September 2011

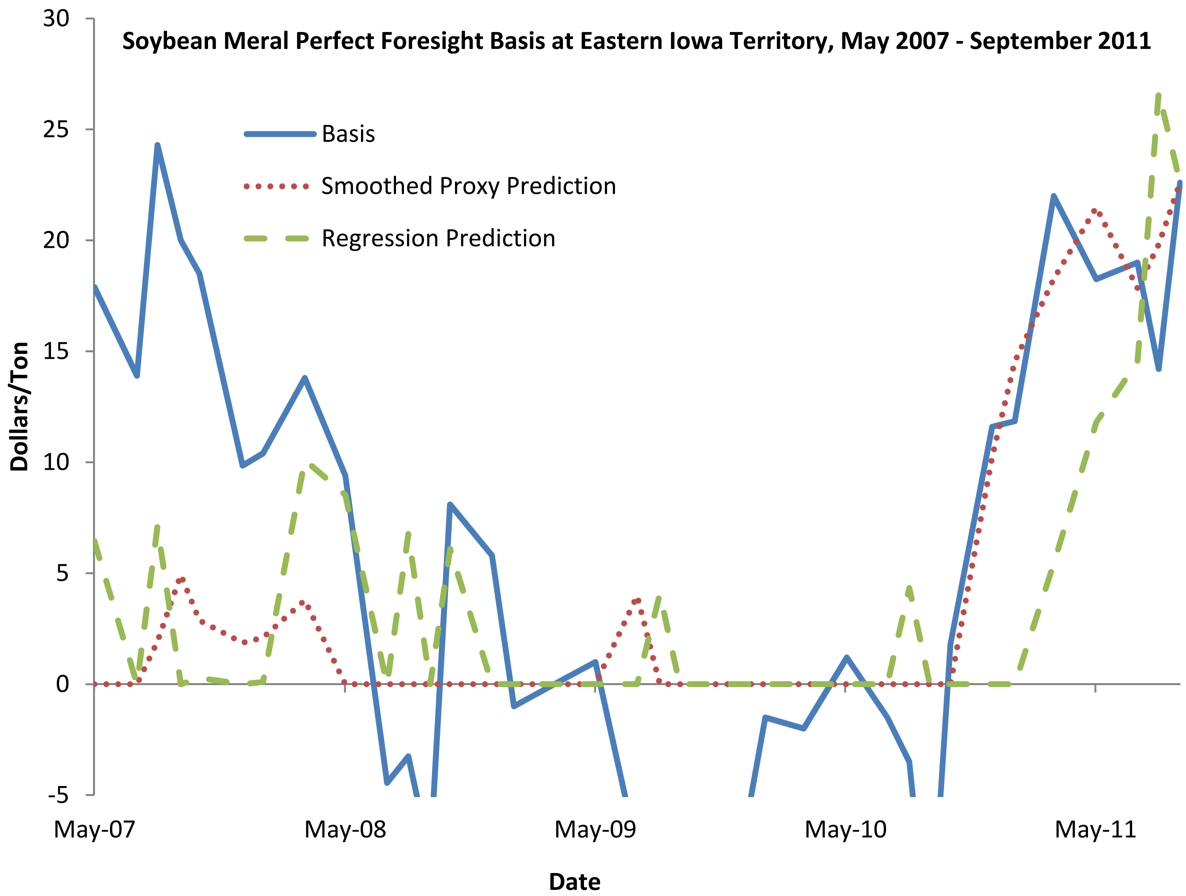


Figure 44. Soybean Meal Perfect Foresight Basis at Eastern Iowa Territory, May 2007 – September 2011

Appendix A - The Chicago Board of Trade Delivery System

The deliverable instrument for soybeans and soybean meal is a shipping certificate. The delivery instrument for soybean oil is a warehouse receipt. The difference between the two is the warehouse receipt is an actual claim on a commodity in store at a regular facility listed for delivery in the contract terms. A shipping certificate is similar to a warehouse receipt, but has no claim to the physical commodity in store, only an agreement if exercised to have the grain in store ready for delivery. These shipping certificates allow for the delivery facilities not to be 'tied up' with storage constraints compared to a warehouse receipt.

The delivery process is initiated by the short seller of the futures contract. The short has four options of delivery – default, delivery, exchange for physical (EFP), and futures offset. Simply put, in futures offset a short seller would buy the amount of contracts he is short to net out his position to be flat futures contracts (or roll them into a subsequent month.) In an EFP transaction, the short seller would negotiate with another party to offset via physical delivery. Default on a contract is rare and would be settled through arbitration between the parties involved in the transaction. Lastly, delivery of the instruments tied to the futures contracts is the last option for a short seller.

Both the shipping certificate and the warehouse receipt follow the same delivery process at the Chicago Board of Trade for futures delivery. The delivery process spans three days – intention day, notice day, and delivery day.

Intention day is two days before the first day of delivery on the futures contract. This day the short notifies the CBOT Clearing House that he intends to deliver on an expiring futures contract. At the end of intention day, the CBOT ranks the holders of long positions by the length of time held and chooses the longest held "long" in the book. On day two, notice day, the CBOT notifies the oldest "long" position in that delivery will take place. It is up to the short also to deliver an 8 invoice to the long. On day three, delivery day, the long pays the invoice and receives the shipping certificate or receipt. In the exchange of payments, the clearing house is the facilitator of the transactions. To help visualize the process, see Appendix A, Figure 1.

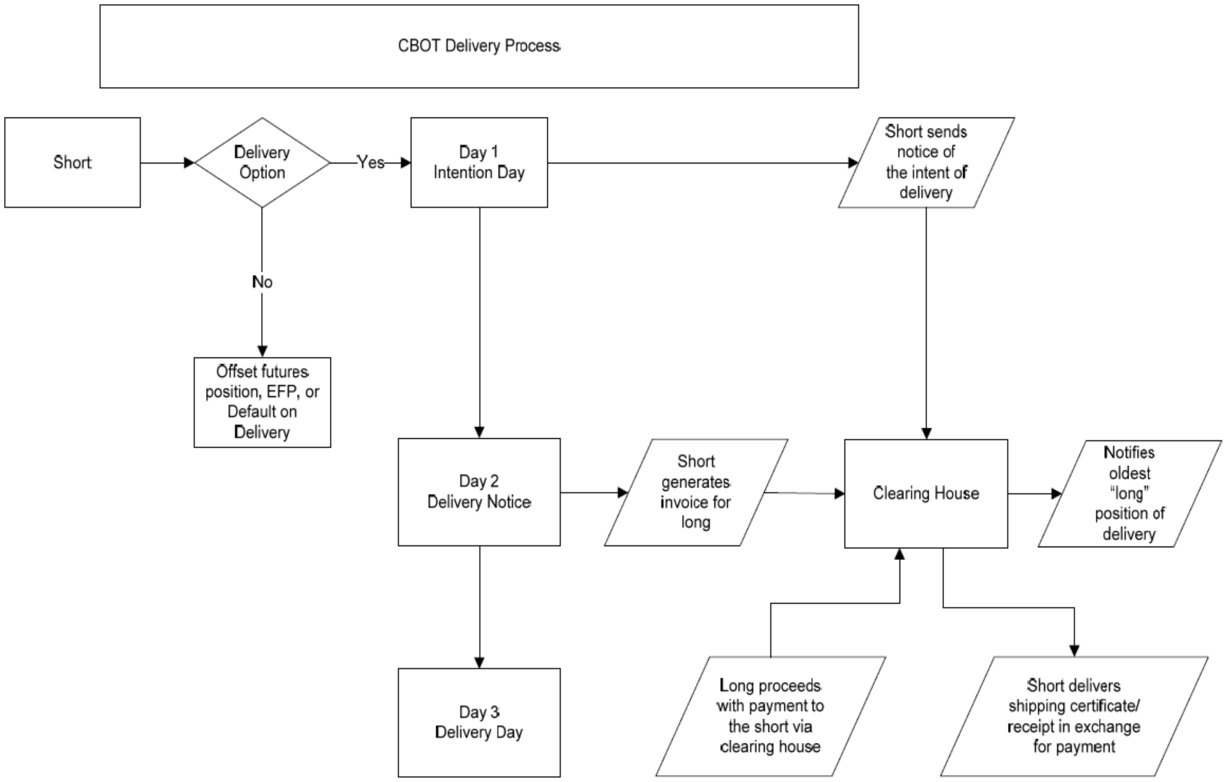


Figure A.1 Chicago Board of Trade Delivery Process

Appendix B – Variable Storage Rate System

The Chicago Board of Trade introduced the variable storage rate system for wheat futures in November 2009. The first contract that utilized the variable storage rate system was the July 2010 CBOT wheat future. Under this system, storage rates would change according to the rules of a running average of carry within the marketplace. If the running average of carries from the 19th calendar day of the previous delivery month until the nearby contract option expiration is above 80% then the storage rate is raised 10/100s of one cent per bushel per day. If the running average of carry during the same time period is less than 50% then the storage rate is decreased by 10/100s of one cent per bushel per day. There is no ceiling to how high these storage rates can go.

Calculating the percentage of cost of carry is the same as before using the following equation,

$$\%\ of\ Full\ Carry = \left[\frac{F2_t - F1_t}{S_t + I_t}\right] X\ 100,$$

Where $F1_t$ is chosen expiring future, $F2_t$ is a future contract expiring after $F1_t$, S_t is the cost of storage of holding the delivery instrument, and I_t is the interest opportunity cost. S_t is computed by taking the contract futures storage rate(Table 4) for the given commodity multiplying it by the difference in days remaining between the first date of delivery of $F2_t$ and the current date t . I_t is computed in the following manner, $I_t = F1_t\ X\ \left(\frac{r_t}{365}\right) X\ n_t$, where $F1_t$ is the future price, r_t is the financing rate, and n_t the amount of days between the first day of delivery of $F2_t$ and the current date, t. The interest rate used to calculate the cost of carry is the 3 month LIBOR rate plus 200 basis points. This is the same method used to calculate the cost of carry in the market in this paper.

REFERENCES

Aulerich, N.M., R.P.H. Fishe, and J.H. Harris. “Why Do Expiring Futures and Cash Prices Diverge for Grain Markets?” Journal of Futures Markets (2011)31:503-533

Good, D. and S. Irwin. “Market Instability in a New Era of Corn, Soybean, and Wheat Prices.” *Choices*, 1st Quarter 2009, 24(1)

Garcia, Philip, Irwin, Scott H., and Smith, Aaron D., Futures Market Failure? Unpublished Working Paper, October 2011. Available at SSRN: http://ssrn.com/abstract=1950262

Gray, Roger W. “Economic Evidence in Manipulation Cases” Research on Speculation Seminar Report, 1990

Hieronymus, T.A. *Economics of Futures Trading for Commercial and Personal Profit, Second Edition.* New York, NY: Commodity Research Bureau, 1977.

Hranaiova, Jana, and William G. Tomek. “Role of Deliver Options In Basis Convergence.” *Journal of Futures Markets* 22(2002):783-809.

Hranaiova, Jana, Robert A. Jarrow, and William G. Tomek. “Estimating the Value of Delivery Options in Futures Contracts.” *Journal of Financial Research* 28(2005):363-83.

Irwin, S.H., P. Garcia, D.L. Good, and E.L. Kunda. “Poor Convergence Performance of CBOT Corn, Soybean and Wheat Futures Contracts: Causes and Solutions.” Marketing and Outlook Research Report 2009-02,Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign, March 2009

Irwin, Scott H., Philip Garcia, Darrel L. Good, Eugene L. Kunda. “Spreads and Non-Convergence in Chicago Board of Trade Corn, Soybean, and Wheat Futures: Are Index Funds to Blame?” *Applied Economic Perspectives and Policy* (2011):115-142

Kaldor, N. 1939. “Speculation and Economic Stability.” Review of Economic Studies 7:1-27.

Peck, Anne E. and Jeffrey C. Williams. “Deliveries on Chicago Board of Trade Wheat, Corn, and Soybean Futures Contracts, 1964-65 – 1988-89.” Food Research Institute Studies 22(1991):129-225.

Pirrong, Stephen et.al. *Grain Futures Contracts: An Economic Appraisal.* Kluwer Academic Publishers, 1993

Schwager, J. *Schwager on Futures: Fundamental Analysis* John Wiley & Sons, Inc., 1995, p. 416.

Seamon. F. 2009. An Introduction to Variable Storage Rates in Wheat Futures. Research and Product Development, CME Group. http://www.cmegroup.com/trading/agricultural/files/VSR-White-Paper-FINAL.pdf

Trostle, R. 2008. Global Agricultural Supply and Demand: Factors Contributing to the Recent Increase in Food Commodity Prices, Washington, D.C.: ERS/USDA WRS-0801, May 2008

Working, Holbrook. “Theory of the Inverse Carrying Charges in Futures Markets.” Journal of Farm Economics 30(1948):1-28

Working, Holbrook. “The Theory of Price of Storage.” American Economic Review 39(1949):1254:1262

Working, Holbrook. “Futures Trading and Hedging.” *American Economic Review* 43(1953):314-343

Working, Holbrook. “Hedging Reconsidered.” *Journal of Farm Economics* 35(1953):544-561.