FORECASTING VOLATILITY IN AGRICULTURAL COMMODITIES MARKETS CONSIDERING MARKET STRUCTURAL BREAKS

by

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Abstract

This decade has seen movements in commodity futures markets never seen before. There are many factors that have intensified price movements and volatility behavior. Those factors likely altering supply and demand include governmental policy within and outside of the U.S, weather shocks, geopolitical conflicts, food safety concerns etc. Whatever the reasons are for price movements it is clear that the volatility behavior in commodity markets constantly change, and risk managers need to use current and efficient tools to mitigate price risk.

This study identified market structural breaks of realized volatility in corn, wheat, soybeans, live cattle, feeder cattle and lean hogs futures markets. Furthermore, this study analyzes the forecasting performance of implied volatility, historical volatility, a composite approach and a naïve approach as forecasters of realized volatility. The forecasting performance of these methods was analyzed in the full period of time of our weekly data from January 1995 to April 2014 and in each identified market regime for each commodity. Previous research has analyzed forecasting performance of implied volatility, a time series alternative and a composite method. However, to the best of my knowledge, they have not worried about market structural breaks in the data that might influence the performance of the mentioned forecasting methods in different periods of time.

Overall, results indicate that indeed there are multiple market structural breaks present in the volatility datasets across all six commodities. We found differences in the forecasting performance of the analyzed methods when individual market regimes were analyzed. There seems to be evidence that corroborates the idea in the literature about the superiority of implied volatility over a historical volatility, a composite approach and a naïve approach. Additionally, implied volatility encompassed all the information contained in the historical volatility and the

naïve measure across each identified market regime in all six commodities. Our results show that when both implied volatility and historical volatility are available, the benefit of combining those measures into a composite forecasting approach is very limited. Our results hold true for a short term 1 week ahead realized volatility forecast. It would be of interest to see how results vary for longer forecasting time horizons.

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Chapter 1 - Introduction

Extreme price variability during the 1970s in the grains, oilseeds, fibers, and livestock commodities brought with it a sense of urgency and need for mechanisms to manage exposure to price risk. One mechanism that emerged was commodity futures markets (Purcell and Koontz 1999). Trade in commodity futures contracts via the organized exchanges currently seen in the United States started around the 1860s.

Financial futures markets offer a wide variety of products that allow users to manage or transfer risk. The United States Department of Commerce stated in 2012 that financial markets in the United States are the largest and most liquid financial markets in the world. In the United States, farmers of agricultural commodities enjoy different alternatives to trade their products. The timing for using different tools varies, but risk management practices are now prevalent across industries, for instance allowing a crop producer the possibility to reduce price uncertainty for his products before planting occurs. One of the tools for trade that farmers directly or indirectly benefit from are futures markets and options contracts on futures contracts. For example, a corn farmer hedging price risk through a forward contract with a grain elevator is indirectly benefiting from the ability of the elevator to hedge price risk in the futures and options markets. At the same time, bigger agribusinesses enjoy the risk management benefits from futures and options that allow them to reduce input and output price risk, therefore manage their operations effectively by transferring price risk to other individuals willing to take that risk. On the other hand there are takers of price risk, which can be hedgers or speculators. Speculators seek to profit by correctly guessing the price movements. Hedgers are individuals that seek to manage price risk present in the physical buying or selling of commodities.

It seems that the dynamic of price volatility is strongly related to the speed in which information can be transmitted in addition to the different factors contributing to price changes. Back in the 20th century Professor Friedrich Hayek, the Austrian Economist and Nobel Prize laureate, conceived the idea that prices are merely a mechanism for communicating information. As economies get more globalized and the methods for spreading that information function quicker, the volatility in the markets adopts new dynamics. Price volatility is a characteristic of commodity markets and is a core reason futures markets surged. The removal of strict production control programs in the agriculture sector and increasing levels of inflation during the 1970's and early 1980's were among the forces imparting price variability, together with increased exposure of the U.S. to the world market via the North America Free Trade Agreement (NAFTA) and the broader General Agreement on Tariffs and Trade after 1990 (Purcell and Koontz 1999). More recently there are a wide host of factors behind the movements of prices in agricultural commodities which include: dynamic weather conditions, changes in global demand, biofuel policies, limited farmland, macroeconomic factors, governmental policies, geopolitical conflicts and food safety concerns.

There is wide interest not only to understand but also to predict volatility in agricultural markets. Price variability or "volatility" is commonly measured using two distinct approaches. The first approach is a backward looking measure called "Historical Volatility." Historical volatility generally measures price variability by calculating the variance of a historical price series. The second approach is a forward looking measure based on market expectations of price movements, this is called "Implied Volatility." There is not a direct way to calculate implied volatility. The most common way to approximate an implied volatility measure is to use the Black Scholes (1973) options pricing formula. Alternatively a combination of the backward looking measure with the markets forward-looking expectations of the markets has been analyzed as an alternative composite forecaster of volatility.

Volatility has usually been analyzed over long periods of time from which the data series are extracted from. However, given different market conditions affecting the volatility in markets at different times, we believe there is a need to characterize data periods according to their volatility behavior in order to better understand the performance of the volatility prediction methods. Practically, we are going to characterize the realized volatility series by identifying market regimes in each commodity combining a statistical approach with a qualitative approach.

1.1 Objectives

This study looks at the forecasting performance of implied volatility, historical volatility, a composite approach, and a naïve model as predictors of realized volatility of corn, wheat, soybeans, live cattle, feeder cattle and lean hogs. Furthermore, this study seeks to characterize these six agricultural commodity markets in different market regimes, according to their volatility behavior. Specific objectives include:

- To identify market structural breaks in realized volatility of corn, wheat, soybeans, live cattle, feeder cattle and lean hogs markets.
- To assess the forecasting performance of implied volatility as a predictor of realized volatility in agricultural commodities markets in the full period of time and different market regimes.
- To assess the forecasting performance of historical volatility as a predictor of realized volatility in agricultural commodities markets full period of time and different market regimes.

- To assess the forecasting performance of a linear hybrid approach composed of implied volatility and historical volatility, as a predictor of realized volatility in agricultural commodities markets full period of time and different market regimes.
- To assess the forecasting performance of a simple naïve expectation, as a predictor of realized volatility in agricultural commodities markets full period of time and different market regimes.

1.2 Motivation

Besides my desire to better understanding the role and functioning of price volatility in agricultural commodities, I ultimately would like this study to shed light about risk management issues to agribusiness practitioners.

Uncertainty that stimulates volatility in future and options agricultural commodities markets increases demand for effective risk management tools. Geo-political situations, weather shocks, demand variations and supply shocks are some of the factors that drive volatility of prices. The factors that drive volatility may not have the same importance in different periods of time and generally, volatility seems a more complex issue in recent years.

The Hightower Report on Futures Analysis and Forecasting (2014) comprised new factors driving grain's market volatility today different from previous years, such as the potential for significant sovereign-sponsored reserve buying, outright investment interest, an ever-growing demand source from energy markets and a divergent global production system that can offer up supply and demand movements from almost anywhere at almost any time of the year. Now, more than ever a grain grower in the mid-west in the United States is exposed to the uncertainties of weather, political unrest, changing levels of exchange rates among others, throughout the world.

The mentioned price volatility drivers have effects on agribusiness that operate on an ever changing business environment. Therefore the necessity to further analyze, update the known and accessible tools with more recent data, and incorporate new ideas to current tools to improve their risk management efficiency. Successful, innovative, available and up-to-date risk management techniques will improve the grains and livestock supply chain in the United States through improving managerial decision making.

Chapter 2 - Literature Review

Volatility is defined by the Commodity Research Bureau (CRB) as a measure of the amount and speed of price changes, regardless of direction. There are three main ways to forecast volatility: Implied volatility methods, historical volatility methods and combinations of both. Implied volatility measures the market's estimate of how volatile the underlying futures price will be from the present until options contracts on futures contracts expiration date. Historical volatility measures how volatile the underlying futures contract has been, based purely on historical performance. In order to evaluate the performance of different forecast methods, a measure of the true realized volatility is needed. True realized volatility is not observable (Anderson & Bollerlsev, 1998), but the literature offers a variety of methods to develop a proxy for it. There is no consensus of which method provides a better estimate of the true realized volatility. Jorion (1995) discussed that one of the reasons implied volatility might provide better forecasts, when compared to historical volatility, is that implied volatility is able to consider forward macro economical events, and incorporate that type of information in the option pricing. Nevertheless, the literature does not universally support this assertion across commodities, model specifications and time frames.

Forecasting volatility is of importance for different market participants including hedgers and speculators. Hedgers, which deal with physical commodities, can be farmers, livestock producers, merchandisers, elevators, food processors, feed manufacturers, exporters and importers. Speculators facilitate trading by providing market liquidity and may be part of the general public or they may be professional traders including members of an exchange (CME Group, 2012). For example, a food processor using corn as raw material, might find it useful to have an accurate idea of how corn prices are going to move in the future, in order to define cash flow demands for upcoming periods of time. This way resources within the organization can be allocated in an effective way. This leads to a need of studying and identifying the most effective way to predict future volatility in different time horizons.

The literature offers a wide variety of information regarding forecasting volatility in agricultural commodities. The forecasting performance of implied volatility, historical volatility and a combination of both has been a topic of study for several academics in the agricultural economics arena. Yet, findings are diverse and farmers and agribusiness using volatility forecast methods as a measure for price movements in their operation cannot be advised in a definitive way, given an ever changing economic environment. To the best of my knowledge in the corn, wheat, soybeans, live cattle, feeder cattle and lean hogs markets: 1. Implied volatility, historical volatility and composite approaches' accuracy has not been analyzed including recent years data; 2. The changes (if any) in volatility forecasting performance of different methods has not been analyzed separately for different market periods.

2.1 Historical Volatility

There are several ways to calculate historical volatility and they range from simple moving averages to complex mathematical models. The moving average methods are calculated by annualizing the standard deviation of price changes in the data series and this measure is usually expressed as a percentage. These calculations are performed involving different time frames and are available to download from private data outlets like Bloomberg L.P. and CRB (Commodity Research Bureau) Data Center. Econometric specifications used to model observed time series models are usually in the form of ARCH (Autoregressive Conditional Heteroskedasticity) specifications. GARCH (Generalized Autoregressive Conditional Heteroskedasticity) specifications are also common in the forecasting performance literature. In this section we find that among the methods to calculate historical volatility, there is some evidence that simple specifications out perform more complex mathematical methods. However, there is not a consensus on which is the most accurate method. Reasonable estimates of volatility are highly dependent on the commodity and season of the year (Purcell and Koontz 1999). The following paragraphs provide brief highlights for the most analyzed time series alternatives.

Time series forecasts like GARCH, in particular the GARCH (1,1) model, are frequently agreed to be a good specification of conditional volatility for both financial assets and agricultural price returns (e.g., Bollerslev, Chou. and Kroner, 1992; Yang and Brorsen, 1992). However, it has not been proved that GARCH specifications provide superior volatility forecasts to simpler time series alternatives (Manfredo, Leuthold and Iriwn, 2001). The ARCH models were first described by Engle (1982) and Bollerslev (1986) described the GARCH models. The GARCH models posit that the variance of return follows a predictable process, driven by the latest squared innovation and by the previous conditional variance (Jorion 1995).

Manfredo, Leuthold and Iriwn (2001) described long run historical averages (HISTAVG), as a model that use all the data available to that point. Often HISTAVG is considered a benchmark for more complex models, in particular GARCH. Historical moving averages (or moving windows) are similar models to long-run historical averages, however they incorporate a fixed number of data observations.

Manfredo, Leuthold and Iriwn (2001) evaluated the performance of GARCH in different specifications, HISTAVG and historical moving averages for fed cattle, feeder cattle and corn cash price returns using data from 1984 to 1997. They concluded that no one of these methods provides superior accuracy across alternative data sets and horizons (e.g. one week or two weeks). Their findings suggested that simple GARCH specifications work just as well as more complicated ones. Using data from 1986 to 1999, Manfredo and Sanders (2004) found that GARCH specifications for historical volatility of live cattle prices have improved their forecasting performance overtime.

Seasonal GARCH (Along the lines of Glosten, Jagammathan and Runkle, GJR, 1993) is a more sophisticated form of the general GARCH model analyzed by Simon (2002) for corn wheat and soybeans. He found that implied volatility encompassed all the information provided by the GJR model. Other specifications of the GARCH include the GARCH (1,1) with a zero-mean specification, GARCH (1,1) with a t-distribution and models with varying (p,q). Brittain, Garcia and Irwin (2011) analyzed the forecasting performance of these GARCH alternative methods on live and feeder cattle option markets. Analyzing out of sample forecasts, they found that the specification that improved accuracy was the GARCH (1,1) with a t-distribution (that allows for normality). Furthermore, their results indicated that GARCH forecast errors were slightly smaller than the ones in implied volatility in live cattle, but this result was reversed in the feeder cattle market.

2.2 Implied Volatility

Implied volatility is estimated by solving the Black Scholes's options pricing formula using trial and error. Different volatility measures are used until the formula solves for a premium that is very close to that observed in the market (Purcell and Koontz 1999). Practical data sources for implied volatility derived from agricultural commodities options such as Bloomberg L.P., a privately held financial software and the CRB (Commodity Research Bureau) Data Center, base the value of implied volatility on the mean of the two nearest-the-money calls and the two nearest-the-money puts using the Black Scholes' options pricing model. The Black Scholes formula, that calculates the option's premium, takes into consideration the current underlying price, the option's strike price, the time until expiration of the security, the risk free interest rate and the implied volatility. Since the option premium is known, as well as the other variables except from the implied volatility, the formula is back solved until you get the closest approximation of the implied volatility. This procedure is applied for put and call options.

One known draw back for Black Scholes' is that it is specified for European options. The use of a European pricing model to calculate implied volatilities derived from American type options can introduce a small upward bias but the bias is small for nearby options that are at the money (Manfredo, Leuthold and Iriwn,. 2001). Furthermore, averaging the nearest to the money calls and puts estimates (Process followed by CRB) is found to provide more accurate volatility estimates (Jorion, 1995). The reason at or near the money options tend to contain the most information regarding volatility is because they are usually the most traded options (Manfredo, Leuthold and Irwin, 2001).

Literature in agricultural commodities markets have failed to consistently prove forecasting superiority of implied volatility methods over historical volatility. Other studies have analyzed this relationship outside the agricultural commodities markets. Christensen and Prabhala (1998) examined the relationship between implied volatility and subsequent realized volatility for the OEX (S&P 100 index) options market and found that implied volatility outperforms past volatility in forecasting future volatility and even subsumes the information content of past volatility in some cases. Jorion (1995) examined the information content and predictive power of implied volatility derived from the Chicago Mercantile Exchange options on foreign currency exchanges using data from January 1985 to February 1992 and concluded that time series models are outperformed by implied volatility calculated using the Black Scholes formula. His results differed from those reported by Lamoureux and Lastrapes (1993) which focused on individual stock options and found that time series approaches contain predictive information over and above that of implied volatility.

Manfredo, Leuthold and Irwin (2001), used weekly data from January 1984 through December 1997 for corn, feeder cattle, fed cattle to analyze cash price volatility to analyze the forecasting performance of the discussed methods. They found that implied volatility derived from corn options using the Black Scholes (1976) model performed consistently well across different time horizons as a forecaster of realized volatility. However, their broader finding was that no single method of volatility forecasting (implied or historical) provides superior accuracy across alternative data sets and horizons. For a similar period of time (1986-1999) and using the Black Scholes model to calculate implied volatility, Manfredo and Sanders (2004) examined the forecasting performance of implied volatility derived from nearby live cattle options contracts in predicting 1-week volatility of nearby live cattle future prices. They found that implied volatility is a biased and inefficient forecaster of 1-week nearby live cattle futures price volatility. However, implied volatility encompassed all information provided by a time series alternative, and it has improved as a forecaster of realized volatility over time.

Simon (2002) studied the forecasting power of the implied volatility of corn, soybean, and wheat futures options at the Chicago Board of Trade, from January 1988 through September 1999 and compared its performance with the forecasting performance of seasonal GARCH specifications (Along the lines of Glosten, Jagammathan and Runkle, GJR, 1993). Implied volatility was calculated using the Black Scholes model specification. He found that the implied volatilities of corn, soybean and wheat future options, 4 weeks before option expiration, have significant predictive power for the underlying futures contract return volatilities through option expiration. Furthermore, his results indicated that grains' implied volatilities have substantial predictive power for realized volatilities, and that out-of-sample seasonal GJR volatility forecasts are encompassed by implied volatility and do not have significant predictive power when implied volatility is included in the models.

More recently, Brittain, Garcia and Irwin (2011) examined the forecasting performance of implied volatility derived from the live and feeder cattle options markets. Their data set span the period of time between Jan 1997 and Jan 2008. They used the Black, Scholes, and Merton (BSM) model to estimate implied volatility, based on the average of implied volatilities of the four options, two calls and two puts, which were closest to the money. They found implied volatility to be upwardly biased and an inefficient predictor of realized volatility with bias most pronounced in live cattle than in feeder cattle.

2.3 Composite Approach

Studies in the agricultural commodities arena and other financial assets have looked at the performance of composite approaches under different model specifications and have concluded that combining blackguard looking measures with forward looking measures provide with additional valuable information in forecasting future realized volatility, as opposed to using implied volatility and historical volatility forecasting methods alone (Manfredo et al, 2001; Benavides, 2004; Benavides and Capistran, 2012). Composite approaches consists of hybrid forecast methods to forecast realized volatility. This method uses historical volatility combined with implied volatility, therefore it takes advantage of past information combined with the forward looking nature of implied volatility. Composite approaches can be specified in different ways varying from simple averaging techniques to assigning weights generated from OLS regressions of past realized volatilities. Benavides and Capistran (2012) discussed that depending on the characteristics of the data to be analyzed, simple averaging techniques may not be flexible enough to efficiently model realized volatility.

Agricultural economists have agreed that composite approaches offer a valuable tool for risk managers in the agribusiness fields. Using data from 1984 to 1987, Mamfredo, Leuthold and Irwin (2001) analyzed composite approaches methods for forecasting realized volatilities in fed cattle, feeder cattle and corn cash markets, compared to historical volatility and implied volatility forecast methods. For the three commodities, they found composite approaches to rank among the top forecasters, when compared with historical and implied volatility by themselves. Furthermore they concluded that simple composites may be more robust across a wide spectrum of forecast horizons than regression composites. When analyzing fed cattle's cash return volatility, Mamfredo, Leuthold and Irwin (2001) concluded that no forecast method proved superior across time horizons. Composite methods ranked higher for short time horizons, but as time horizon increased, composite approaches decreased in ranking compared to implied volatility and historical volatility specifications. Similar results hold true for feeder cattle. In the case of corn, no particular forecast proved superior across different time horizons. The overall conclusion from their study was that when both time series forecasts and implied volatility are available, it might be convenient to combine the information from both forecast methods. Furthermore, their finding suggested that simple composite methods and historical forecast specification might perform as well as more complicated specifications. Granted that the results of this practice is going to be sensitive to the model specification, time horizons and commodity analyzed.

Outside the agricultural commodities arena, Benavides (2004) examined the volatility accuracy of a univariate GARCH, a multivariate ARCH, implied volatility and a composite forecast model for the case of the Mexican peso-USD exchange rate futures returns. He concluded that composite forecast model was the most accurate forecast method. His results support those of Manfredo, Leuthold and Irwin (2001), suggesting that if implied volatility type and historical volatility type forecast methods are available then the forecaster should take advantage of both methods.

2.4 Market Structural Changes

The definition of market regimes before analyzing the forecasting performance of agricultural commodities' volatility forecast methods is not something common in the literature. Studies in areas not related to agriculture have attempted to identify structural changes in their data sets before performing econometrical analysis. The Chow (1960) test and the Bai and Perron (2003) statistical test both analyze parameter instability and structural change. The Chow test and the Bain and Perron test have been applied in the literature to econometric work in order to identify regimes in the data set where the estimated parameters will hold robust.

Chow (1960) developed a procedure that tested for regime change at a specific known date. Given the significant shortcoming of this procedure, say the specific break date must be suspected by the analyst, the Chow test is now used in the literature by applying it to all the possible observations in the data set, but this practice still does not solve the question of the exact number of breaks (if more than one) and on which dates they occurred. The Chow test can be performed using statistical packages like SAS and Stata. Bai and Perron (1998; 2003) addressed the problem of the estimation of the break dates and developed an algorithm to obtain global minimizers of the sum of the square residuals. Their study is now known as the Bai and Perron test and it is available in statistical packages like SAS (9.4).

Complementing the statistical approach, some studies have posed the idea of combining it with a qualitative ad-hoc method. Kar et. al (2013) proposed a unified approach that combines the ad-hoc method for identifying structural changes, with the statistical approach in order to avoid the limitations of each approach alone. Kar et. al (2013) discussed that studies using the statistical approach provide a uniform technique to identify the breaks, but a significant shortcoming is that it is limited to the power of the commonly used statistical tests. On the other hand, the main shortcoming of the ad-hoc approach is that it lacks of consistency across studies, in other words there is not a unified framework in the literature that can be applied in this study.

There is not a consensus on whether the Chow test is more appropriate than the Bai and Perron test but studies have combined both approaches in identifying shocks. Wakamatsu and Aruga (2013) studied the impact of the shale gas revolution on the U.S. and Japanese natural gas market. In their study they used first the Chow test to test for a single break and later the Bai and Perron approach to test for unknown number of breaks and dates.

2.5 Major Market Changes

Since 1995 there has been several events that might have changed the way the markets work and hence commodity price volatility. This sub-section provides with a brief description of The U.S. bill containing the Energy Policy Act in 2005 and its increase in 2007, the financial crisis that struck the U.S. and world economy in 2008 and the major 2010-2011 droughts which occurred in the biggest grains producers in the world, as some of the main factors potentially affecting the market structural changes in this study. We contemplate the idea that these mentioned events will be relevant in shaping the market regimes to be later identified in this study.

The bill containing the Energy Policy Act of 2005 was passed by the U.S. congress in July 29, 2005. This bill changed U.S. tax policy on energy and provided loans destined towards energy production of various types. The bill contemplated the “Renewable Fuel Standard” which increased the target of the amount of biofuel that must be mixed with gasoline sold in the U.S. to 7.5 billion U.S. gallons by 2012, up 1 billion U.S. gallons from 1990. The Energy Independence and Security Act of 2007 increased this target again to 36 billion U.S. gallons by 2022. Ethanol, made mostly from corn, is the highest biofuel produced in the U.S. accounting for 94 percent of all biofuel production in 2012, the remainder is biodiesel, which is made from vegetable oils (chiefly soy oil) as well as animal fats, waste oils, and greases (USDA, ERS, 2012).

The bill was particularly controversial and critiqued by sectors whom argued it increased competition of grains for food consumption. Increased pressure in the corn markets is likely transferred to other agricultural crops and to livestock, since corn is commonly used as feed.

High food prices from 2007 through mid-2008 had serious implications for food nutrition security, macroeconomic stability, and political security. That is the way in which Joachim von Braun (2008) from the International Food Policy Research Institute, started explaining the linkage between the financial crisis and the agricultural commodities sector. He went further and said that the financial crisis in 2008 stemmed from flawed regulatory regimes and subprime mortgage lending. Capital diverted from the collapsing housing market, speculation in agricultural futures, as well as hoc market and trade policies contributed to the level and volatility of commodity prices further increase. It is important to mention that research has failed to prove that the increase in speculators participation in commodity futures markets consistently led futures price changes (Irwin, Sanders and Merrin 2009; Sanders, Irwin and Merrin 2010).

The mentioned research also highlights historical pattern of attacks upon speculation during periods of extreme market volatility (Irwin, Sanders and Merrin 2009).

Different linkages can be identified between the financial crisis and the agricultural commodities markets. Allocation of capital in the broader spectrum, as capital got scarcer and uncertainty in the stock markets increased during the financial crisis, competition for capital allocation increased, which might have constrained agricultural expansion, in times when developing middle classes in countries like China and India are demanding more protein foods. From a final consumer perspective, besides the troubles caused by decreases in wages and considerable cuts in jobs, consumers had to deal with higher prices for staple food which spiked during the financial crisis.

The Economic Research Service of the USDA (2011) included weather shocks as one of the causes of the spike in food prices from June 2010 to February 2011. In particular, underlying recent crop price increased due to a series of adverse weather events in a number of major world producing regions, like Brazil, the United States and Russia that occurred in a relatively compressed time period (USDA, ERS 2011). Data from the USDA allowed me to do calculations and illustrate the importance of the mentioned countries in the agricultural commodities global markets. In 2013 these 3 countries together accounted for: 62% of the global production of soybeans, 45% of the global production of corn, 16% of the global production of wheat, 39% of the global production of beef and 15% of the global production of swine meat (USDA, PSD)

The 2010 drought in Brazil was associated with unusually warm seas in the Atlantic Ocean off the Brazilian coast. In 2010, Russia experienced continuous droughts that started in June 2010, combined with widespread wildfires (USDA, ERS 2011). In the United States from September until December 2010, historical low precipitations occurred in Kansas, Colorado and

Texas, important producers of hard red winter wheat. Western Kansas had the 11th lowest in more than 100 years; eastern Colorado had the 3rd lowest on record; the Texas panhandle the 15th lowest (USDA, ERS 2011).

Some of the adverse drought impacts include yield losses in agricultural crops and part of the agricultural crops are used as feed to animal protein production. Therefore it is possible that the combined weather effects in 2010, combined with remaining fears from the 2008 financial crisis, might have had an impact on the volatility structure across agricultural commodities.

Chapter 3 - Data

This analysis was performed using futures and options market data for corn, wheat, soybeans, live cattle, feeder cattle and lean hogs from the CME Group. Specifically, the data was obtained from Bloomberg Professional Service data terminals. The data includes weekly series of futures' contracts closing price, puts and calls option contract's implied volatility, and historical volatility of futures prices over the period of time beginning January 13th, 1995 and ending April 25th, 2014. The weekly futures price provided by Bloomberg, consists of the last closing price of a specific commodity, the last trading day of the week.

To avoid using data close to the delivery time, the prices and volatilities were defined to have at least 15 days before the expiration date. This method is consistent with other studies in the agricultural commodities volatility forecasting arena (i.e. Manfredo and Sanders, 2004). Furthermore, by rolling over to the next available contract 15 days before the expiration of the current contract, we are making sure that we are using a highly liquid contract at the time the forecast is analyzed. There was a small percentage of implied volatility missing observations across the six commodities at the beginning of the data series. Those observations were deleted for the purpose of this analysis.

Historical call implied volatility and historical put implied volatility weekly series were downloaded from Bloomberg and then averaged to come up with our implied volatility data series for each commodity. Jorion (1995) discussed that averaging the implied volatility from both puts and calls, reduces estimation error. Bloomberg calculates option's implied volatility by creating a weighted average of the volatilities of the two closest options and then the estimate for put options and call options is averaged. Manfredo and Sanders (2004) described that using the nearby at-the-money options price minimizes the small upward bias in the volatility estimate caused by using a European option pricing model like the Black Scholes, for American style options (Bloomberg data comes American style options).

Bloomberg calculates the 20-days historical volatility from the standard deviation of day to day logarithmic historical price changes in futures contracts prices. The 20-day price volatility equals the annualized standard deviation of the relative price change for the 20 most recent trading day's closing price, expressed as a percentage.

Our data series were cross checked with The Commodity Research Bureau (CRB) data. CRB is a privately own provider of commodity and futures data. The futures prices and implied volatility CRB's data series were very highly correlated with those coming from Bloomberg. Although we found strong correlation between the 20-day historical volatility data series from both data providers, the strength of this correlation was not as high as the one from the futures prices and implied volatility.

The futures' closing price data series were used to estimate the realized volatility. The true realized volatility is not observable (Manfredo and Sanders, 2004). Jorion (1997) proposed a common method for developing a proxy for realized volatility. This proxy is accepted in the risk management arena and defines realized volatility as the square root of the average of squared returns over a particular time horizon. The formula is shown below:

(3.1) $$\boldsymbol{\sigma_{t+h} = \sqrt{\frac{1}{h}\sum_{j=1}^{h} R_{t+j}^{2}}}$$

where σ_{t+h} is realized volatility, h is the time horizon and R_t is the continuously compounded return estimated as:

(3.2) $$R_t = \ln(P_t) - \ln(P_{t-1})$$

where P_t and (P_{t-1}) are the futures prices observed in time period t and t-1, respectively. Since we initially estimate 1-week ahead realized volatility (h=1), the realized volatility equation reduces to:

(3.3) $$\sigma_{t+1} = \sqrt{R_{t+1}^2}$$

Because implied volatility theoretically represents the annualized average volatility expected over the remaining life of the option contract (Manfredo and Sanders, 2004), the realized volatility measure is annualized to be consistent with the implied volatility as follows:

(3.4) $$\sigma_{t+1} = \sqrt{R_{t+1}^2 * 52}$$

Our composite approach was created by regressing the realized volatility measure against implied volatility and historical volatility. The weights for each method were then determined by the regression coefficients in each variable. Because of this reason in each commodity and in different market regimes the weights of implied and historical volatility in their composite approach, were determined by the results of the mentioned regression.

The naïve expectation was defined as the realized volatility measure of one period behind for the period analyzed. For example in our data, the naïve volatility forecast for week X_t would be the realized volatility value in week X_{t-1}. The idea of analyzing a naïve forecast is that if no other volatility forecast is available, how valuable it would be for a risk manager to use the realized volatility values as a forecast measure for volatility in following periods.

3.1 Preliminary analysis

This section shows the results of the summary statistics for the full period of time of our data which begins in January 13th, 1995 and ending April 25th, 2014. The summary statistics includes the mean, standard deviation, maximum, minimum and total number of observations. Additionally, graphs that illustrate the futures prices range (last, highest and lowest futures prices) for each of the six commodities analyzed are presented. The summary statistics analysis was performed using Stata.

Table 3.1, Descriptive Statistics for Realized Volatility, Implied Volatility and Historical Volatility expressed as %

Commodity	Variable	# Obs	Mean	Std. Dev.	Min	Max
Corn	Realized Volatility	997	21.705	19.946	0.000	136.123
	Implied Volatility	997	27.445	8.415	11.225	60.590
	Historical Volatility	997	26.834	11.489	6.940	113.890
Wheat	Realized Volatility	1007	23.730	19.923	0.000	135.419
	Implied Volatility	1005	28.852	8.220	3.800	74.040
	Historical Volatility	1007	29.901	10.660	7.810	89.420
Soybeans	Realized Volatility	1003	18.939	16.999	0.000	150.354
	Implied Volatility	1003	24.560	7.521	10.685	54.720
	Historical Volatility	1003	23.215	9.780	6.090	66.760
Live Cattle	Realized Volatility	1001	13.490	12.170	0.000	111.788
	Implied Volatility	1001	15.277	4.254	6.620	56.870
	Historical Volatility	1001	16.092	6.613	4.880	47.870
Feeder Cattle	Realized Volatility	982	11.653	10.403	0.000	80.873
	Implied Volatility	982	12.531	4.080	3.405	66.590
	Historical Volatility	982	13.442	5.100	5.320	44.250
Lean Hogs	Realized Volatility	986	23.893	25.037	0.000	198.853
	Implied Volatility	986	23.139	7.083	9.810	79.140
	Historical Volatility	986	29.929	15.173	9.420	125.050

The cattle markets are the least volatile over time and the grains markets are more volatile overall in this time period based on mean realized volatility. Within the livestock markets, lean hogs showed the highest average realized volatility followed by live cattle. In the grains markets, wheat showed the highest average realized volatility over time followed by corn.

Prices and volatilities were plotted and shown below for each of the six commodities. These graphs were created using Microsoft Office Excel.

Figure 3.1, Corn Implied and Historical Volatility (%)

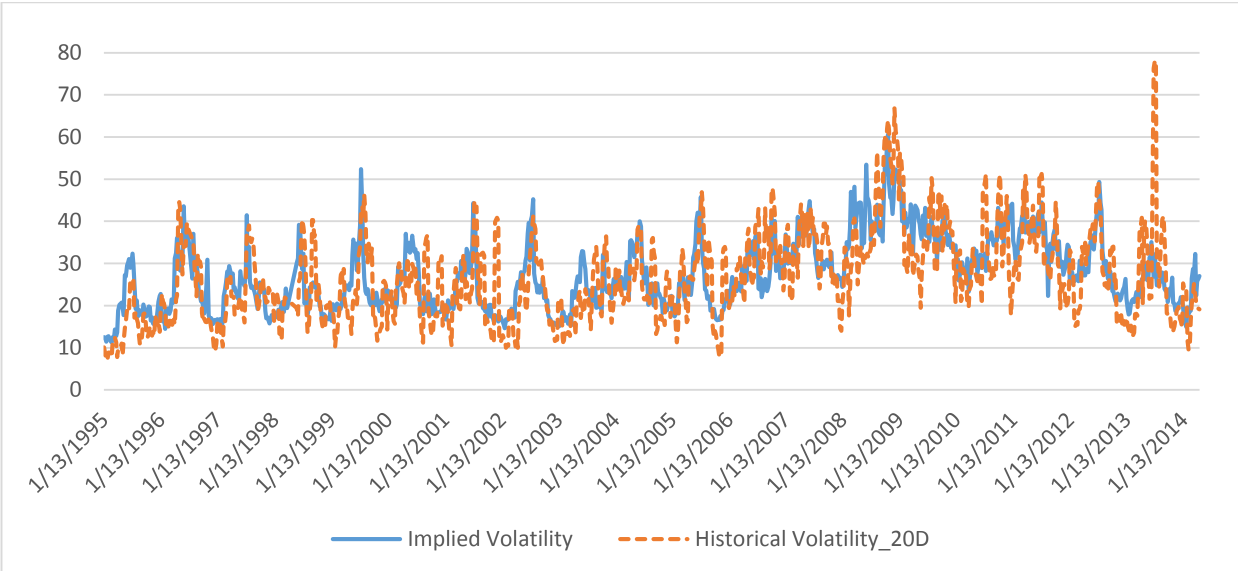


Figure 3.2, Soybeans Implied and Historical Volatility (%)

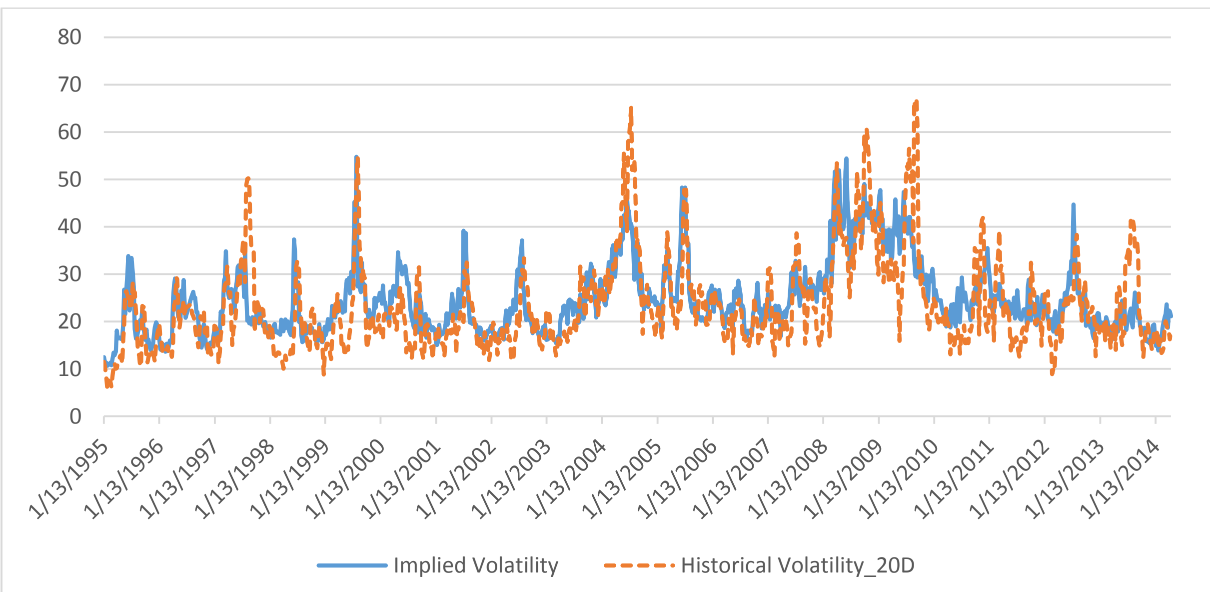


Figure 3.3, Wheat Implied and Historical Volatility (%)

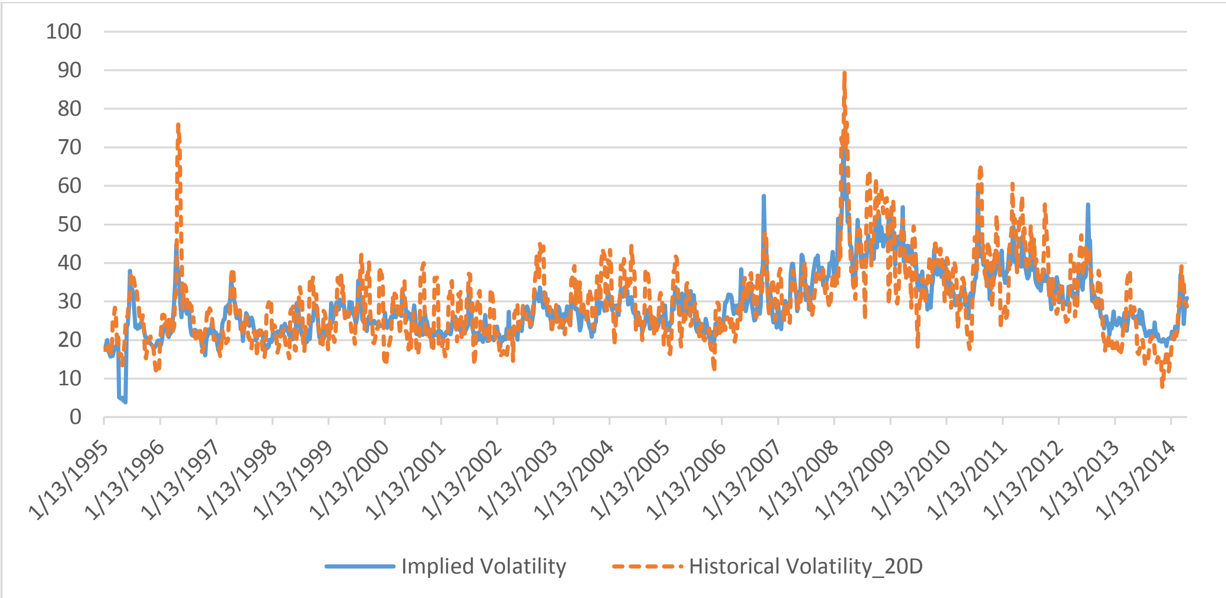


Figure 3.4, Live Cattle Implied and Historical Volatility (%)

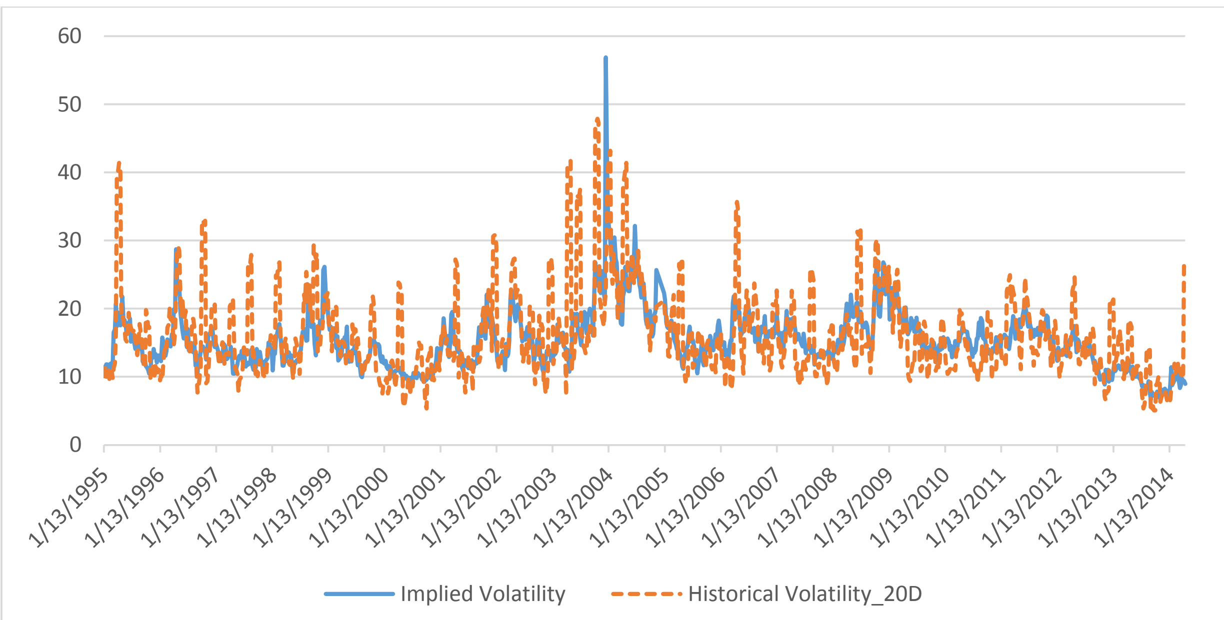


Figure 3.5, Feeder Cattle Implied and Historical Volatility (%)

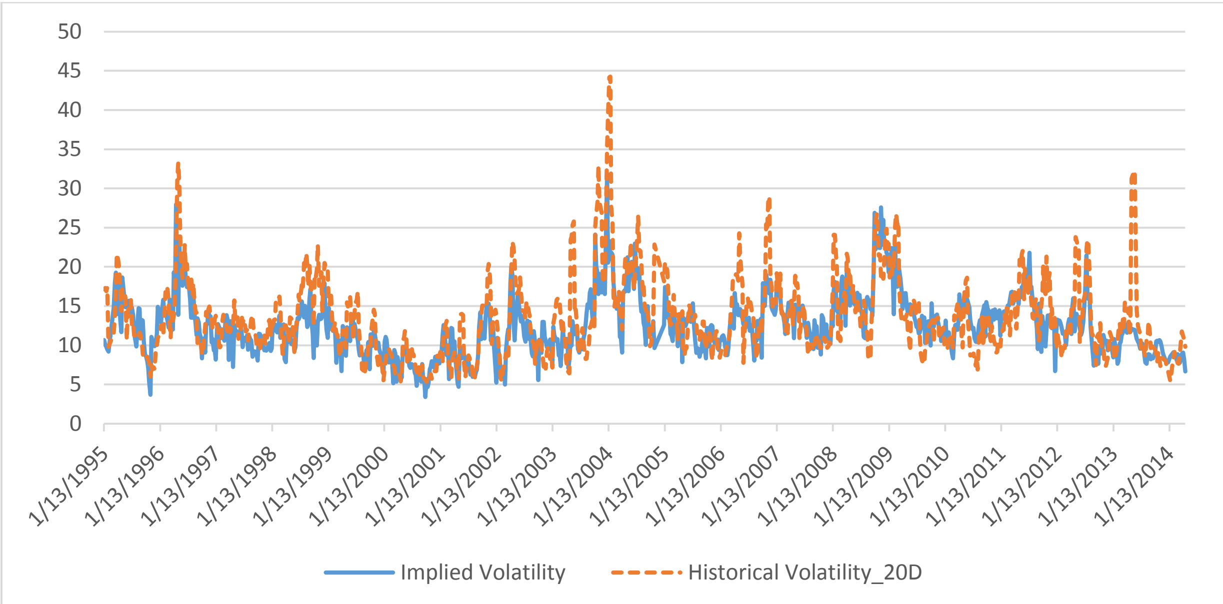
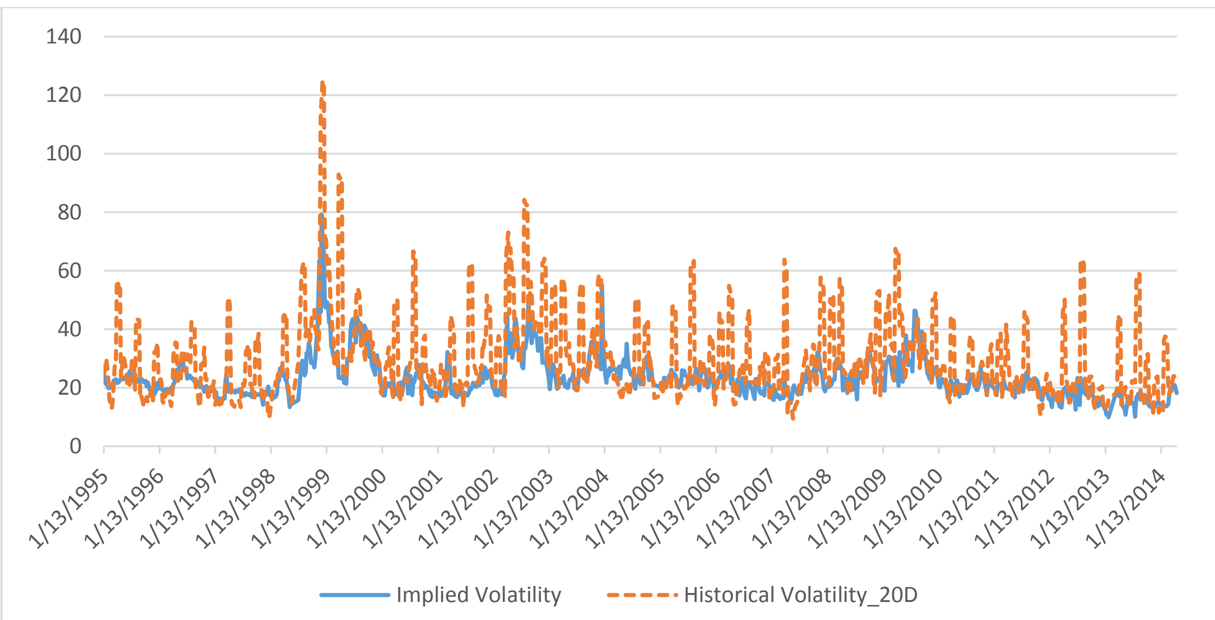


Figure 3.6, Lean Hogs Implied and Historical Volatility (%)



Visually inspecting the previous graphs reveals that across all six commodities, the volatility measures, and therefore price variability, has increased roughly after the 2000s. Different factors could be contributing to this but in general, market complexities constantly change. For example, the introduction of ethanol policy act in 2006 in the U.S., the global financial crisis in 2008, changes in weather, changes in demand trends, increasing population, energy costs and geopolitical conflicts are just some of the factors that have been contributing to this trend.

Chapter 4 - Identifying Market Structural Changes

The idea of identifying the existence, timing, and number of market structural changes is to define market regimes for the corn, wheat, soybeans, live cattle, feeder cattle and lean hogs markets individually. The benefit of identifying market regimes is to remove the impact of those market structural changes on the forecasting performance of historical, implied and combined volatility forecasts by separating the data sets using the breaks identified in our analysis.

In order to identify market structural changes, several steps were followed. In our research, we are defining market structural changes with the objective of improving forecasting accuracy, therefore including variables in the model to account for the structural changes would potentially not improve the forecasting accuracy of the model, given the events that affect the markets structure are more likely unforeseen.

The identification of the market structural breaks consisted of two main stages. The first stage combined statistical tests like the Chow (1960) test for single break and the Bai and Perron (2003) test for multiple structural breaks. In the second stage we complement the statistical approach with previous knowledge about the agricultural commodities markets, and other subjectively defined rules explained more in detail later in this chapter, to further refine conclusions regarding structural breaks.

Previous literature discusses the limitations of using the statistical method or qualitative "ad hoc" methods alone. Kar et al (2013) discussed that the "ad-hoc" approach lacks consistency across studies and the pure statistical approach has low power and is not able to accurately identify genuine structural breaks, especially for high volatility series. Consistency is of big importance in our study given the variety of products in the agricultural commodities arena that are being analyzed. We believe that the statistical analysis alone might pose bias given the frequency and high volatility of our data sets. That said, both approaches were combined with the objective of improving the accuracy in the identification of breaks.

4.1 Estimation Methods for Market Regimes

First for every commodity we performed the Chow test for market structural changes. The Chow test examines for regime change at a priori known dates. More specifically, the Chow test procedure splits the sample into two sub periods, estimates the parameters for each sub period, and then test tests the equality of the two sets of parameters using a classic F statistic. Limitations of the Chow test are widely discussed in the literature. Hansen (2001) explained an important limitation of the Chow test. The break date must be known a priori, in that case a researcher has two choices: to pick an arbitrary candidate break date or to pick a break date based on some known feature of the data. In the first case, the Chow test may be uninformative, as the true break date can be missed. In the second case, the Chow test can be misleading, as the candidate break date is endogenous (it is correlated with the data) and the test is likely to indicate a break falsely when none in fact exists (Hansen, 2001). If the Chow test tested positive for structural changes, then we proceeded to perform the Bai and Perron test for multiple market structural changes to define the number and dates of the breaks.

The Bai and Perron (BP) test emerged as a result of a key short-coming of the Chow test: that the candidate break must be known a priori. The BP test allows for multiple unknown breakpoints and is a sequential method that starts by testing for a single structural break. If the test rejects the null hypothesis that there is no structural break, the sample is split in two and the test is reapplied to each subsample. This sequence continues until each subsample test fails to find evidence of a break (Hansen, 2001). The BP test requires analysts to define the maximum number of breaks considered in the data series (M) and a specified minimum length of each regime. These specifications can vary according to the knowledge of the researcher about the analyzed market, the frequency of the data, and the number of observations available. Therefore this process can be a little subjective.

We performed the BP test specifying different maximum number of breaks allowed and different regime length specifications. For consistency across all six commodities after analyzing all the different test outputs we decided that allowing the test for a maximum of 20 breaks (i.e. M=20) was the most adequate. Regarding the minimum length of the regime, we consider 25 weeks a reasonable regime length, recognizing difference across all six commodities examined. We think that market structural changes in our context are specially driven by supply and demand shocks, therefore this mentioned period of time would let enough time for those factors to interact and reach a new equilibrium.

It is important to mention that when different numbers of breaks were allowed or different minimum length of the regimes were specified, the BP test suggested different number of breaks and break dates.

There are different approaches in interpreting the results of the BP test. Our approach aligns with the strategy suggested by Bai and Perron (2003). They suggested to first look at the UD max or the WD max tests to see if at least one break is present. The UD max or the WD max present with the null hypothesis of no break present in the series and the alternative hypothesis of unknown number of breaks up to M. If the UD max/WD max test's null hypothesis is rejected, meaning the test indicates the presence of at least one break, we move to the supF(l+1|l) sequential examination to decide the number of breaks. The supF(l+1|l) statistics is constructed using global minimizers for the break date, this test selects M such that the test supF(l+1|l) are significant for l>= m. For every M, the supF(l+1|l) test presents the null hypothesis of no break and the alternative hypothesis of l+1 breaks, l=0 up to l=M. Bai and Perron (2003) discussed that this method for interpreting the BP tests leads to the best results and is recommended for empirical applications.

Alternatives in the context of estimating the number of breaks exist. The Bayesian Information Criterion (BIC) and the Scwarz Criterion (LWZ) are both provided in the BP results using SAS statistical package, but Bai and Perron (2003) discussed several reasons to use the above described strategy instead of using BIC or LWZ criterion. The reasons include that the BIC and LWZ perform reasonable well in the absence of serial correlation, but variations exist when this is not the case.

After defining the different regimes using the BP test, we then incorporated our ad hoc approach. We first found out summary statistics for each regime and defined a rule to merge regimes in which the mean of realized volatility was within 20% of the previous regime. That is, if the BP process suggested a change that identified two regimes with average realized volatility within 20%, we collapsed these two regimes down to one regime. Each new set of regimes was analyzed and sequentially merged using the same procedure. We applied this procedure for each of the six commodities.

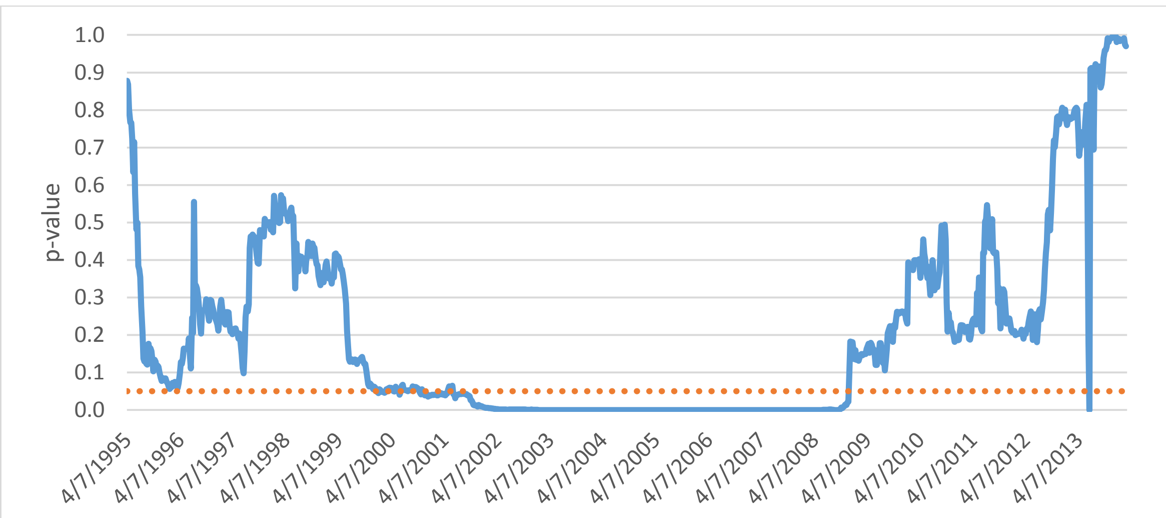
4.2 Results

This section includes analysis performed using SAS (9.4), Stata and Microsoft Office Excel. SAS (9.4) was used to perform the Chow test and the Bai and Perron test. Stata was used to generate the summary statistics for all the market regimes in each commodities. Microsoft Office Excel was used to create the graphs.

To perform the Chow test we needed to know the break data a priori. To add objectiveness to this analysis, we applied the Chow test to every possible observation within the data series for each commodity. The Chow test proved statistically significant for more than one data point in each of the six commodities. This leads us to believe that there is more than one structural break in each data sets.

Figure 4.1 illustrates the Chow results for corn (To see the Chow test results for wheat, soybeans, live cattle, feeder cattle and lean hogs please see Appendix A- Identifying Market Structural Changes). The orange line in figure 4.1 represents the statistical significance at the 95 % level of confidence. For every observation below the orange line it means that there is a break in that data point. Overall, this suggests that data sets should likely not be analyzed as a whole and that market regimes need to be identified before performing econometric analysis.

Figure 4.1, Corn Chow Test Results



Since the Chow tests showed that there are structural changes in each data series, the next step was to perform the Bai and Perron tests. For interpreting the BP test we follow Bai and Perron (2003), as described earlier. The Bai Perron test for multiple structural breaks was applied to all the commodities analyzed in this study in order to identify the exact number of breaks and their dates. The following section shows the results of the BP test for corn. For similar output performed to wheat, soybeans, live cattle, feeder cattle and lean hogs please refer to Appendix A-Identifying Market Structural Changes.

Table 4.1 is the UDmax F test for multiple structural changes and Table 4.2 is the WDmax F test for multiple structural changes applied to corn realized volatility data series. The UDmax and the WDmax F tests, part of the Bai Perron's Multiple Structural Change test results, were statistical significant at the 95 % level of confidence. This suggests a rejection of the null hypothesis of no structural changes present in the series. In other words, there is enough statistical evidence to believe that there are at least one structural break in the data. This confirms the Chow test results.

Table 4.1, Corn UDmax F test

Number of breaks	UDmaxF	Pr > UDmaxF
20	119.4965	<.0001

Table 4.2, Corn WDmax F test

Number of breaks	Alpha	WDmaxF	Pr > WDmaxF
20	0.100	128.896486	<.0001
	0.050	133.523034	<.0001
	0.025	137.772286	<.0001
	0.010	142.607136	<.0001

The UDmax and the WDmax tests also proved statistically significant at the 95% level of confidence for wheat, soybeans, live cattle, feeder cattle and lean hogs. The next step is to identify the number of breaks and their dates. For that purpose we use the supF(l+1|l) test statistics.

Table 4.3, Corn supF (l+1|l) test

l	New Break	supF(l+1|l)	Pr > supF(l+1|l)
0	575	61.3765	<.0001
1	823	33.9560	0.4697
2	**963**	**102.2520**	**<.0001**
3	575	38.8401	0.1212
4	912	23.0118	0.9998
5	575	36.7505	0.2283
6	912	23.0118	0.9998
7	823	21.1860	0.9998
8	476	16.9966	0.9999
9	476	16.9966	0.9999
10	184	15.8791	0.9999
11	240	17.3066	0.9999
12	323	16.7491	0.9999
13	30	25.6835	0.9989
14	331	23.4596	0.9997
15	158	15.8019	0.9999
16	575	23.6349	0.9997
17	158	15.8019	0.9999
18	158	15.8019	0.9999
19	158	15.8019	0.9999
20	158	15.8019	0.9999

Table 4.3 shows the results for the supF (l+1|l) applied to the corn data series. This test should be interpreted sequentially such that for every M, the supF(l+1|l) test presents the null hypothesis of no break and the alternative hypothesis of l+1 breaks, l=0 up to l=M. The "New Break" column in this table represents the date of the observation point in the data series and the statistical significance is given by the "Pr > supF(l+1|l)" column. Under those circumstances, at the 95% level of confidence, we stop rejecting the null hypothesis of no break at l=3. This leads us to believe that there are 3 breaks (l=2) present in the corn realized volatility series. Each commodity stopped rejecting the null hypothesis at different l values.

Table 4.4, Corn BP break dates

Number of breaks	Break	Date	95% Confidence Limits	
3	679	01/11/2008	676	682
	727	12/12/2008	724	730
	963	06/21/2013	959	967

Since the supF (l+1|l) test suggested l=2 +1 breaks, we move to the BP break table from the Bai Perron's Multiple Structural Change test results to find the data points where the breaks were identified (Table 4.4) . In this situation "Number of Breaks" = 2 suggests that the two breaks are in observations 679 and 727 which corresponds to January 11th, 2008 and Dec 12th, 2008 respectively. The third break point is given by the supF (l+1|l) test in table 4.3 under the "New Break" column. The third data point is 963 which corresponds to June 21st, 2013.

In summary, and following the same procedure above, we identified the break points in the wheat, soybean, live cattle, feeder cattle and lean hog series of realized volatility. In the wheat markets we found a total of 7 regimes, 6 in soybeans, 14 in live cattle, 17 in feeder cattle and 22 in lean hogs. This is the end of the statistical approach in identifying the market structural breaks. The next step was to combine these results with our ad-hoc approach to further refine identification of market regimes.

Table 4.5, Corn break dates summary statistics

Reg.	Dates	# Obs	Mean	Std. Dev.	Min	Max	% Change
1	1/13/1995-1/11/2008	670	0.196	0.174	0.000	1.102	
2	1/18/2008-12/12/2008	48	0.410	0.356	0.000	1.361	209.051
3	12/19/2008-6/21/2013	236	0.250	0.209	0.000	0.936	61.111
4	7/5/2013-4/25/2014	43	0.149	0.124	0.004	0.725	59.531

*% Change= % change in mean.

Recall our ad hoc approach consisted of merging regimes in which the realized volatility means were within 20%. Table 4.5 shows the summary statistics results of the breaks identified using the Bai Perron's test in the corn series of realized volatility. The "% Change" column was calculated using the mean realized volatility for each regime, compared to the previous regime. In the case of corn no regimes were merged as each regime on average was more than 20% different than the previous regime.

The same procedure was applied to wheat, soybeans, live cattle, feeder cattle and lean hogs with different results. Tables 4.6 to 4.11 summarize the weekly realized volatility data series for the full period and each defined market regime in all 6 commodities.

Table 4.6, Corn Merged Regimes with Realized Volatility Summary Statistics

	Dates	# Obs	Mean	Std. Dev.	CV	Min	Max
Full Period	1/13/1995-4/25/2014	997	0.217	0.199	0.919	0.000	1.361
Regime 1	1/13/1995-1/11/2008	670	0.196	0.174	0.888	0.000	1.102
Regime 2	1/18/2008-12/12/2008	48	0.410	0.356	0.870	0.000	1.361
Regime 3	12/19/2008-6/21/2013	236	0.250	0.209	0.833	0.000	0.936
Regime 4	7/5/2013-4/25/2014	43	0.149	0.124	0.831	0.004	0.725

Table 4.7, Wheat Merged Regimes with Realized Volatility Summary Statistics

	Dates	# Obs	Mean	Std. Dev.	CV	Min	Max
Full Period	1/13/1995-4/25/2014	1007	0.237	0.199	0.840	0.000	1.354
Regime 1	1/13/1995-4/5/1996	65	0.202	0.145	0.717	0.005	0.764
Regime 2	4/12/1996-4/18/1997	54	0.266	0.242	0.911	0.000	1.184
Regime 3	4/25/1997-11/16/2007	552	0.212	0.167	0.790	0.000	1.006
Regime 4	11/23/2007-1/16/2009	61	0.390	0.298	0.765	0.011	1.354
Regime 5	1/23/2009-1/1/2010	50	0.266	0.197	0.740	0.014	0.758
Regime 6	1/8/2010-12/3/2010	48	0.325	0.279	0.860	0.008	1.325
Regime 7	12/10/2010-4/25/2014	177	0.236	0.197	0.832	0.006	1.099

Table 4.8, Soybeans Merged Regimes with Realized Volatility Summary Statistics

	Dates	# Obs	Mean	Std. Dev.	CV	Min	Max
Full Period	1/13/1995-4/25/2014	1003	0.189	0.170	0.898	0.000	1.504
Regime 1	1/13/1995-8/22/2003	446	0.155	0.135	0.871	0.000	0.901
Regime 2	8/29/2003-7/1/2005	97	0.250	0.215	0.859	0.002	1.104
Regime 3	7/8/2005-11/9/2007	123	0.184	0.138	0.749	0.002	0.582
Regime 4	11/16/2007-9/4/2009	95	0.318	0.269	0.847	0.011	1.504
Regime 5	9/11/2009-4/25/2014	242	0.180	0.141	0.783	0.000	0.772

Table 4.9, Live Cattle Merged Regimes with Realized Volatility Summary Statistics

	Dates	# Obs	Mean	Std. Dev.	CV	Min	Max
Full Period	1/13/1995-4/25/2014	1001	0.135	0.122	0.902	0.000	1.118
Regime 1	1/13/1995-4/5/1996	65	0.126	0.094	0.746	0.000	0.379
Regime 2	4/12/1996-10/11/1996	27	0.190	0.165	0.873	0.005	0.661
Regime 3	10/18/1996-7/17/1998	92	0.106	0.080	0.759	0.000	0.347
Regime 4	7/24/1998-6/18/1999	48	0.171	0.137	0.802	0.003	0.654
Regime 5	6/25/1999-4/6/2001	94	0.088	0.071	0.810	0.003	0.388
Regime 6	4/13/2001-2/14/2003	97	0.150	0.138	0.920	0.003	0.687
Regime 7	2/21/2003-1/21/2005	95	0.203	0.173	0.853	0.000	1.118
Regime 8	1/28/2005-10/21/2011	352	0.136	0.117	0.859	0.000	0.683
Regime 9	10/28/2011-4/25/2014	131	0.106	0.095	0.896	0.000	0.541

Table 4.10, Feeder Cattle Merged Regimes with Realized Volatility Summary Statistics

	Dates	# Obs	Mean	Std. Dev.	CV	Min	Max
Full Period	1/13/1995-4/25/2014	982	0.117	0.104	0.893	0.000	0.809
Regime 1	1/13/1995-5/29/1998	173	0.124	0.108	0.869	0.002	0.734
Regime 2	6/5/1998-5/14/1999	50	0.152	0.107	0.702	0.015	0.495
Regime 3	5/21/1999-1/26/2001	89	0.056	0.041	0.738	0.002	0.163
Regime 4	2/2/2001-2/7/2003	106	0.096	0.085	0.880	0.002	0.413
Regime 5	2/14/2003-5/16/2008	267	0.129	0.115	0.891	0.002	0.809
Regime 6	5/23/2008-6/5/2009	55	0.171	0.137	0.800	0.002	0.505
Regime 7	6/12/2009-5/17/2013	201	0.117	0.094	0.800	0.000	0.508
Regime 8	5/31/2013-4/25/2014	41	0.067	0.055	0.820	0.001	0.200

Table 4.11, Lean Hogs Merged Regimes with Realized Volatility Summary Statistics

	Dates	# Obs	Mean	Std. Dev.	CV	Min	Max
Full Period	1/13/1995-4/25/2014	986	0.239	0.250	1.048	0.000	1.989
Regime 1	1/13/1995-11/1/1996	95	0.214	0.198	0.928	0.005	1.186
Regime 2	11/8/1996-1/16/1998	63	0.142	0.158	1.114	0.000	0.884
Regime 3	1/23/1998-11/5/1999	87	0.362	0.357	0.985	0.007	1.989
Regime 4	11/12/1999-9/7/2001	96	0.212	0.233	1.098	0.005	1.321
Regime 5	9/14/2001-8/8/2003	100	0.312	0.316	1.015	0.000	1.906
Regime 6	8/15/2003-5/18/2007	193	0.212	0.204	0.961	0.000	1.230
Regime 7	5/25/2007-4/2/2010	150	0.297	0.275	0.925	0.013	1.446
Regime 8	4/7/2010-4/25/2014	203	0.192	0.204	1.064	0.002	1.639

The previous tables are complemented with the following graphs. Figures 4.2 to 4.7 illustrate the weekly realized volatility levels in the different regimes for corn, wheat, soybeans, live cattle, feeder cattle and lean hogs.

Figure 4.2, Corn Realized Volatility by Regime

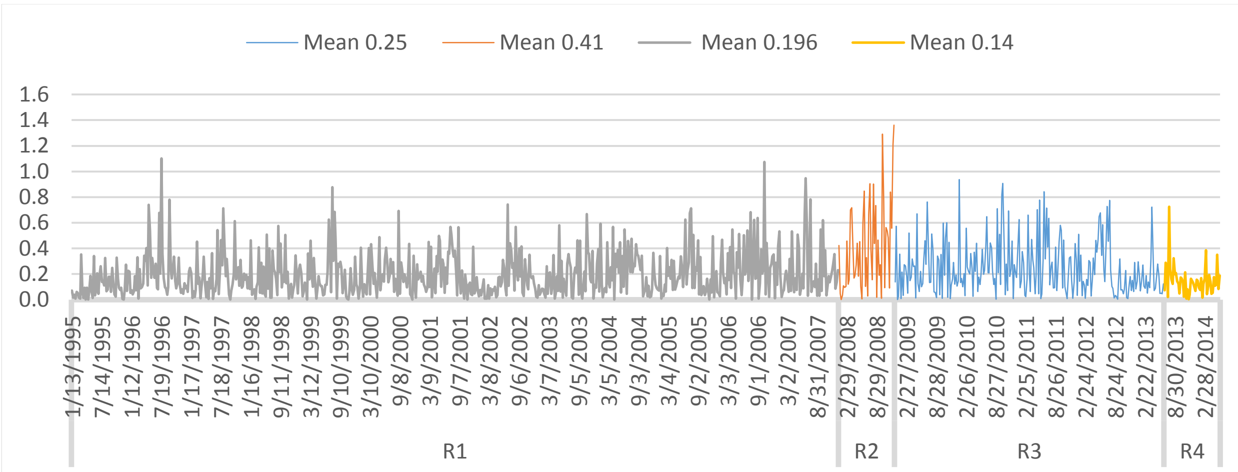


Figure 4.3, Wheat Realized Volatility by Regime

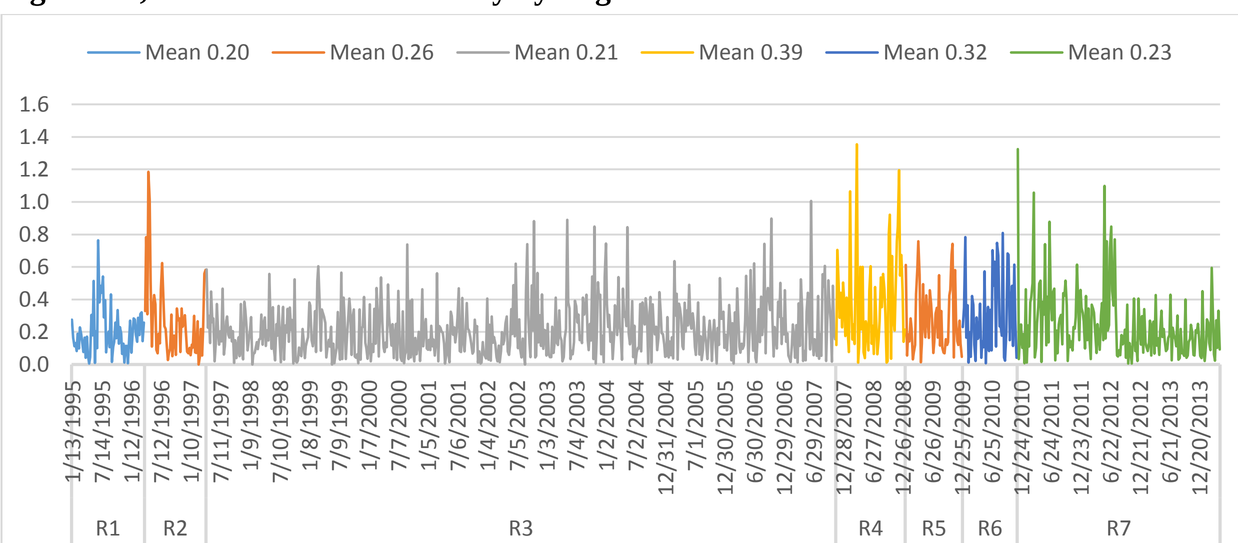


Figure 4.4, Soybeans Realized Volatility by Regime

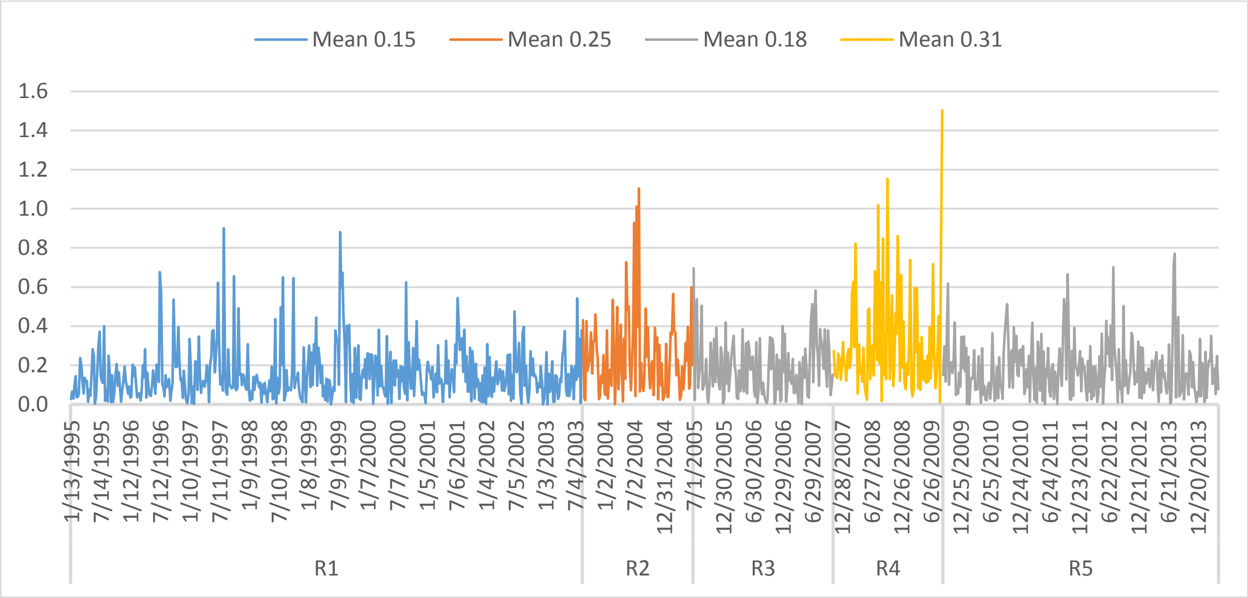


Figure 4.5, Live Cattle Realized Volatility by Regime

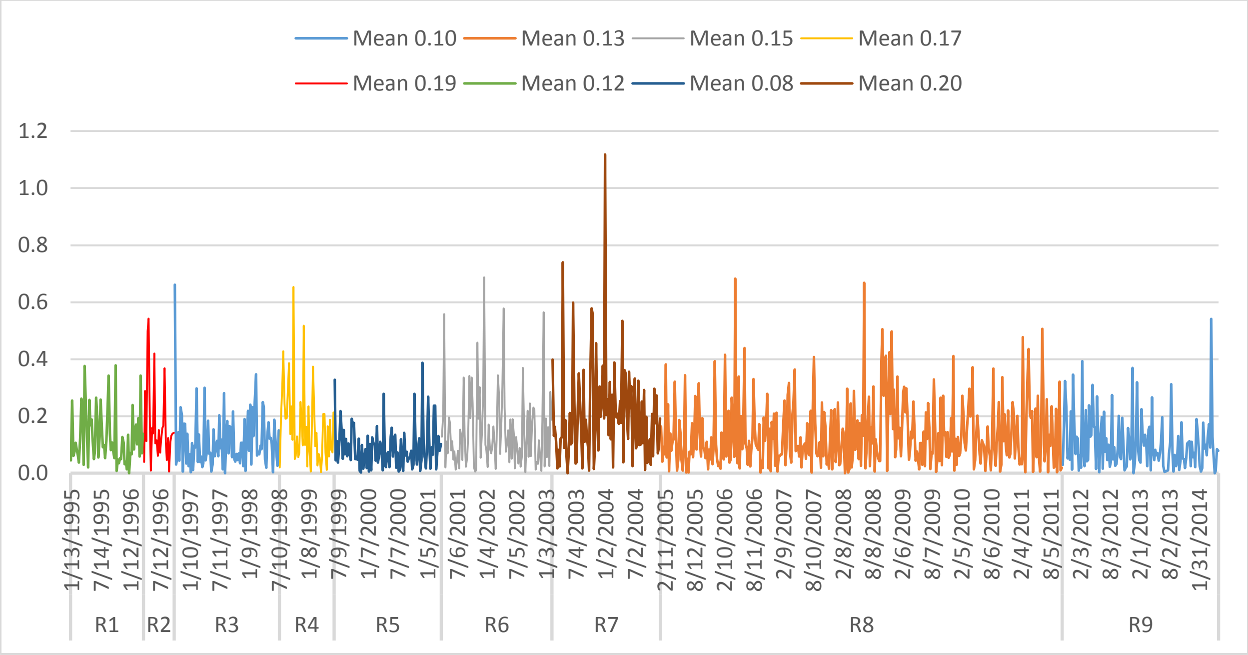


Figure 4.6, Feeder Cattle Realized Volatility by Regime

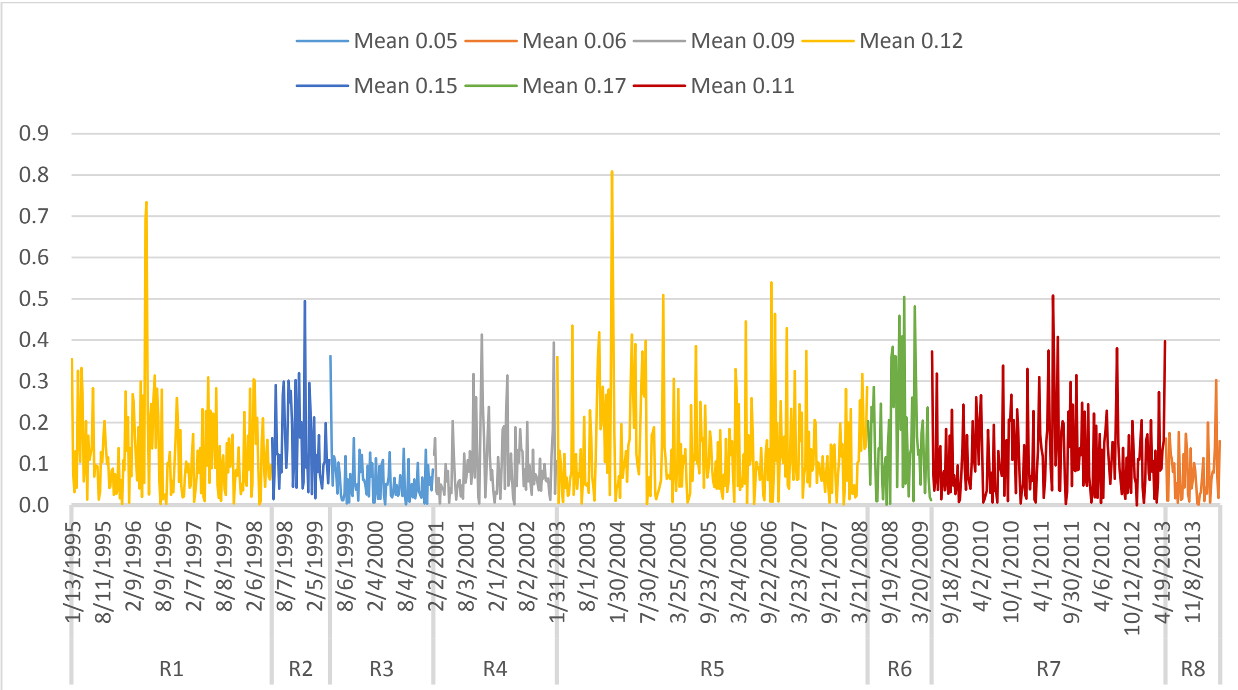
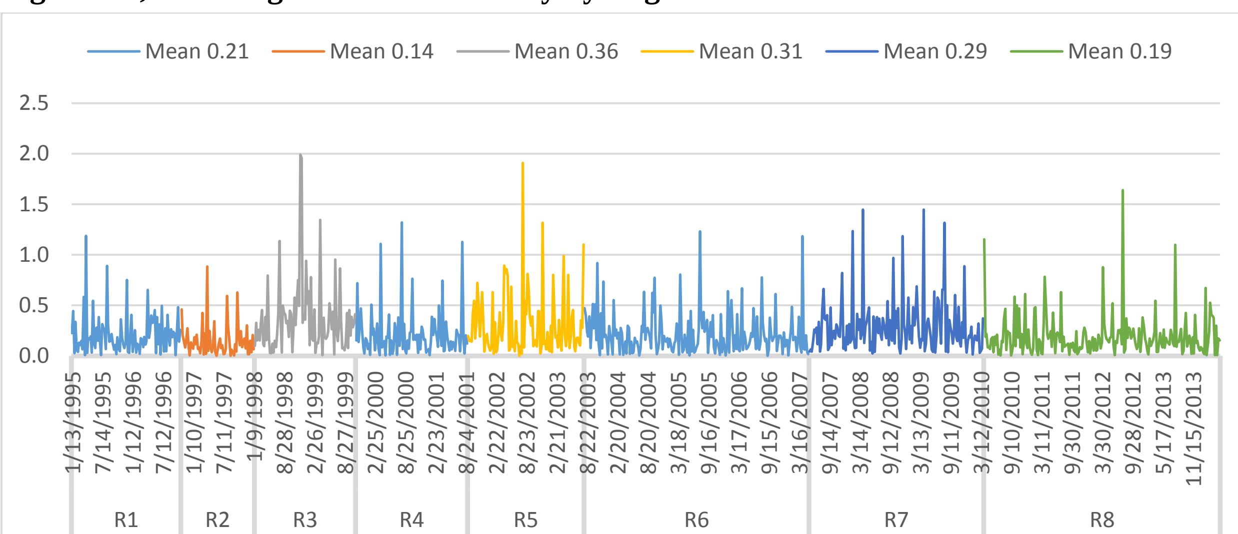


Figure 4.7, Lean hogs Realized Volatility by Regime



In summary, the combination of the statistical method and the ad-hoc approach allowed us to identify different market regimes for corn, wheat, soybeans, live cattle, feeder cattle and lean hogs individually.

The regime with the highest average realized volatility (0.41), regime 2 from 1/18/2008 to 12/12/2008, in the corn markets coincides with the U.S. financial crisis that spread throughout the world causing the 2008 world crisis, which made grains futures prices to spike to levels never seen in the past. Though regimes start date and end date varied, in the case of wheat (regime 4, from 11/23/2007 to 1/16/2009) and soybeans (regime 4, from 11/16/2007 to 9/4/2009), both with the highest average realized volatility, 0.39 and 0.31 respectively, also contained at least the 2008 period.

In the case of corn, the second highest average realized volatility regime includes the 2010-2011 period of time. In 2010-2011, major droughts occurred in the biggest grains producing regions in the world, U.S., Russia and Brazil, which together account for 45% of the global corn production. We expected that the introduction of the Energy Policy Act in 2005 and its increase in 2007 might have created a market regime during that period, but it did not occur. Instead, the 2005-2007 period is contained in regime 1 which spans the period between 1995 and 2007 with relatively low realized volatility mean compared to regimes 2 and 3. By visual inspection of figure 4.2 we can see that the realized volatility pattern in the 2005-2007 period is similar to the rest of the time contained in that regime.

Major events that might help to explain the breaks identified in the rest of the commodities are harder to define specifically, except for the case of feeder cattle where the 2008 financial crisis was captured in regime 6 and showed the highest average realized volatility across regimes.

In general, the livestock markets showed a larger number of market regimes compared to the grain markets. Live cattle was the commodity with the most market regimes (9) and corn the commodity with the fewest regimes (4). Although the ad hoc approach is often considered subjective, and recognizing the differences in the markets characteristics in the grains and livestock markets, the definition of a single rule for merging regimes in all six commodities provided consistency to this analysis. In addition to consistency, merging the market regimes with similar characteristics allowed us to have enough observations in each regime to perform the econometric analysis to analyze the forecasting performance of implied volatility, historical volatility and the composite approach. This process is discussed in Chapter 5.

Chapter 5 - Forecasting Performance Analysis

To evaluate the forecasting performance of implied volatility, historical volatility, composite method and a naïve forecast method in predicting future realized volatility, 5 statistical tests were applied to each commodity. The first section of this chapter (5.1) explains the tests and their econometric specification. The second section (5.2) of this chapter shows the results of the tests in predicting 1-week ahead realized volatility for each commodity. The results are fully explained for corn, the results for other commodities can be interpreted similarly.

Implied volatility is derived from the nearby, at or near the money options using the Black Scholes pricing formula. Because of this, the tests performed on implied volatility as a forecast method not only evaluate the commodities option market's ability to forecast future volatility, but also the efficacy of the Black Scholes model to estimate price volatility in agricultural commodities markets. Additionally, and for this same reason it is difficult to fully identify if the bias and inefficiency in any given forecast specification is due to the market's ability in forecasting future volatility or perhaps the Black Scholes model itself.

As a benchmark for the tests described below we calculated the Mean Absolute Errors (MAE), Root Mean Squared Errors (RMSE), and Mean Absolute Percentage Errors (MAPE) for each of the six commodities in the full period of time and perform pair tests among the estimates. Performing pair tests allowed us to define whether the point values are statistically different between each forecast method. This procedure complements our results from the described econometric tests regarding forecasting performance ability. MAEs, RMSEs and MAPEs are all commonly used measures to evaluate forecast methods. They serve different purposes and is the task of a risk manager to decide which framework fits best to every situation. For example using RMSE might be better in a situation where the individual is risk averse and is worried about extreme events, as it penalizes big forecast errors more. By evaluating the analyzed forecast methods using the mentioned frameworks, this research provides a comprehensive analysis of the forecasting performance of implied volatility, historical volatility, a composite approach and a naïve approach that allows compares forecasting performance not only across commodities and market regimes but also across different ways to evaluate the forecasting methods.

5.1 Test specifications

The following subsections explain in detail the tests used to assess multiple characteristics of the forecast methods analyzed in this study.

5.1.1 Test for forecast optimality

The test for forecast optimality was described by Figlewski (1997) and the equations used are shown below:

(5.1.1.1) $$RV_t = \alpha_1 + \beta_1 IV_{t-1} + v_{t1}$$

(5.1.1.2) $$RV_t = \alpha_2 + \beta_2 HV_{t-1} + v_{t2}$$

(5.1.1.3) $$RV_t = \alpha_3 + \beta_3 IV_{t-1} + \beta_4 HV_{t-1} + v_{t3}$$

The volatility forecast is unbiased and efficient if α_1=0 and β_1=1 in equation 5.1.1.1; α_2=0 and β_2=1 in equation 5.1.1.2; α_3=0 and β_3+β_4=1 in equation 5.1.1.3. However, Manfredo and Sanders (2004) discussed that there might be interpretative and econometric problems associated with this traditional approach test. For this reason, the following tests were also incorporated into the analysis to assess bias and efficiency in the forecast method. The tests for forecasting optimality were applied in this study but the results are not shown since the forecasting optimality is going to be analyzed using different tests.

5.1.2 Test for forecast bias

The following OLS regression is used to determine if the forecast is unbiased and is consistent with the one used by Pons (2000):

(5.1.2) $$e_t = \gamma + v_t$$

Where e_t is the difference between the realized volatility measure and the volatility forecast estimate (Implied volatility method, historical volatility method or the composite approach). The forecast is unbiased if we fail to reject the Ho: $\gamma=0$. The alternative hypothesis $\gamma<0$ suggests that the forecast systematically overestimates the realized volatility and $\gamma>0$ suggests that the forecast systematically underestimates the realized volatility.

5.1.3 Test for forecast efficiency

The weak form forecast efficiency is tested using the following OLS regressions as described by Manfredo and Sanders (2004):

(5.1.3.1) $$e_t = \alpha_1 + \beta\widehat{RV} + v_{t1}$$

(5.1.3.2) $$e_t = \alpha_2 + \rho e_{t-1} + v_{t2}$$

Equation 5.1.3.1 is known as the Beta efficiency test and equation 5.1.3.2 is known as the Rho efficiency test. The condition for weak efficiency is that $\beta = 0$ and $\rho = 0$ respectively. If we fail to reject the null hypothesis of $\beta = 0$ in equation 5.1.3.1 then we can say that the forecast is efficient, meaning that the forecast method incorporates all the information regarding future volatility and the forecast pass this condition of weak efficiency. In equation 5.1.3.2, if we fail to reject the null hypothesis of $\rho = 0$, then we can say that there is no time series pattern to the forecast errors and that the forecast passes this condition for weak efficiency. Both conditions need to be fulfilled in order to call the forecast method efficient.

5.1.4 Test for forecast encompassing

We also have an interest in studying if implied volatility, being a forward looking measure, encompasses all the information contained in alternative forecasts. Harvey et al. (1998) described a framework to test the ability of a forecast to encompass an alternative forecast using the following OLS regression:

(5.1.4) $$e_{1t} = \alpha + \lambda(e_{1t} - e_{2t}) + v_t$$

Where e_{1t} is the forecast error series of the preferred forecast and e_{2t} is the forecast error series of the competing forecast. Manfredo and Sanders (2004) explained that the null hypothesis of λ=0 suggests that the covariance between the preferred forecast error series (e_{1t}) and the difference between the preferred and competing series ($e_{1t} - e_{2t}$) is zero. In other words, the preferred forecast encompasses the competing forecast and the competing forecast contains no useful information beyond the preferred.

5.1.5 Test for time change

It is also of interest to find out if the quality of forecasts is changing overtime. Manfredo and Sanders (2004) discussed some of the reasons why this is of interest including advances in computer technology, option pricing models, market liquidity and statistical forecasting techniques that might have improved the market's ability to forecast volatility over time. Alternatively we contemplate the idea that the forecast errors might have been increasing over time in some cases, meaning that the analyzed forecasts techniques have decreased their ability to forecast future volatility. This could be due to an increase in the complexities of the markets given more globalized trade systems and new forms of market regulations. In order to analyze time change in the forecast methods, Bailey and Brorsen (1998) proposed the following OLS regression where the absolute values of the forecast errors are regressed against a time trend as follows:

$$|e_t| = \alpha + \theta Trend_t + v_t \quad (5.1.5)$$

The null hypothesis of this test is $\theta = 0$ and suggests no systematic change in the forecast over time. This conclusion would suggest that the forecast errors are not getting bigger or smaller over the analyzed time period, therefore the forecast method ability to predict realized volatility, has stayed the same overtime.

5.2 1-Week Realized Volatility Forecast Results

The reasons behind the identification of the market regimes include that the agricultural commodities global markets are ever changing and their structures are regularly affected by economic, weather and political factors. Therefore we analyze forecast performance in individual market regimes in addition to the full period of time. The test for forecast bias, test for forecast efficiency, test for forecast encompassing and test for time change, were applied to the full period and to each regime in each of the six commodities analyzed in this study. A detailed interpretation of the tests results is provided in the case of corn and the rest of the commodities test results can be interpreted similarly. The actual econometric output for each of the tests in all six commodities can be found in the Forecasting Performance Analysis Annex Section. Additionally, this section shows the results of the Mean Absolute Errors, Root Mean Squared Errors and Mean Absolute Percentage Errors for each commodity in the full period of time and in individual market regimes in each commodity for the four forecast methods analyzed.

5.2.1 Corn

In chapter 4 we identified 4 market regimes for corn. The full length of the data captures weekly observations from January 1995 until April 2014. Regime 1 is the period of time between January 13th, 1995 and January 11th, 2008 with 669 observations; regime 2 is the period between January 11th, 2008 and December 12th, 2008 with 48 observations; regime 3 is the period between December 12th, 2008 and June 21st, 2013 with 236 observations; and regime 4 is the period between June 21st, 2014 and April 25th, 2014 with 44 observations.

Table 5.1, Test for Forecast Bias - Corn

Test	Full Period	R1	R2	R3	R4
1. IV model	Y	Y	Y	Y	Y
2. HV model	Y	Y	Y	Y	Y
3. Composite model	Y	Y	Y	Y	Y
4. Naïve model	Y	Y	Y	Y	Y

*Y= The forecast method is unbiased.
*N= The forecast method is biased.
* From equation 5.1.2.

Using the test for forecast bias we can conclude that in the case of corn, implied volatility, historical volatility, a linear combination of both and a naïve approach, provide an unbiased method for forecasting future 1-week ahead realized volatility over the full period examined. This conclusion also holds across the four individual regimes.

Table 5.2, Test for Forecast Efficiency- Corn

Test	Full Period	R1	R2	R3	R4
***Beta efficiency**					
1. IV model	Y	Y	Y	Y	Y
2. HV model	Y	Y	Y	Y	Y
3. Composite model	Y	Y	Y	Y	Y
4. Naïve model	Y	Y	Y	Y	Y
***Rho efficiency**					
1. IV model	Y	N	Y	Y	Y
2. HV model	Y	Y	Y	Y	Y
3. Composite model	Y	N	Y	Y	Y
4. Naïve model	Y	Y	Y	Y	Y

*Y= The forecast passes the beta efficiency/rho efficiency test for weak efficiency.
*N= The forecast fails the beta efficiency/rho efficiency test for weak efficiency.
*From equations 5.1.3.1 and 5.1.3.2.

Using the forecast efficiency test, we consider a forecast efficient if it passes both conditions of weak efficiency: the beta efficiency and the rho efficiency conditions.

The condition for weak efficiency using the beta efficiency test is satisfied across the four forecast methods when we applied the test to the full period of time. This means that implied volatility, historical volatility, a composite method and a naïve approach, efficiently incorporate all the information regarding future 1-week ahead volatility. This conclusion holds when we applied the test to the four market regimes.

The condition for weak efficiency using the rho efficiency test is also satisfied across the four forecast methods when the test is applied to the full period of time. This suggests that there is no time series pattern to the forecast errors. This conclusion holds across all the regimes and across the four forecast methods analyzed with the exception of regime one. In regime one we found that implied volatility and the composite model fail to pass this condition of weak efficiency.

In conclusion, using the full length of the data we find that implied volatility, historical volatility, a composite method and a naïve approach prove to be efficient forecasters of future 1-week realized volatility. This conclusion holds for regimes two, three and four. In regime one we find that the implied volatility and composite approach are not efficient forecasters of future 1-week realized volatility.

The "beta efficiency test" was consistent across regimes and across forecast methods. In the "rho efficiency test" case, the results for regime 1 (with 669 observations) in the implied volatility model and the composite model proved not to prevail in the full period analysis, meaning that the period of time contained in regimes 2, 3 and 4 (with a total of 328 observations) have stronger effects on the full period results.

Table 5.3, Test for Forecast Encompassing- Corn

Test	**Full Period**	**R1**	**R2**	**R3**	**R4**
Preferred forecast					
1. Implied Volatility	Y	Y	Y	Y	N
2. Historical Volatility	N	N	Y	N	Y
Preferred forecast					
1. Implied Volatility	Y	Y	Y	Y	Y
2. Naïve model	N	N	Y	N	Y
Preferred forecast					
1.Historical Volatility	Y	Y	Y	Y	Y
2. Naïve model	N	N	Y	Y	N

*Y= The forecast encompasses the information contained in the alternative forecast.
*N= The forecast does not encompass the information contained in the alternative forecast.
*From equation 5.1.4.

The test for forecast encompassing evaluates if the preferred forecast encompasses all the information provided by the alternative forecast. In our analysis we first set up implied volatility to be the preferred forecast and historical volatility to be the alternative forecast then we flipped the test specification to have historical volatility as the preferred forecast and implied volatility be the alternative forecast. Later, we set up implied volatility to be the preferred forecast and naïve approach to be the alternative forecast then we flipped the test specification to have the naïve approach as the preferred forecast and implied volatility be the alternative forecast. Lastly, we set up historical volatility to be the preferred forecast and naïve approach to be the alternative forecast then we flipped the test specification to have the naïve approach as the preferred forecast and historical volatility be the alternative forecast.

In the full period scenario, the implied volatility forecast method encompasses all the information contained in the historical volatility forecast method. Implied volatility forecast method encompasses all the information contained in the naive forecast method. Historical volatility forecast method encompasses all the information contained in the naive forecast method. This result is reversed when we changed the preferred methods. As expected, implied volatility does contain useful information beyond historical volatility, meaning historical volatility did not encompass all the information contained in an implied volatility forecast. The naïve approach did not encompass the information contained in an implied or historical volatility approach. The results for each regime can be interpreted similarly.

The full period results might be driven by the results in regimes one and three in the historical volatility forecast method. This suggests that regimes one and three have stronger influence on the results in the full period, where historical volatility was found not to encompass the information contained in the implied volatility forecast method. In the analysis of the implied volatility forecast method, the results from the full period are driving those of the regimes one, two and three.

Table 5.4, Test for Time Change- Corn

Test	Full Period	R1	R2	R3	R4
1. IV model	Y^+	Y^+	Y^+	N	N
2. HV model	Y^+	Y^+	N	N	N
3. Composite model	Y^+	Y^+	N	N	N
4. Naïve model	Y^+	Y^+	N	N	N

*Y^+= The forecast errors are getting bigger overtime.
*Y^- = The forecast errors are getting smaller overtime.
*N= The forecast does not show systematic change over time.
*From equation 5.1.5.

Using the test for time change for the full period of time we find that the implied volatility, the historical volatility, a composite approach and naïve approach all show systematic change over time. Specifically, the forecast errors generated by these four forecasts are getting bigger and therefore the forecast has not improved over time. For the market regimes we find different results; for example in regimes 3 and 4, we did not find systematic change in the forecast over time across the forecast methods. For specific information regarding the magnitude of the change please refer to the annex section.

We believe that the results from the regime 1 are driving the conclusions for the results using the full period of time. This might be intuitive given that the length of the regime 1 is considerably bigger compared to the length of the regimes 2, 3 and 4. More specifically we believe that the 3 forecasts methods increased their forecast errors in the first regime (1998-2008) given that the volume and open interest was lower compared to more recent periods.

5.2.3 Wheat

In chapter 4 we identified 7 market regimes for wheat. The full length of the data captures weekly observations from January 1995 until April 2014. Regime 1 is the period between January 13th, 1995 and April 5th, 1996 with 64 observations; regime 2 is the period between April 5th, 1996 and April 18th, 1997 with 54 observations; regime 3 is the period between April 18th, 1997 and November 16th, 2007 with 550 observations; regime 4 is the period between November 16th, 2007 and January 16th, 2009 with 61 observations; regime 5 is the period between January 16th, 2009 and January 1st, 2010 with 50 observations; regime 6 is the period between January 1st, 2010 and December 3rd, 2010 with 48 observations; and regime 7 is the period between December 3rd, 2010 and April 25th, 2014 with 177 observations.

Table 5.5, Test for Forecast Bias- Wheat

Test	Full Period	R1	R2	R3	R4	R5	R6	R7
1. IV model	Y	Y	Y	Y	Y	Y	Y	Y
2. HV model	Y	Y	Y	Y	Y	Y	Y	Y
3. Composite model	Y	Y	Y	Y	Y	Y	Y	Y
4. Naïve model	Y	Y	Y	Y	Y	Y	Y	Y

*Y= The forecast method is unbiased.
*N= The forecast method is biased.
*From equation 5.1.2.

Table 5.6, Test for Forecast Efficiency- Wheat

Test	Full Period	R1	R2	R3	R4	R5	R6	R7
***Beta efficiency**								
1. IV model	Y	Y	Y	Y	Y	Y	Y	Y
2. HV model	Y	Y	Y	Y	Y	Y	Y	Y
3. Composite model	Y	Y	Y	Y	Y	Y	Y	Y
4. Naïve model	Y	Y	Y	Y	Y	Y	Y	Y
***Rho efficiency**								
1. IV model	Y	Y	N	Y	Y	N	Y	Y
2. HV model	Y	Y	N	Y	Y	Y	Y	Y
3. Composite model	Y	Y	Y	Y	Y	Y	Y	Y
4. Naïve model	Y	Y	Y	Y	Y	Y	Y	Y

*Y= The forecast passes the beta efficiency/rho efficiency test for weak efficiency.
*N= The forecast fails the beta efficiency/rho efficiency test for weak efficiency.
*From equations 5.1.3.1 and 5.1.3.2.

Table 5.7, Test for Forecast Encompassing- Wheat

Test	Full Period	R1	R2	R3	R4	R5	R6	R7
Preferred forecast								
1. Implied Volatility	Y	Y	Y	Y	Y	Y	Y	Y
2. Historical Volatility	N	Y	N	N	Y	Y	Y	Y
Preferred forecast								
1. Implied Volatility	Y	Y	Y	Y	Y	Y	Y	Y
2. Naïve model	N	N	N	N	Y	Y	Y	N
Preferred forecast								
1.Historical Volatility	Y	Y	N	Y	Y	Y	Y	Y
2. Naïve model	N	N	Y	N	Y	Y	Y	N

*Y= The forecast encompasses the information contained in the alternative forecast.
*N= The forecast does not encompass the information contained in the alternative forecast.
*From equation 5.1.4.

Table 5.8, Test for Time Change- Wheat

Test	Full Period	R1	R2	R3	R4	R5	R6	R7
1. IV model	Y^+	N	N	Y^+	N	N	Y^+	Y^-
2. HV model	Y^+	N	N	Y^+	N	N	Y^+	Y^-
3. Composite model	Y^+	N	N	Y^+	N	N	Y^+	Y^-
4. Naïve model	Y^+	N	Y^-	Y^+	N	N	N	Y^-

*Y^+= The forecast errors are getting bigger overtime.
*Y^- = The forecast errors are getting smaller overtime.
*N= The forecast does not show systematic change over time.

The four forecast methods were unbiased in the full period and across individual regimes. The four forecast methods were efficient in the full period of time but implied volatility and historical volatility were inefficient in some of the individual regimes. Implied volatility encompassed all the information contained in the historical volatility forecast in the full period and across individual regimes, but historical volatility encompassed all the information contained in the implied volatility forecast in 2 out of the 7 individual market regimes only. When the implied volatility method was compared to the naïve approach, implied volatility encompassed all the information contained in the naive volatility forecast in the full period and across individual regimes, but the naïve approach encompassed all the information contained in the implied volatility forecast in some of the regimes. The forecast errors were getting bigger for the four forecast methods in the full period of time, meaning that over time the prediction power of the analyzed forecast methods have decreased. Results varied in individual market regimes.

5.2.3 Soybeans

In chapter 4 we identified 5 market regimes for soybeans. The full length of the data captures weekly observations from January 1995 until April 2014. Regime 1 is the period between January 13th, 1995 and August 22nd, 2003 with 445 observations; regime 2 is the period between August 22nd, 2003 and July 1st, 2005 with 97 observations; regime 3 is the period between July 1st, 2005 and November 9th, 2007 with 123 observations; regime 4 is the period between November 9th, 2007 and September 4th, 2009 with 95 observations; and regime 5 is the period between September 4th, 2009 and April 25th, 2014 with 247 observations.

Figure 5.1, Test for Forecast Bias- Soybeans

Test	Full Period	R1	R2	R3	R4	R5
1. IV model	Y	Y	Y	Y	Y	Y
2. HV model	Y	Y	Y	Y	Y	Y
3. Composite model	Y	Y	Y	Y	Y	Y
4. Naïve model	Y	Y	Y	Y	Y	Y

*Y= The forecast method is unbiased.
*N= The forecast method is biased.
*From equation 5.1.2.

Figure 5.2, Test for Forecast Efficiency- Soybeans

Test	Full Period	R1	R2	R3	R4	R5
***Beta efficiency**						
1. IV model	Y	Y	Y	Y	Y	Y
2. HV model	Y	Y	Y	Y	Y	Y
3. Composite model	Y	Y	Y	Y	Y	Y
4. Naïve model	Y	Y	Y	Y	Y	Y
***Rho efficiency**						
1. IV model	Y	Y	Y	Y	Y	Y
2. HV model	Y	Y	Y	Y	Y	Y
3. Composite model	Y	Y	Y	Y	Y	Y
4. Naïve model	Y	Y	Y	Y	Y	Y

*Y= The forecast passes the beta efficiency/rho efficiency test for weak efficiency.
*N= The forecast fails the beta efficiency/rho efficiency test for weak efficiency.
*From equations 5.1.3.1 and 5.1.3.2.

Figure 5.3, Test for Forecast Encompassing- Soybeans

Test	Full Period	R1	R2	R3	R4	R5
Preferred forecast						
1. Implied Volatility	Y	Y	Y	Y	Y	Y
2. Historical Volatility	N	N	N	N	Y	Y
Preferred forecast						
1. Implied Volatility	Y	Y	Y	Y	Y	Y
2. Naïve model	N	N	N	N	Y	Y
Preferred forecast						
1.Historical Volatility	Y	Y	Y	Y	Y	Y
2. Naïve model	N	N	N	N	Y	N

*Y= The forecast encompasses the information contained in the alternative forecast.
*N= The forecast does not encompass the information contained in the alternative forecast.
*From equation 5.1.4.

Figure 5.4, Test for Time Change- Soybeans

Test	Full Period	R1	R2	R3	R4	R5
1. IV model	Y^+	N	N	N	N	N
2. HV model	Y^+	N	N	N	N	N
3. Composite model	Y^+	N	N	N	N	N
4. Naïve model	Y^+	N	N	N	N	N

*Y^+= The forecast errors are getting bigger overtime.
*Y^- = The forecast errors are getting smaller overtime.
*N= The forecast does not show systematic change over time.
*From equation 5.1.5.

The four forecast methods were unbiased in the full period and across individual regimes. The four forecast methods were efficient in the full period of time and also in the individual market regimes. Implied volatility encompassed all the information contained in the historical volatility forecast in the full period and across individual regimes, but historical volatility encompassed all the information contained in the implied volatility forecast in 2 out of the 5 individual market regimes only. When the implied volatility method was compared to the naïve approach, implied volatility encompassed all the information contained in the naive volatility forecast in the full period and across individual regimes, but the naïve approach encompassed all the information contained in the implied volatility forecast in just two of the regimes. The forecast errors were getting bigger for the three forecast methods in the full period of time, but results did not show systematic change in individual market regimes. This might be surprising, but is possible indeed. We expect there is systematic change in the full period just by considering the variability in the realized volatility series where it seems to be instability in the behavior of this variable. When each regime is analyzed individually, it is possible that realized volatility behaves in a more stable way within each regimes, since the market shocks were removed through the identification of the market regimes.

5.2.4 Live cattle

In chapter 4 we identified 9 market regimes for live cattle. The full length of the data captures weekly observations from January 1995 until April 2014. Regime 1 is the period of time between January 13th, 1995 and April 5th, 1996 with 64 observations; regime 2 is the period between April 5th, 1996 and October 11th, 1996 with 27 observations; regime 3 is the period between October 11th, 1996 and July 17th, 1998 with 92 observations; regime 4 is the period between July 17th, 1998 and June 18th, 1999 with 48 observations; regime 5 is the period of time between June 18th, 1999 and April 6th, 2001 with 94 observations; regime 6 is the period between April 6th, 2001 and February 14th, 2003 with 97 observations; regime 7 is the period between February 14th, 2003 and January 21st, 2005 with 95 observations ; regime 8 is the period between January 21st, 2005 and October 21st, 2011 with 352 observations; and regime 9 is the period between October 21st, 2011 and April 25th, 2014 with 137 observations.

Figure 5.5, Test for Forecast Bias- Live cattle

Test	**Full Period**	**R1**	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**	**R9**
1. IV model	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
2. HV model	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
3. Composite model	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
4. Naïve model	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

*Y= The forecast method is unbiased.
*N= The forecast method is biased.
*From equation 5.1.2.

Figure 5.6, Test for Forecast Efficiency- Live cattle

Test	Full Period	R1	R2	R3	R4	R5	R6	R7	R8	R9
***Beta efficiency**										
1. IV model	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
2. HV model	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
3. Composite model	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
4. Naïve model	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
***Rho efficiency**										
1. IV model	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
2. HV model	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
3. Composite model	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
4. Naïve model	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

*Y= The forecast passes the beta efficiency/rho efficiency test for weak efficiency.
*N= The forecast fails the beta efficiency/rho efficiency test for weak efficiency.
*From equations 5.1.3.1 and 5.1.3.2.

Figure 5.7, Test for Forecast Encompassing- Live cattle

Test	Full Period	R1	R2	R3	R4	R5	R6	R7	R8	R9
Preferred forecast										
1. Implied Volatility	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
2. Historical Volatility	N	N	Y	Y	Y	Y	Y	N	N	N
Preferred forecast										
1. Implied Volatility	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
2. Naïve model	N	N	Y	Y	Y	Y	Y	N	N	N
Preferred forecast										
1.Historical Volatility	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
2. Naïve model	N	Y	Y	Y	Y	Y	Y	Y	Y	Y

*Y= The forecast encompasses the information contained in the alternative forecast.
*N= The forecast does not encompass the information contained in the alternative forecast.
*From equation 5.1.4.

Figure 5.8, Test for Time Change- Live cattle

Test	Full Period	R1	R2	R3	R4	R5	R6	R7	R8	R9
1. IV model	N	N	N	N	N	N	N	N	N	N
2. HV model	N	N	N	N	N	N	N	N	N	N
3. Composite model	N	N	N	N	N	N	N	N	N	N
4. Naïve model	N	N	N	N	N	N	N	N	N	N

*Y^+= The forecast errors are getting bigger overtime.
*Y^- = The forecast errors are getting smaller overtime.
*N= The forecast does not show systematic change over time.
*From equation 5.1.5.

The four forecast methods were unbiased in the full period and across individual regimes. The four forecast methods were efficient in the full period of time and also in the individual market regimes. Implied volatility encompassed all the information contained in the historical volatility forecast in the full period and across individual regimes; historical volatility encompassed all the information contained in the implied volatility forecast in 5 out of the 9 individual market regimes. When the implied volatility method was compared to the naïve approach, implied volatility encompassed all the information contained in the naive volatility forecast in the full period and across individual regimes, but the naïve approach encompassed all the information contained in the implied volatility forecast in some of the regimes. The four forecast methods did not show systematic change over time in the full period of time and also in the individual market regimes.

5.2.5 Feeder cattle

In chapter 4 we identified 8 market regimes for feeder cattle. The full length of the data captures weekly observations from January 1995 until April 2014. Regime 1 is the period of time between January 13th, 1995 and May 29th, 1998 with 172 observations; regime 2 is the period between May 29th, 1998 and May 14th, 1999 with 50 observations; regime 3 is the period between May 14th, 1999 and January 26th, 2001 with 89 observations; regime 4 is the period between January 26th, 2001 and February 7th, 2003 with 106 observations; regime 5 is the period between February 7th, 2003 and May 16th, 2008 with 267 observations; regime 6 is the period between May 16th, 2008 and June 5th, 2009 with 55 observations; regime 7 is the period between June 5th, 2009 and May 17th, 2013 with 201 observations; and regime 8 is the period between May 17th, 2013 and April 25th, 2014 with 47 observations.

Figure 5.9, Test for Forecast Bias- Feeder cattle

Test	Full Period	R1	R2	R3	R4	R5	R6	R7	R8
1. IV model	Y	Y	Y	Y	Y	Y	Y	Y	Y
2. HV model	Y	Y	Y	Y	Y	Y	Y	Y	Y
3. Composite model	Y	Y	Y	Y	Y	Y	Y	Y	Y
4. Naïve model	Y	Y	Y	Y	Y	Y	Y	Y	Y

*Y= The forecast method is unbiased.
*N= The forecast method is biased.
*From equation 5.1.2.

Figure 5.10, Test for Forecast Efficiency- Feeder cattle

Test	Full Period	R1	R2	R3	R4	R5	R6	R7	R8
***Beta efficiency**									
1. IV model	Y	Y	Y	Y	Y	Y	Y	Y	Y
2. HV model	Y	Y	Y	Y	Y	Y	Y	Y	Y
3. Composite model	Y	Y	Y	Y	Y	Y	Y	Y	Y
4. Naïve model	Y	Y	Y	Y	Y	Y	Y	Y	Y
***Rho efficiency**									
1. IV model	Y	Y	Y	Y	N	Y	Y	Y	Y
2. HV model	N	Y	Y	Y	N	Y	Y	Y	Y
3. Composite model	Y	Y	Y	Y	N	Y	Y	Y	Y
4. Naïve model	Y	Y	Y	Y	Y	Y	Y	Y	Y

*Y= The forecast passes the beta efficiency/rho efficiency test for weak efficiency.
*N= The forecast fails the beta efficiency/rho efficiency test for weak efficiency.
*From equations 5.1.3.1 and 5.1.3.2.

Figure 5.11, Test for Forecast Encompassing- Feeder cattle

Test	Full Period	R1	R2	R3	R4	R5	R6	R7	R8
Preferred forecast									
1. Implied Volatility	Y	Y	Y	Y	Y	Y	Y	Y	Y
2. Historical Volatility	N	N	Y	Y	Y	N	Y	Y	Y
Preferred forecast									
1. Implied Volatility	Y	Y	Y	Y	N	Y	Y	Y	Y
2. Naïve model	N	N	Y	Y	Y	N	Y	Y	Y
Preferred forecast									
1.Historical Volatility	N	Y	Y	Y	N	Y	Y	Y	Y
2. Naïve model	N	Y	Y	Y	Y	Y	N	Y	Y

*Y= The forecast encompasses the information contained in the alternative forecast.
*N= The forecast does not encompass the information contained in the alternative forecast.
*From equation 5.1.4.

Figure 5.12, Test for Time Change- Feeder cattle

Test	Full Period	R1	R2	R3	R4	R5	R6	R7	R8
1. IV model	N	N	N	N	N	N	N	N	N
2. HV model	N	N	N	N	N	Y	N	N	N
3. Composite model	N	N	N	N	N	N	N	N	N
4. Naïve model	N	N	N	N	N	N	N	N	N

*Y^+= The forecast errors are getting bigger overtime.
*Y^- = The forecast errors are getting smaller overtime.
*N= The forecast does not show systematic change over time.

The four forecast methods were unbiased in the full period and across individual regimes. Implied volatility, the naïve approach and the composite method were efficient forecasters in the full period of time and in the individual market regimes except for regime 4; the historical volatility method was inefficient in the full period of time and in regime 4. Implied volatility encompassed all the information contained in the historical volatility forecast in the full period and across individual regimes; historical volatility encompassed all the information contained in the implied volatility forecast in 6 out of the 8 individual market regimes. When the implied volatility method was compared to the naïve approach, implied volatility encompassed all the information contained in the naive volatility forecast in the full period and across individual regimes, but the naïve approach encompassed all the information contained in the implied volatility forecast in some of the regimes. The four forecast methods did not show systematic change over time in the full period of time and also in the individual market regimes, except for the historical volatility approach in regime 5, where forecast errors were getting smaller overtime.

5.2.6 Lean Hogs

In the chapter 4 we identified 8 market regimes for lean hogs. The full length of the data captures weekly observations from January 1995 until April 2014. Regime 1 is the period of time between January 13th, 1995 and November 1st, 1996 with 94 observations; regime 2 is the period between November 1st, 1996 and January 16th, 1998 with 63 observations; regime 3 is the period between January 16th, 1998 and November 5th, 1999 with 87 observations; regime 4 is the period between November 5th, 1999 and September 7th, 2001 with 95 observations; regime 5 is the period between September 7th, 2001 and August 8th, 2003 with 100 observations; regime 6 is the period between August 8th, 2003 and May 18th, 2007 with 193 observations; regime 7 is the period between May 18th, 2007 and April 2nd, 2010 with 150 observations; and regime 8 is the period between April 2nd, 2010 and April 25th, 2014 with 203 observations.

Figure 5.13, Test for Forecast Bias- Lean hogs

Test	Full Period	R1	R2	R3	R4	R5	R6	R7	R8
1. IV model	Y	Y	Y	Y	Y	Y	Y	Y	Y
2. HV model	Y	Y	Y	Y	Y	Y	Y	Y	Y
3. Composite model	Y	Y	Y	Y	Y	Y	Y	Y	Y
4. Naïve model	Y	Y	Y	Y	Y	Y	Y	Y	Y

*Y= The forecast method is unbiased.
*N= The forecast method is biased.
*From equation 5.1.2.

Figure 5.14, Test for Forecast Efficiency- Lean hogs

Test	Full Period	R1	R2	R3	R4	R5	R6	R7	R8
***Beta efficiency**									
1. IV model	Y	Y	Y	Y	Y	Y	Y	Y	Y
2. HV model	Y	Y	Y	Y	Y	Y	Y	Y	Y
3. Composite model	Y	Y	Y	Y	Y	Y	Y	Y	Y
4. Naïve model	Y	Y	Y	Y	Y	Y	Y	Y	Y
***Rho efficiency**									
1. IV model	Y	N	Y	Y	Y	Y	Y	Y	Y
2. HV model	Y	N	Y	N	Y	Y	Y	Y	Y
3. Composite model	Y	N	Y	Y	Y	Y	Y	Y	Y
4. Naïve model	Y	Y	Y	Y	Y	Y	Y	Y	Y

*Y= The forecast passes the beta efficiency/rho efficiency test for weak efficiency.
*N= The forecast fails the beta efficiency/rho efficiency test for weak efficiency.
*From equations 5.1.3.1 and 5.1.3.2.

Figure 5.15, Test for Forecast Encompassing- Lean hogs

Test	Full Period	R1	R2	R3	R4	R5	R6	R7	R8
Preferred forecast									
1. Implied Volatility	Y	Y	Y	Y	Y	Y	Y	Y	Y
2. Historical Volatility	N	Y	Y	N	Y	Y	Y	Y	Y
Preferred forecast									
1. Implied Volatility	Y	N	Y	Y	Y	Y	Y	Y	Y
2. Naïve model	N	Y	Y	Y	Y	Y	Y	Y	N
Preferred forecast									
1.Historical Volatility	Y	N	Y	N	Y	Y	Y	Y	Y
2. Naïve model	N	Y	Y	Y	Y	Y	Y	Y	Y

*Y= The forecast encompasses the information contained in the alternative forecast.
*N= The forecast does not encompass the information contained in the alternative forecast.
*From equation 5.1.4.

Figure 5.16, Test for Time Change- Lean hogs

Test	Full Period	R1	R2	R3	R4	R5	R6	R7	R8
1. IV model	N	N	N	N	N	N	N	N	N
2. HV model	N	N	N	N	N	N	N	N	N
3. Composite model	N	N	N	N	N	N	N	N	N
4. Naïve model	N	N	N	N	N	N	N	N	N

*Y^{+}= The forecast errors are getting bigger overtime.
*Y^{-} = The forecast errors are getting smaller overtime.
*N= The forecast does not show systematic change over time.
*From equation 5.1.5.

The four forecast methods were unbiased in the full period and across individual regimes. The four forecast methods were efficient forecasters in the full period of time, but results varied in individual market regimes; historical volatility was inefficient in two out of the 8 market regimes and implied volatility along with the composite method were inefficient on one out of 8 market regimes. Implied volatility encompassed all the information contained in the historical volatility forecast in the full period and across individual regimes; historical volatility encompassed all the information contained in the implied volatility forecast in 7 out of the 8 individual market regimes. When the implied volatility method was compared to the naïve approach, implied volatility encompassed all the information contained in the naive volatility forecast in the full period and across individual regimes except for regime 1, the naïve approach encompassed all the information contained in the implied volatility forecast in all the regimes except for regime 8 and the full period of time. The four forecast methods did not show systematic change over time in the full period of time and also in the individual market regimes.

5.2.7 Mean Absolute Errors Analysis

We calculated the Mean Absolute Errors (MAE) from each forecast method for the forecast error series of all six commodities in the full period of time and in each individual regime. Results are shown below.

Corn

Table 5.9, Mean Absolute Errors and Pair Tests Results for Corn (Full Period)

	IV model	HV Model	Comp Model	Naïve		
MAE	0.139887	0.144528	0.139666	0.149448		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.003076	0.216706	0.000965	0.000499	0.000001	0.000000

Table 5.10, Mean Absolute Errors and Pair Tests Results for Corn (Regime 1)

	IV model	HV Model	Comp Model	Naïve		
MAE	0.125432	0.129538	0.125321	0.133276		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.017461	0.154297	0.012615	0.002228	0.000127	0.000100

Table 5.11, Mean Absolute Errors and Pair Tests Results for Corn (Regime 2)

	IV model	HV Model	Comp Model	Naïve		
MAE	0.278309	0.270283	0.270271	0.283540		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.505823	0.500817	0.954321	0.324187	0.633276	0.322185

Table 5.12, Mean Absolute Errors and Pair Tests Results for Corn (Regime 3)

	IV model	HV Model	Comp Model	Naïve		
MAE	0.161104	0.165014	0.160729	0.165363		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.065487	0.654072	0.094063	0.776174	0.098772	0.097029

Table 5.13, Mean Absolute Errors and Pair Tests Results for Corn (Regime 4)

	IV model	HV Model	Comp Model	Naïve		
MAE	0.07678	0.07448	0.07444	0.07840		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.73171	0.72601	0.55641	0.60741	0.69833	0.60372

Wheat

Table 5.14, Mean Absolute Errors and Pair Tests Results for Wheat (Full Period)

	IV model	HV Model	Comp Model	Naïve		
MAE	0.14468	0.14563	0.14452	0.14816		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.40381	0.22773	0.28565	0.06256	0.03398	0.02629

Table 5.15, Mean Absolute Errors and Pair Tests Results for Wheat (Regime 1)

	IV model	HV Model	Comp Model	Naïve		
MAE	0.10226	0.10234	0.10058	0.10440		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.98761	0.61479	0.51357	0.71541	0.70699	0.52407

Table 5.16, Mean Absolute Errors and Pair Tests Results for Wheat (Regime 2)

	IV model	HV Model	Comp Model	Naïve		
MAE	0.15389	0.16844	0.15469	0.14816		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.29161	0.89023	0.41485	0.12905	0.63616	0.62705

Table 5.17, Mean Absolute Errors and Pair Tests Results for Wheat (Regime 3)

	IV model	HV Model	Comp Model	Naïve		
MAE	0.12873	0.12942	0.12874	0.13057		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.42630	0.39896	0.43165	0.04876	0.06943	0.07024

Table 5.18, Mean Absolute Errors and Pair Tests Results for Wheat (Regime 4)

	IV model	HV Model	Comp Model	Naïve		
MAE	0.23504	0.23265	0.23424	0.23651		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.62095	0.42465	0.69526	0.49273	0.83683	0.74718

Table 5.19, Mean Absolute Errors and Pair Tests Results for Wheat (Regime 5)

	IV model	HV Model	Comp Model	Naïve		
MAE	0.16114	0.16081	0.16045	0.15708		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.93223	0.79237	0.85314	0.55934	0.53843	0.59945

Table 5.20, Mean Absolute Errors and Pair Tests Results for Wheat (Regime 6)

	IV model	HV Model	Comp Model	Naïve		
MAE	0.22206	0.22197	0.22155	0.21668		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.98567	0.85217	0.94529	0.40005	0.56357	0.61152

Table 5.21, Mean Absolute Errors and Pair Tests Results for Wheat (Regime 7)

	IV model	HV Model	Comp Model	Naïve		
MAE	0.14081	0.14366	0.14110	0.14666		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.14533	0.52057	0.41709	0.01031	0.01194	0.01211

Soybeans

Table 5.22, Mean Absolute Errors and Pair Tests Results for Soybeans (Full Period)

	IV model	HV Model	Comp Model	Naïve		
MAE	0.11713	0.11964	0.11698	0.12239		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.04089	0.58069	0.01111	0.32182	0.00086	0.00063

Table 5.23, Mean Absolute Errors and Pair Tests Results for Soybeans (Regime 1)

	IV model	HV Model	Comp Model	Naïve		
MAE	0.09529	0.09749	0.09531	0.09751		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.13932	0.83704	0.13073	0.98539	0.18857	0.19068

Table 5.24, Mean Absolute Errors and Pair Tests Results for Soybeans (Regime 2)

	IV model	HV Model	Comp Model	Naïve		
MAE	0.15445	0.16052	0.15354	0.16017		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.30719	0.34723	0.28651	0.94653	0.47346	0.40835

Table 5.25, Mean Absolute Errors and Pair Tests Results for Soybeans (Regime 3)

	IV model	HV Model	Comp Model	Naïve		
MAE	0.11122	0.11319	0.11108	0.11595		
	IV-HV	IV-Comp	HV-Comp	Naïve-HV	Naïve-IV	Naïve-Comp
Paired Test	0.42829	0.78273	0.32246	0.31322	0.16615	0.15706

Table 5.26, Mean Absolute Errors and Pair Tests Results for Soybeans (Regime 4)

	IV model	HV Model	Comp Model	Naïve		
MAE	0.20146	0.19971	0.20145	0.20031		
	IV-HV	IV-Comp	HV-Comp	Naïve-HV	Naïve-IV	Naïve-Comp
Paired Test	0.38225	0.99882	0.40863	0.70435	0.37640	0.67568

Table 5.27, Mean Absolute Errors and Pair Tests Results for Soybeans (Regime 5)

	IV model	HV Model	Comp Model	Naïve		
MAE	0.10914	0.10922	0.10915	0.11048		
	IV-HV	IV-Comp	HV-Comp	Naïve-HV	Naïve-IV	Naïve-Comp
Paired Test	0.95165	0.99487	0.88309	0.34659	0.05999	0.32734

Live Cattle

Table 5.28, Mean Absolute Errors and Pair Tests Results for Live Cattle (Full Period)

	IV model	HV Model	Comp Model	Naïve		
MAE	0.08530	0.08904	0.08525	0.08953		
	IV-HV	IV-Comp	HV-Comp	Naïve-HV	Naïve-IV	Naïve-Comp
Paired Test	0.00018	0.89684	0.00117	0.14295	0.00010	0.00030

Table 5.29, Mean Absolute Errors and Pair Tests Results for Live Cattle (Regime 1)

	IV model	HV Model	Comp Model	Naïve		
MAE	0.06924	0.07343	0.06907	0.07473		
	IV-HV	IV-Comp	HV-Comp	Naïve-HV	Naïve-IV	Naïve-Comp
Paired Test	0.11335	0.82496	0.13620	0.23557	0.07203	0.06802

Table 5.30, Mean Absolute Errors and Pair Tests Results for Live Cattle (Regime 2)

	IV model	HV Model	Comp Model	Naïve		
MAE	0.11403	0.12171	0.09963	0.12023		
	IV-HV	IV-Comp	HV-Comp	Naïve-HV	Naïve-IV	Naïve-Comp
Paired Test	0.42437	0.27040	0.15320	0.79249	0.39528	0.15760

Table 5.31, Mean Absolute Errors and Pair Tests Results for Live Cattle (Regime 3)

	IV model	HV Model	Comp Model	Naïve		
MAE	0.06590	0.06569	0.06566	0.06325		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.67392	0.47676	0.93755	0.07999	0.08180	0.10112

Table 5.32, Mean Absolute Errors and Pair Tests Results for Live Cattle (Regime 4)

	IV model	HV Model	Comp Model	Naïve		
MAE	0.10467	0.10113	0.10293	0.10334		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.24728	0.50853	0.44706	0.44513	0.43326	0.89996

Table 5.33, Mean Absolute Errors and Pair Tests Results for Live Cattle (Regime 5)

	IV model	HV Model	Comp Model	Naïve		
MAE	0.05249	0.05213	0.05156	0.05257		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.72000	0.30422	0.46142	0.56554	0.90416	0.30124

Table 5.34, Mean Absolute Errors and Pair Tests Results for Live Cattle (Regime 6)

	IV model	HV Model	Comp Model	Naïve		
MAE	0.09926	0.10180	0.09480	0.10197		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.51315	0.20023	0.07880	0.94858	0.30371	0.10918

Table 5.35, Mean Absolute Errors and Pair Tests Results for Live Cattle (Regime 7)

	IV model	HV Model	Comp Model	Naïve		
MAE	0.11523	0.12234	0.11730	0.12057		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.28189	0.54018	0.44710	0.27921	0.38065	0.62881

Table 5.36, Mean Absolute Errors and Pair Tests Results for Live Cattle (Regime 8)

	IV model	HV Model	Comp Model	Naïve		
MAE	0.08921	0.09032	0.08950	0.09046		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.26741	0.41261	0.46840	0.60339	0.25777	0.40520

Table 5.37, Mean Absolute Errors and Pair Tests Results for Live Cattle (Regime 9)

	IV model	HV Model	Comp Model	Naïve		
MAE	0.06964	0.07157	0.06948	0.07178		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.19815	0.84998	0.24793	0.70696	0.22678	0.22165

Feeder Cattle

Table 5.38, Mean Absolute Errors and Pair Tests Results for Feeder Cattle (Full Period)

	IV model	HV Model	Comp Model	Naïve		
MAE	0.07301	0.07536	0.07300	0.07642		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.00559	0.86896	0.00812	0.12237	0.00093	0.00104

Table 5.39, Mean Absolute Errors and Pair Tests Results for Feeder Cattle (Regime 1)

	IV model	HV Model	Comp Model	Naïve		
MAE	0.07464	0.07600	0.07469	0.07751		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.53706	0.70987	0.56601	0.39410	0.26087	0.27493

Table 5.40, Mean Absolute Errors and Pair Tests Results for Feeder Cattle (Regime 2)

	IV model	HV Model	Comp Model	Naïve		
MAE	0.08652	0.08326	0.07695	0.08761		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.31734	0.01280	0.07259	0.07431	0.34838	0.00816

Table 5.41, Mean Absolute Errors and Pair Tests Results for Feeder Cattle (Regime 3)

	IV model	HV Model	Comp Model	Naïve		
MAE	0.03408	0.03448	0.03408	0.03495		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.39307	0.99225	0.38311	0.40153	0.22571	0.22606

Table 5.42, Mean Absolute Errors and Pair Tests Results for Feeder Cattle (Regime 4)

	IV model	HV Model	Comp Model	Naïve		
MAE	0.06166	0.06269	0.06171	0.06108		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.24020	0.92913	0.39903	0.38952	0.75674	0.74772

Table 5.43, Mean Absolute Errors and Pair Tests Results for Feeder Cattle (Regime 5)

	IV model	HV Model	Comp Model	Naïve		
MAE	0.08071	0.08401	0.08037	0.08377		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.14378	0.68846	0.16473	0.80487	0.20581	0.19717

Table 5.44, Mean Absolute Errors and Pair Tests Results for Feeder Cattle (Regime 6)

	IV model	HV Model	Comp Model	Naïve		
MAE	0.10605	0.10799	0.10688	0.11133		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.59854	0.72187	0.49334	0.46156	0.21781	0.34437

Table 5.45, Mean Absolute Errors and Pair Tests Results for Feeder Cattle (Regime 7)

	IV model	HV Model	Comp Model	Naïve		
MAE	0.07452	0.07481	0.07458	0.07493		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.61063	0.73031	0.61869	0.81049	0.53597	0.60230

Table 5.46, Mean Absolute Errors and Pair Tests Results for Feeder Cattle (Regime 8)

	IV model	HV Model	Comp Model	Naïve		
MAE	0.04625	0.04706	0.04551	0.04556		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.43159	0.37878	0.26075	0.21157	0.61983	0.97553

Lean Hogs

Table 5.47, Mean Absolute Errors and Pair Tests Results for Lean Hogs (Full Period)

	IV model	HV Model	Comp Model	Naïve		
MAE	0.16305	0.16676	0.16305	0.16769		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.00875	0.94150	0.01117	0.20529	0.00204	0.00232

Table 5.48, Mean Absolute Errors and Pair Tests Results for Lean Hogs (Regime 1)

	IV model	HV Model	Comp Model	Naïve		
MAE	0.13684	0.14332	0.13660	0.13913		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.01797	0.81553	0.01745	0.31218	0.65888	0.61522

Table 5.49, Mean Absolute Errors and Pair Tests Results for Lean Hogs (Regime 2)

	IV model	HV Model	Comp Model	Naïve		
MAE	0.10590	0.10352	0.10583	0.10440		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.50810	0.57235	0.51838	0.69514	0.71431	0.72888

Table 5.50, Mean Absolute Errors and Pair Tests Results for Lean Hogs (Regime 3)

	IV model	HV Model	Comp Model	Naïve		
MAE	0.22895	0.23293	0.22890	0.23340		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.64757	0.91665	0.65118	0.95531	0.68646	0.68686

Table 5.51, Mean Absolute Errors and Pair Tests Results for Lean Hogs (Regime 4)

	IV model	HV Model	Comp Model	Naïve		
MAE	0.14335	0.14377	0.14341	0.14499		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.90850	0.98534	0.82210	0.69903	0.58521	0.63933

Table 5.52, Mean Absolute Errors and Pair Tests Results for Lean Hogs (Regime 5)

	IV model	HV Model	Comp Model	Naïve		
MAE	0.22864	0.22858	0.22754	0.23028		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.98482	0.54100	0.65217	0.60343	0.66684	0.49368

Table 5.53, Mean Absolute Errors and Pair Tests Results for Lean Hogs (Regime 6)

	IV model	HV Model	Comp Model	Naïve		
MAE	0.14221	0.14334	0.14336	0.14228		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.17024	0.14667	0.81395	0.16867	0.83532	0.16371

Table 5.54, Mean Absolute Errors and Pair Tests Results for Lean Hogs (Regime 7)

	IV model	HV Model	Comp Model	Naïve		
MAE	0.18721	0.18876	0.18844	0.18570		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.63562	0.71263	0.85407	0.28036	0.42199	0.42415

Table 5.55, Mean Absolute Errors and Pair Tests Results for Lean Hogs (Regime 8)

	IV model	HV Model	Comp Model	Naïve		
MAE	0.12950	0.12749	0.12943	0.12715		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.27492	0.53350	0.28174	0.71270	0.24428	0.26001

The above tables show the MAE estimates for each forecast method across the analyzed commodities and the paired difference tests results first in the full period of time and then in each individual market regime.

Numerically across all six commodities, the composite method showed the smallest mean absolute errors in the full period of time, immediately followed by the implied volatility. Historical volatility ranked as the third forecast method with the smallest mean absolute errors and the worst performing forecast according to this measure was the naïve forecast. The numerical difference between the forecast methods was always very small and we moved forward and analyzed the MAE point estimates differences using paired tests.

Looking at the paired tests in the full period of time we can see that there is no significant statistical difference between the implied volatility method and the composite method across all six commodities. This suggests that the numerical differences between the MAEs generated from the forecast errors from the implied volatility model and the composite model might be due to chance. It is important to recall that the share of the composite forecast coming from implied volatility varies across the six commodities and across individual regimes in each commodity, this may have influence in our conclusions regarding the statistical differences between the MAEs from implied volatility and the composite method. We found statistical differences between the MAEs of implied volatility and the composite method when compared to the MAE of the historical volatility forecast, except for wheat. Therefore based on this measure, a decision maker would be better off by using either the implied volatility model or the composite model to predict one week ahead realized volatility in corn, soybeans, live cattle, feeder cattle and lean hogs based solely on this measure.

The results for each individual market regime can be interpreted in a similar way. Overall, we found differences in the rankings in individual regimes across all six commodities but in general the naïve forecast seems to be the worst performing method in a numerical way.

This conclusion sheds some light regarding the advantage of creating a composite method and strengthen our previous results in this chapter, where the composite method did not appear to have forecasting performance superiority compared to implied volatility and historical volatility alone. Based solely on the MAE values, a decision maker would be just as well by using available implied volatility estimates without having to develop a composite approach.

5.2.8 Root Mean Squared Errors Analysis

We calculated the Root Mean Squared Errors (RMSE) from each forecast method for the forecast error series of all six commodities in the full period of time and in each individual regime. Results are shown below.

Corn

Table 5.56, Root Mean Squared Errors and Pair Tests Results for Corn (Full Period)

	IV Model	**HV Model**	**Comp Model**	**Naive**		
RMSE	0.18657	0.19282	0.18649	0.19742		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.00053	0.67104	0.00019	0.00841	0.00000	0.00000

Table 5.57, Root Mean Squared Errors and Pair Tests Results for Corn (Regime 1)

	IV Model	HV Model	Comp Model	Naive		
RMSE	0.16327	0.16983	0.16326	0.17356		
	IV-HV	IV-Comp	HV-Comp	Naïve-HV	Naïve-IV	Naïve-Comp
Paired Test	0.00200	0.85530	0.00168	0.00672	0.00015	0.00015

Table 5.58, Root Mean Squared Errors and Pair Tests Results for Corn (Regime 2)

	IV Model	HV Model	Comp Model	Naive		
RMSE	0.34698	0.33685	0.33685	0.34378		
	IV-HV	IV-Comp	HV-Comp	Naïve-HV	Naïve-IV	Naïve-Comp
Paired Test	0.43355	0.42905	0.9864795	0.63760	0.7892	0.6356

Table 5.59, Root Mean Squared Errors and Pair Tests Results for Corn (Regime 3)

	IV Model	HV Model	Comp Model	Naive		
RMSE	0.20395	0.20742	0.20354	0.20747		
	IV-HV	IV-Comp	HV-Comp	Naïve-HV	Naïve-IV	Naïve-Comp
Paired Test	0.09912	0.13414	0.17191	0.96662	0.17626	0.17191

Table 5.60, Root Mean Squared Errors and Pair Tests Results for Corn (Regime 4)

	IV Model	HV Model	Comp Model	Naive		
RMSE	0.11932	0.10864	0.10864	0.12238		
	IV-HV	IV-Comp	HV-Comp	Naïve-HV	Naïve-IV	Naïve-Comp
Paired Test	0.52785	0.52728	0.98802	0.49540	0.47944	0.49510

Wheat

Table 5.61, Root Mean Squared Errors and Pair Tests Results for Wheat (Full Period)

	IV Model	HV Model	Comp Model	Naive		
RMSE	0.19039	0.19341	0.19034	0.19744		
	IV-HV	IV-Comp	HV-Comp	Naïve-HV	Naïve-IV	Naïve-Comp
Paired Test	0.02093	0.73257	0.01182	0.02083	0.00184	0.00176

Table 5.62, Root Mean Squared Errors and Pair Tests Results for Wheat (Regime 1)

	IV Model	HV Model	Comp Model	Naive		
RMSE	0.13493	0.13403	0.13215	0.14112		
	IV-HV	IV-Comp	HV-Comp	Naïve-HV	Naïve-IV	Naïve-Comp
Paired Test	0.87102	0.34632	0.57595	0.27008	0.45090	0.27119

Table 5.63, Root Mean Squared Errors and Pair Tests Results for Wheat (Regime 2)

	IV Model	HV Model	Comp Model	Naive		
RMSE	0.20033	0.23507	0.19499	0.20223		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.17666	0.47156	0.17713	0.13087	0.91488	0.72302

Table 5.64, Root Mean Squared Errors and Pair Tests Results for Wheat (Regime 3)

	IV Model	HV Model	Comp Model	Naive		
RMSE	0.16530	0.16668	0.16530	0.16728		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.12562	0.99105	0.12680	0.30481	0.08056	0.08052

Table 5.65, Root Mean Squared Errors and Pair Tests Results for Wheat (Regime 4)

	IV Model	HV Model	Comp Model	Naive		
RMSE	0.29098	0.29255	0.29088	0.29472		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.82311	0.91951	0.78868	0.69358	0.73475	0.71542

Table 5.66, Root Mean Squared Errors and Pair Tests Results for Wheat (Regime 5)

	IV Model	HV Model	Comp Model	Naive		
RMSE	0.19354	0.19313	0.19266	0.18901		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.90862	0.71639	0.79483	0.58640	0.57004	0.61985

Table 5.67, Root Mean Squared Errors and Pair Tests Results for Wheat (Regime 6)

	IV Model	HV Model	Comp Model	Naive		
RMSE	0.27299	0.27587	0.27235	0.27363		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.50070	0.79076	0.51912	0.69855	0.93369	0.87449

Table 5.68, Root Mean Squared Errors and Pair Tests Results for Wheat (Regime 7)

	IV Model	HV Model	Comp Model	Naive		
RMSE	0.18944	0.19073	0.18935	0.19534		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.49139	0.83102	0.37534	0.12342	0.07307	0.07216

Soybeans

Table 5.69, Root Mean Squared Errors and Pair Tests Results for Soybeans (Full Period)

	IV Model	HV Model	Comp Model	Naive		
RMSE	0.15934	0.16296	0.15910	0.16812		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.01898	0.48879	0.00363	0.01004	0.00015	0.00016

Table 5.70, Root Mean Squared Errors and Pair Tests Results for Soybeans (Regime 1)

	IV Model	HV Model	Comp Model	Naive		
RMSE	0.12932	0.12532	0.12931	0.13387		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.00000	0.89195	0.00000	0.00000	0.03992	0.03957

Table 5.71, Root Mean Squared Errors and Pair Tests Results for Soybeans (Regime 2)

	IV Model	HV Model	Comp Model	Naive		
RMSE	0.19521	0.20638	0.19499	0.21328		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.18739	0.87370	0.21257	0.45650	0.16921	0.15135

Table 5.72, Root Mean Squared Errors and Pair Tests Results for Soybeans (Regime 3)

	IV Model	HV Model	Comp Model	Naive		
RMSE	0.13064	0.13296	0.13053	0.13690		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.39568	0.81666	0.31766	0.25124	0.17112	0.16887

Table 5.73, Root Mean Squared Errors and Pair Tests Results for Soybeans (Regime 4)

	IV Model	HV Model	Comp Model	Naive		
RMSE	0.26775	0.26749	0.26666	0.26771		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.85559	0.60080	0.60819	0.87979	0.97737	0.66245

Table 5.74, Root Mean Squared Errors and Pair Tests Results for Soybeans (Regime 5)

	IV Model	HV Model	Comp Model	Naive		
RMSE	0.14046	0.13965	0.13942	0.14098		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.64181	0.44924	0.67219	0.36020	0.71029	0.28473

Live Cattle

Table 5.75, Root Mean Squared Errors and Pair Tests Results for Live Cattle (Full Period)

	IV Model	HV Model	Comp Model	Naive		
RMSE	0.11533	0.12119	0.11447	0.12139		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.02801	0.13530	0.02961	0.57922	0.02752	0.02735

Table 5.76, Root Mean Squared Errors and Pair Tests Results for Live Cattle (Regime 1)

	IV Model	HV Model	Comp Model	Naive		
RMSE	0.08956	0.09269	0.08936	0.09314		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.29954	0.81119	0.32523	0.70942	0.29621	0.28323

Table 5.77, Root Mean Squared Errors and Pair Tests Results for Live Cattle (Regime 2)

	IV Model	HV Model	Comp Model	Naive		
RMSE	0.15676	0.16207	0.13922	0.16047		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.65648	0.20327	0.23778	0.79531	0.61797	0.18218

Table 5.78, Root Mean Squared Errors and Pair Tests Results for Live Cattle (Regime 3)

	IV Model	HV Model	Comp Model	Naive		
RMSE	0.07986	0.07993	0.07979	0.07863		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.89086	0.82454	0.77063	0.29805	0.43599	0.43122

Table 5.79, Root Mean Squared Errors and Pair Tests Results for Live Cattle (Regime 4)

	IV Model	HV Model	Comp Model	Naive		
RMSE	0.13507	0.13469	0.13356	0.13516		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.87347	0.42624	0.55929	0.83521	0.94866	0.54313

Table 5.80, Root Mean Squared Errors and Pair Tests Results for Live Cattle (Regime 5)

	IV Model	HV Model	Comp Model	Naive		
RMSE	0.07063	0.07041	0.06994	0.07055		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.82435	0.37903	0.44822	0.82408	0.91557	0.44728

Table 5.81, Root Mean Squared Errors and Pair Tests Results for Live Cattle (Regime 6)

	IV Model	HV Model	Comp Model	Naive		
RMSE	0.13430	0.13623	0.12882	0.13669		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.61852	0.10171	0.15479	0.82557	0.39102	0.11618

Table 5.82, Root Mean Squared Errors and Pair Tests Results for Live Cattle (Regime 7)

	IV Model	HV Model	Comp Model	Naive		
RMSE	0.16059	0.17130	0.15649	0.17209		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.53586	0.33473	0.43961	0.64838	0.49987	0.41720

Table 5.83, Root Mean Squared Errors and Pair Tests Results for Live Cattle (Regime 8)

	IV Model	HV Model	Comp Model	Naive		
RMSE	0.11442	0.11632	0.11422	0.11644		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.12976	0.58131	0.13084	0.67482	0.14712	0.12804

Table 5.84, Root Mean Squared Errors and Pair Tests Results for Live Cattle (Regime 9)

	IV Model	HV Model	Comp Model	Naive		
RMSE	0.09281	0.09469	0.09229	0.09468		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.23224	0.53281	0.21398	0.99688	0.29359	0.22832

Feeder Cattle

Table 5.85, Root Mean Squared Errors and Pair Tests Results for Feeder Cattle (Full Period)

	IV Model	HV Model	Comp Model	Naive		
RMSE	0.09705	0.10129	0.09702	0.10204		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.06028	0.74356	0.06531	0.37419	0.03188	0.03405

Table 5.86, Root Mean Squared Errors and Pair Tests Results for Feeder Cattle (Regime 1)

	IV Model	HV Model	Comp Model	Naive		
RMSE	0.09916	0.10396	0.09915	0.10422		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.29255	0.90463	0.30029	0.92606	0.19259	0.19765

Table 5.87, Root Mean Squared Errors and Pair Tests Results for Feeder Cattle (Regime 2)

	IV Model	HV Model	Comp Model	Naive		
RMSE	0.10525	0.10422	0.10117	0.10557		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.73408	0.26644	0.38364	0.55770	0.78202	0.28018

Table 5.88, Root Mean Squared Errors and Pair Tests Results for Feeder Cattle (Regime 3)

	IV Model	HV Model	Comp Model	Naive		
RMSE	0.04055	0.04078	0.04055	0.04110		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.59202	0.98931	0.58177	0.59837	0.40172	0.40385

Table 5.89, Root Mean Squared Errors and Pair Tests Results for Feeder Cattle (Regime 4)

	IV Model	HV Model	Comp Model	Naive		
RMSE	0.08339	0.08412	0.08317	0.08175		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.38928	0.64467	0.37123	0.29898	0.45947	0.52400

Table 5.90, Root Mean Squared Errors and Pair Tests Results for Feeder Cattle (Regime 5)

	IV Model	HV Model	Comp Model	Naive		
RMSE	0.10625	0.11395	0.10527	0.11348		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.28051	0.29496	0.25598	0.65166	0.29973	0.26962

Table 5.91, Root Mean Squared Errors and Pair Tests Results for Feeder Cattle (Regime 6)

	IV Model	HV Model	Comp Model	Naive		
RMSE	0.13097	0.13038	0.12979	0.13546		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.88249	0.62434	0.74461	0.24241	0.31855	0.22518

Table 5.92, Root Mean Squared Errors and Pair Tests Results for Feeder Cattle (Regime 7)

	IV Model	HV Model	Comp Model	Naive		
RMSE	0.09310	0.09329	0.09306	0.09344		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.74853	0.80664	0.65730	0.74861	0.67198	0.63073

Table 5.93, Root Mean Squared Errors and Pair Tests Results for Feeder Cattle (Regime 8)

	IV Model	HV Model	Comp Model	Naive		
RMSE	0.05527	0.05572	0.05501	0.05511		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.70119	0.77324	0.58908	0.66620	0.91059	0.95515

Lean Hogs

Table 5.94, Root Mean Squared Errors and Pair Tests Results for Lean Hogs (Full Period)

	IV Model	HV Model	Comp Model	Naive		
RMSE	0.24438	0.24903	0.24436	0.24970		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.05480	0.87789	0.05897	0.31568	0.03907	0.04102

Table 5.95, Root Mean Squared Errors and Pair Tests Results for Lean Hogs (Regime 1)

	IV Model	HV Model	Comp Model	Naive		
RMSE	0.19674	0.19843	0.19650	0.19264		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.54537	0.71880	0.48512	0.16339	0.41256	0.42307

Table 5.96, Root Mean Squared Errors and Pair Tests Results for Lean Hogs (Regime 2)

	IV Model	HV Model	Comp Model	Naive		
RMSE	0.15422	0.15676	0.15422	0.15613		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.74603	0.96907	0.74552	0.70359	0.79591	0.79568

Table 5.97, Root Mean Squared Errors and Pair Tests Results for Lean Hogs (Regime 3)

	IV Model	HV Model	Comp Model	Naive		
RMSE	0.33867	0.34983	0.33864	0.34142		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.46719	0.97297	0.47970	0.52938	0.89368	0.89595

Table 5.98, Root Mean Squared Errors and Pair Tests Results for Lean Hogs (Regime 4)

	IV Model	HV Model	Comp Model	Naive		
RMSE	0.23141	0.22963	0.22900	0.23042		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.57557	0.32900	0.73310	0.71018	0.62243	0.55267

Table 5.99, Root Mean Squared Errors and Pair Tests Results for Lean Hogs (Regime 5)

	IV Model	HV Model	Comp Model	Naive		
RMSE	0.31218	0.31256	0.31167	0.31433		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.90981	0.75346	0.67734	0.54916	0.55318	0.47395

Table 5.100, Root Mean Squared Errors and Pair Tests Results for Lean Hogs (Regime 6)

	IV Model	HV Model	Comp Model	Naive		
RMSE	0.20317	0.20286	0.20285	0.20319		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.61528	0.59887	0.96466	0.59894	0.95382	0.61555

Table 5.101, Root Mean Squared Errors and Pair Tests Results for Lean Hogs (Regime 7)

	IV Model	HV Model	Comp Model	Naive		
RMSE	0.27356	0.27132	0.27051	0.27308		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.43980	0.21945	0.62331	0.44266	0.79052	0.35321

Table 5.102, Root Mean Squared Errors and Pair Tests Results for Lean Hogs (Regime 8)

	IV Model	HV Model	Comp Model	Naive		
RMSE	0.20165	0.20341	0.20164	0.20371		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.43781	0.93973	0.43018	0.66307	0.41440	0.41092

The above tables show the RMSE estimates for each forecast method across the analyzed commodities and the paired difference tests results first in the full period of time and then in each individual market regime.

Numerically across all six commodities, the composite method showed the smallest root mean square errors in the full period of time, immediately followed by the implied volatility. Historical volatility ranked as the third forecast method with the smallest mean absolute errors and the worst performing forecast according to this measure was the naïve forecast. The numerical difference between the forecast methods was always very small and we moved forward and analyzed the point estimates difference using paired tests.

Looking at the paired test in the full period of time we can see that there is no significant statistical difference between the implied volatility method and the composite method across all six commodities. This suggests that the numerical differences between the RMSEs generated from the forecast errors from the implied volatility model and the composite model might be due to chance. We found statistical differences between the RMSEs of implied volatility and the composite method when compared to the RMSEs of the historical volatility forecast. Furthermore, the RMSEs from the naïve method were always statistically different than those from the implied volatility and composite method. Therefore based on this measure, a decision maker would be better off by using either the implied volatility model or the composite model to predict one week ahead realized volatility in any of the six commodities.

The results for each individual market regime can be interpreted in a similar way. Overall, we found numerical differences in the rankings in individual regimes across all six commodities. In most of the individual regimes for each commodities the composite method ranked the highest in a numerical way. In all commodities, most of the time the individual regimes did not show statistically significant differences between the four forecast methods analyzed.

5.2.9 Mean Absolute Percentage Errors Analysis

We calculated the Mean Absolute Percentage Errors (MAPE) from each forecast method for the forecast error series of all six commodities in the full period of time and in each individual regime. Results are shown below.

Corn

Table 5.103, Mean Absolute Percentage Errors and Pair Tests Results for Corn (Full Period)

	IV Model	HV Model	Comp Model	Naive		
MAPE	2.41734	2.52647	2.41483	2.61081		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.02086	0.61022	0.01188	0.04517	0.00531	0.00456

Table 5.104, Mean Absolute Percentage Errors and Pair Tests Results for Corn (Regime 1)

	IV Model	HV Model	Comp Model	Naive		
MAPE	2.03492	2.21358	2.03405	2.32608		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.00005	0.65582	0.00003	0.00164	0.00000	0.00000

Table 5.105, Mean Absolute Percentage Errors and Pair Tests Results for Corn (Regime 2)

	IV Model	HV Model	Comp Model	Naive		
MAPE	4.05031	4.11104	4.10588	4.03484		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.81706	0.83138	0.14467	0.72295	0.91971	0.73892

Table 5.106, Mean Absolute Percentage Errors and Pair Tests Results for Corn (Regime 3)

	IV Model	HV Model	Comp Model	Naive		
MAPE	3.13289	3.16322	3.13160	3.12821		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.62539	0.96171	0.65848	0.24038	0.94563	0.96360

Table 5.107, Mean Absolute Percentage Errors and Pair Tests Results for Corn (Regime 4)

	IV Model	HV Model	Comp Model	Naive		
MAPE	2.10179	1.90859	1.90864	2.14658		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.44260	0.44208	0.98011	0.47706	0.76607	0.47788

Wheat

Table 5.108, Mean Absolute Percentage Errors and Pair Tests Results for Wheat (Full Period)

	IV Model	HV Model	Comp Model	Naive		
MAPE	2.18028	2.22851	2.18161	2.30378		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.22072	0.74747	0.19180	0.02323	0.01805	0.01593

Table 5.109, Mean Absolute Percentage Errors and Pair Tests Results for Wheat (Regime 1)

	IV Model	HV Model	Comp Model	Naive		
MAPE	1.83262	1.96705	1.79565	2.37075		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.64831	0.79265	0.33096	0.08994	0.18300	0.09736

Table 5.110, Mean Absolute Percentage Errors and Pair Tests Results for Wheat (Regime 2)

	IV Model	HV Model	Comp Model	Naive		
MAPE	1.11675	1.22512	1.17354	1.00215		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.29501	0.18256	0.66495	0.02031	0.36775	0.21839

Table 5.111, Mean Absolute Percentage Errors and Pair Tests Results for Wheat (Regime 3)

	IV Model	HV Model	Comp Model	Naive		
MAPE	2.26262	2.26722	2.26259	2.26957		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.84946	0.85151	0.84893	0.89970	0.81418	0.81308

Table 5.112, Mean Absolute Percentage Errors and Pair Tests Results for Wheat (Regime 4)

	IV Model	HV Model	Comp Model	Naive		
MAPE	2.64093	2.68471	2.66207	2.63494		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.57039	0.51142	0.62845	0.53202	0.91730	0.66573

Table 5.113, Mean Absolute Percentage Errors and Pair Tests Results for Wheat (Regime 5)

	IV Model	HV Model	Comp Model	Naive		
MAPE	1.47640	1.49210	1.49099	1.54967		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.82074	0.75977	0.96415	0.44569	0.54561	0.48343

Table 5.114, Mean Absolute Percentage Errors and Pair Tests Results for Wheat (Regime 6)

	IV Model	HV Model	Comp Model	Naive		
MAPE	2.96660	3.12749	2.91501	3.00618		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.22850	0.21015	0.20987	0.33816	0.72258	0.50001

Table 5.115, Mean Absolute Percentage Errors and Pair Tests Results for Wheat (Regime 7)

	IV Model	HV Model	Comp Model	Naive		
MAPE	2.06892	2.01819	2.05705	2.09537		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.58988	0.49295	0.61486	0.12027	0.77854	0.63976

Soybeans

Table 5.116, Mean Absolute Percentage Errors and Pair Tests Results for Soybeans (Full Period)

	IV Model	HV Model	Comp Model	Naive		
MAPE	2.73795	2.75127	2.72444	2.89170		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.82778	0.22844	0.60591	0.00421	0.02185	0.00981

Table 5.117, Mean Absolute Percentage Errors and Pair Tests Results for Soybeans (Regime 1)

	IV Model	HV Model	Comp Model	Naive		
MAPE	2.53409	2.47391	2.53250	2.49254		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.55268	0.61110	0.55558	0.72935	0.71975	0.72815

Table 5.118, Mean Absolute Percentage Errors and Pair Tests Results for Soybeans (Regime 2)

	IV Model	HV Model	Comp Model	Naive		
MAPE	3.20972	2.99093	3.24576	3.10379		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.50716	0.46844	0.50087	0.40327	0.64467	0.60367

Table 5.119, Mean Absolute Percentage Errors and Pair Tests Results for Soybeans (Regime 3)

	IV Model	HV Model	Comp Model	Naive		
MAPE	3.37871	3.23432	3.33516	3.47295		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.39707	0.48215	0.48215	0.02691	0.48635	0.26205

Table 5.120, Mean Absolute Percentage Errors and Pair Tests Results for Soybeans (Regime 4)

	IV Model	HV Model	Comp Model	Naive		
MAPE	1.58787	1.61784	1.63602	1.59841		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.26155	0.28461	0.46716	0.23600	0.47302	0.30865

Table 5.121, Mean Absolute Percentage Errors and Pair Tests Results for Soybeans (Regime 5)

	IV Model	HV Model	Comp Model	Naive		
MAPE	3.00936	3.03417	3.01294	3.07630		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.02631	0.05042	0.01747	0.15616	0.05965	0.57223

Live Cattle

Table 5.122, Mean Absolute Percentage Errors and Pair Tests Results for Live Cattle (Full Period)

	IV Model	HV Model	Comp Model	Naive		
MAPE	2.60510	2.72717	2.61668	2.76619		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.00387	0.48257	0.02049	0.01858	0.00040	0.00149

Table 5.123, Mean Absolute Percentage Errors and Pair Tests Results for Live Cattle (Regime 1)

	IV Model	HV Model	Comp Model	Naive		
MAPE	1.09024	1.20551	1.06510	1.19469		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.14621	0.29511	0.14437	0.74721	0.17409	0.13179

Table 5.124, Mean Absolute Percentage Errors and Pair Tests Results for Live Cattle (Regime 2)

	IV Model	HV Model	Comp Model	Naive		
MAPE	2.61275	2.70818	1.78385	2.68563		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.86645	0.14213	0.27840	0.86368	0.86894	0.23700

Table 5.125, Mean Absolute Percentage Errors and Pair Tests Results for Live Cattle (Regime 3)

	IV Model	HV Model	Comp Model	Naive		
MAPE	2.33522	2.35540	2.35775	2.30902		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.60873	0.14237	0.95546	0.39667	0.70473	0.49245

Table 5.126, Mean Absolute Percentage Errors and Pair Tests Results for Live Cattle (Regime 4)

	IV Model	HV Model	Comp Model	Naive		
MAPE	2.99833	3.14049	3.02339	2.99405		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.46594	0.63961	0.48504	0.31840	0.95229	0.72940

Table 5.127, Mean Absolute Percentage Errors and Pair Tests Results for Live Cattle (Regime 5)

	IV Model	HV Model	Comp Model	Naive		
MAPE	2.07982	2.11666	2.14524	2.09290		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.41671	0.21676	0.62611	0.50124	0.66977	0.35061

Table 5.128, Mean Absolute Percentage Errors and Pair Tests Results for Live Cattle (Regime 6)

	IV Model	HV Model	Comp Model	Naive		
MAPE	2.78107	2.70229	2.71767	2.71072		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.67982	0.63470	0.92750	0.93142	0.64002	0.97188

Table 5.129, Mean Absolute Percentage Errors and Pair Tests Results for Live Cattle (Regime 7)

	IV Model	HV Model	Comp Model	Naive		
MAPE	1.75844	1.83176	1.78218	1.81891		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.54442	0.76436	0.54549	0.69588	0.54024	0.65694

Table 5.130, Mean Absolute Percentage Errors and Pair Tests Results for Live Cattle (Regime 8)

	IV Model	HV Model	Comp Model	Naive		
MAPE	3.22371	3.29325	3.20589	3.29388		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.19365	0.35552	0.16520	0.96478	0.22261	0.16114

Table 5.131, Mean Absolute Percentage Errors and Pair Tests Results for Live Cattle (Regime 9)

	IV Model	HV Model	Comp Model	Naive		
MAPE	2.29026	2.34584	2.29182	2.37637		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.52587	0.95569	0.59739	0.12589	0.40113	0.46035

Feeder Cattle

Table 5.132, Mean Absolute Percentage Errors and Pair Tests Results for Feeder Cattle (Full Period)

	IV Model	HV Model	Comp Model	Naive		
MAPE	2.52645	2.60811	2.53128	2.65852		
	IV-HV	IV-Comp	HV-Comp	Naïve-HV	Naïve-IV	Naïve-Comp
Paired Test	0.13227	0.35059	0.17905	0.25690	0.03933	0.04750

Table 5.133, Mean Absolute Percentage Errors and Pair Tests Results for Feeder Cattle (Regime 1)

	IV Model	HV Model	Comp Model	Naive		
MAPE	2.59598	2.59019	2.60007	2.56693		
	IV-HV	IV-Comp	HV-Comp	Naïve-HV	Naïve-IV	Naïve-Comp
Paired Test	0.96309	0.59166	0.93921	0.86057	0.88600	0.87013

Table 5.134, Mean Absolute Percentage Errors and Pair Tests Results for Feeder Cattle (Regime 2)

	IV Model	HV Model	Comp Model	Naive		
MAPE	1.21323	1.16607	1.09649	1.21734		
	IV-HV	IV-Comp	HV-Comp	Naïve-HV	Naïve-IV	Naïve-Comp
Paired Test	0.35435	0.04362	0.10752	0.17699	0.79481	0.02864

Table 5.135, Mean Absolute Percentage Errors and Pair Tests Results for Feeder Cattle (Regime 3)

	IV Model	HV Model	Comp Model	Naive		
MAPE	1.96838	1.99805	1.96808	2.05749		
	IV-HV	IV-Comp	HV-Comp	Naïve-HV	Naïve-IV	Naïve-Comp
Paired Test	0.50969	0.74691	0.49897	0.17722	0.23439	0.23131

Table 5.136, Mean Absolute Percentage Errors and Pair Tests Results for Feeder Cattle (Regime 4)

	IV Model	HV Model	Comp Model	Naive		
MAPE	2.09369	2.11364	2.03390	1.90093		
	IV-HV	IV-Comp	HV-Comp	Naïve-HV	Naïve-IV	Naïve-Comp
Paired Test	0.58550	0.14348	0.10688	0.08532	0.17794	0.25126

Table 5.137, Mean Absolute Percentage Errors and Pair Tests Results for Feeder Cattle (Regime 5)

	IV Model	HV Model	Comp Model	Naive		
MAPE	2.42407	2.53857	2.40971	2.63145		
	IV-HV	IV-Comp	HV-Comp	Naïve-HV	Naïve-IV	Naïve-Comp
Paired Test	0.14649	0.78131	0.09372	0.12072	0.06030	0.03292

Table 5.138, Mean Absolute Percentage Errors and Pair Tests Results for Feeder Cattle (Regime 6)

	IV Model	HV Model	Comp Model	Naive		
MAPE	4.50130	4.06460	4.11953	5.02285		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.36900	0.29617	0.66117	0.18572	0.05940	0.14202

Table 5.139, Mean Absolute Percentage Errors and Pair Tests Results for Feeder Cattle (Regime 7)

	IV Model	HV Model	Comp Model	Naive		
MAPE	2.27508	2.25272	2.26851	2.24510		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.26713	0.30906	0.31921	0.69597	0.22724	0.35221

Table 5.140, Mean Absolute Percentage Errors and Pair Tests Results for Feeder Cattle (Regime 8)

	IV Model	HV Model	Comp Model	Naive		
MAPE	3.37715	3.55030	3.29476	3.32017		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.32005	0.19515	0.22539	0.18894	0.44803	0.77148

Lean Hogs

Table 5.141, Mean Absolute Percentage Errors and Pair Tests Results for Lean Hogs (Full Period)

	IV Model	HV Model	Comp Model	Naive		
MAPE	2.95111	3.03224	2.95607	3.07483		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.06043	0.20005	0.09651	0.13918	0.00367	0.00602

Table 5.142, Mean Absolute Percentage Errors and Pair Tests Results for Lean Hogs (Regime 1)

	IV Model	HV Model	Comp Model	Naive		
MAPE	2.69718	2.69892	2.71796	2.43635		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.98145	0.40949	0.82177	0.21858	0.25200	0.20433

Table 5.143, Mean Absolute Percentage Errors and Pair Tests Results for Lean Hogs (Regime 2)

	IV Model	HV Model	Comp Model	Naive		
MAPE	3.43673	3.39181	3.43387	3.48536		
	IV-HV	IV-Comp	HV-Comp	Naïve-HV	Naïve-IV	Naïve-Comp
Paired Test	0.75889	0.17408	0.77253	0.34255	0.78095	0.76811

Table 5.144, Mean Absolute Percentage Errors and Pair Tests Results for Lean Hogs (Regime 3)

	IV Model	HV Model	Comp Model	Naive		
MAPE	2.25007	2.62081	2.23049	2.32173		
	IV-HV	IV-Comp	HV-Comp	Naïve-HV	Naïve-IV	Naïve-Comp
Paired Test	0.29946	0.37552	0.30325	0.27919	0.50471	0.46594

Table 5.145, Mean Absolute Percentage Errors and Pair Tests Results for Lean Hogs (Regime 4)

	IV Model	HV Model	Comp Model	Naive		
MAPE	2.99389	3.05591	2.98930	3.13137		
	IV-HV	IV-Comp	HV-Comp	Naïve-HV	Naïve-IV	Naïve-Comp
Paired Test	0.69637	0.97664	0.12495	0.64317	0.11130	0.42343

Table 5.146, Mean Absolute Percentage Errors and Pair Tests Results for Lean Hogs (Regime 5)

	IV Model	HV Model	Comp Model	Naive		
MAPE	1.89440	1.89835	1.88719	1.92122		
	IV-HV	IV-Comp	HV-Comp	Naïve-HV	Naïve-IV	Naïve-Comp
Paired Test	0.92575	0.68270	0.70029	0.43927	0.59024	0.45438

Table 5.147, Mean Absolute Percentage Errors and Pair Tests Results for Lean Hogs (Regime 6)

	IV Model	HV Model	Comp Model	Naive		
MAPE	3.75775	3.82079	3.81796	3.77033		
	IV-HV	IV-Comp	HV-Comp	Naïve-HV	Naïve-IV	Naïve-Comp
Paired Test	0.12141	0.12799	0.52754	0.23326	0.40717	0.26387

Table 5.148, Mean Absolute Percentage Errors and Pair Tests Results for Lean Hogs (Regime 7)

	IV Model	HV Model	Comp Model	Naive		
MAPE	1.57410	1.58974	1.58155	1.55911		
	IV-HV	IV-Comp	HV-Comp	Naïve-HV	Naïve-IV	Naïve-Comp
Paired Test	0.71494	0.84332	0.74791	0.37256	0.62155	0.60987

Table 5.149, Mean Absolute Percentage Errors and Pair Tests Results for Lean Hogs (Regime 8)

	IV Model	HV Model	Comp Model	Naive		
MAPE	2.84271	2.95890	2.84700	2.94090		
	IV-HV	**IV-Comp**	**HV-Comp**	**Naïve-HV**	**Naïve-IV**	**Naïve-Comp**
Paired Test	0.19285	0.25716	0.19405	0.55107	0.18904	0.19547

The above tables show the MAPEs estimates for each forecast method across the analyzed commodities and the paired difference tests results first in the full period of time and then in each individual market regime.

Numerically in corn and soybeans, the composite method showed the smallest mean absolute percentage errors in the full period of time, immediately followed by the implied volatility; in wheat, live cattle, feeder cattle and lean hogs the implied volatility forecast method showed the smallest mean absolute percentage errors in the full period of time. Historical volatility ranked as the third forecast method with the smallest mean absolute percentage errors and the worst performing forecast according to this measure was the naïve forecast. The numerical difference between the forecast methods was always very small and we moved forward and analyzed this point estimates difference using paired tests.

Looking at the paired test in the full period of time we can see that there is no significant statistical difference between the implied volatility method and the composite method across all six commodities. This suggests that the numerical differences between the MAPEs generated from the forecast errors from the implied volatility model and the composite model might be due to chance. We found statistical differences between the MAPEs of implied volatility and the composite method when compared to the MAPEs of the historical volatility forecast in the case of corn, live cattle and lean hogs. Furthermore, the MAPEs from the naïve method were statistically different than those from the implied volatility and composite method in all six commodities. Therefore based on this measure, a decision maker would be better off by using either the implied volatility model or the composite model to predict one week ahead realized volatility in any of the six commodities.

The results for each individual market regime can be interpreted in a similar way. Overall, we found numerical differences in the rankings in individual regimes across all six commodities. In most of the individual regimes for each commodities the composite method ranked the highest. In all commodities, most of the time the individual regimes did not show statistically significant differences between the four forecast methods analyzed.

5.2.10 Summary

Across the grain markets of corn, wheat and soybeans, implied volatility, historical volatility and a linear combination of both were all unbiased forecasters of 1 week ahead realized volatility. Since the implied volatility and the historical volatility were both unbiased forecasters of realized volatility, it is not surprising that the linear combination of both is also unbiased. This conclusion holds for the full time period analysis and for the different market regimes analyzed.

In the full period of time, implied volatility, historical volatility and a linear combination of both were all found efficient forecasters of 1-week ahead realized volatility across the corn, wheat and soybeans markets using the beta efficiency and the rho efficiency condition tests. Results for individual market regimes varied across these three commodities and across the three forecast methods.

Except for the most recent regime for corn, implied volatility encompassed all the information contained in the historical volatility forecast method across the 3 grains markets in the full period of time and across all the market regimes. On the other hand, our analysis shows that historical volatility contains all the information available in the implied volatility forecast just in some of the regimes across the grain markets.

Across the corn, wheat and soybeans markets using the full period of time, implied volatility, historical volatility and a the composite forecasts methods all showed that their forecast errors have increased over time. This suggests that the mentioned volatility forecast models are getting worst at predicting 1-week ahead realized volatility in the period of time starting in January of 1995 and ending on April of 2014, however some of the more recent regimes showed forecast errors either non statistically significant or getting smaller. In general, results were mixed when the market regimes where analyzed separately.

Implied volatility, historical volatility and a linear combination of both were all unbiased forecasters of 1-week ahead realized volatility in the livestock markets which included live cattle, feeder cattle and lean hogs. Since the implied volatility and the historical volatility were both unbiased forecasters of realized volatility, it is not surprising that the linear combination of both is also unbiased. This conclusion holds for the full time period analysis and for the different market regimes analyzed.

In the live cattle and lean hogs markets implied volatility, historical volatility and the composite forecast methods were all efficient forecasters of 1-week realized volatility when the full spectrum of the data was analyzed. In the feeder cattle market and using the full period of time implied volatility and the composite method were efficient but the historical volatility forecast method was inefficient at forecasting 1 week- ahead realized volatility. When the market regimes where analyzed separately the results were mixed across regimes and across forecast methods. In the live cattle market the three forecast methods were efficient across all the regimes. In the feeder cattle and lean hogs markets there were market regimes where all three forecast methods were inefficient. In the lean hogs market there was a regime where historical volatility was the only inefficient forecaster when compared with the implied volatility and composite forecast method.

Our analysis shows that using the full period of time, the implied volatility forecast method encompasses all the information contained in the historical volatility forecast method across the live cattle, feeder cattle and lean hogs markets. This result is reversed when the historical volatility is set up as the preferred forecast. When historical volatility is set up as the preferred forecast, historical volatility does not encompass all the information provided by the alternative forecast, the implied volatility forecast in this case across the livestock markets, using the full spectrum of the data. When the market regimes were analyzed separately we still find the implied volatility forecast method to encompass all the information provided by the historical volatility forecast method across the three livestock markets and across all the regimes. When the historical volatility was set up as the preferred forecasts, the results were mixed across regimes and across the livestock markets. Some regimes showed that the historical volatility forecast method does not encompass all the information provided in the implied volatility forecast method, but other regimes showed the opposite.

The implied volatility, historical volatility and composite forecast methods did not show systematic change over time across all the regimes and when the full spectrum of the data was analyzed in the live cattle, feeder cattle and lean hogs markets.

When we further complemented our forecasting performance assessment by analyzing alternative forecast methods based on “Mean Absolute Errors”, “Root Mean Squared Errors” and “Mean Absolute Percentage Errors” we found evidence that support our previous results in the full period of time. The mentioned analysis showed that the composite forecast ranked the highest as a forecast method followed by implied volatility in a numerical way across all six commodities. Nevertheless, when we compared the MAEs, RMSEs and MAPEs point estimates using paired tests, the differences between the composite method and the implied volatility method were not statistically significant most of the time across all six commodities.

The difference in the nature of the conclusions regarding the volatility forecast performance in the grain and livestock markets might be explained in part by the nature of their underlying futures contracts. The CME Group (2014) describes their grain futures contracts as global benchmarks where people from all over the world offsets their risk. The livestock contracts say live cattle, feeder cattle and lean hogs, are more regional where nearly all of their hedging customers are located within the United States. Although now it is clear that the grain markets and livestock markets enjoy of depth and liquidity now a days, the average trading volume of corn, wheat and soybeans averaged about 17% higher than the average volume of live cattle, feeder cattle and lean hogs in 2014. Future research may look at grains versus livestock patterns in the forecasting performance arena.

Chapter 6 - Conclusions

In an ever changing economic environment, higher speed in the globalization of the markets, and more efficient ways of communicating information, the factors affecting volatility in commodity markets are going to be more and more complex. Many of the points we wish to make in this study are indeed related to changes in market structures over time due to different macro and micro economic factors and how those affect the volatility forecasting field. It seems that many of the studies analyzing forecast methods of realized volatility of future prices devote much of the attention complex trading methods and model specifications. While those analysis are of interest to certain people, we intend this study to shed light to agribusiness risk managers in a practical way. In that direction, this study makes use of accessible sources of information and accessible methods of analyzing forecasting performance of implied volatility, historical volatility and a composite approach as forecasters of realized volatility. This research supplements the literature by separating the full length of the data in individual market regimes in order to remove the impact of market shocks from the forecasting performance assessment.

This research uses weekly data from January 1995 to April 2014 to identify market regimes in the corn, wheat, soybeans, live cattle, feeder cattle and lean hogs futures markets. Consequently, the mentioned data was used to assess the performance of implied volatility, historical volatility, a linear combination of implied and historical volatility and a naïve approach, as forecasters of realized volatility in the mentioned commodity markets. The forecasting performance was assessed using the full length of the data and in every individual market regime. Descriptive statistics indicated that in the grains markets, wheat had the highest realized volatility and in the livestock markets lean hogs had the highest realized volatility over the full time period. Across the grains and livestock markets lean hogs was the most volatile market using realized volatility as a measure over the full time period.

In order to identify market structural breaks in each of the six commodities a statistical approach was combined with an ad-hoc more subjective method. The ad-hoc method complements the pure numerical nature of the statistical approach by incorporating the researcher’s assessment or inclusion of prior information into the analysis. In the grain markets 4 regimes were identified for corn, 7 for wheat and 5 for soybeans. Some of the regimes identified in the grain markets coincide with easy to identify- economic shocks. For example, across the grains markets, the regime containing the 2008 period has the highest average realized volatility across the rest of the regimes in each commodity. In 2008 different factors led to a world financial crisis probably not seen since the “Great Depression” in the 1930s. During the 2008 period, futures prices of agricultural commodities spiked to all times high causing the volatilities structures to change in the markets. In the livestock markets, 9 regimes were identified for live cattle, 8 for feeder cattle and 8 for lean hogs. Similarly to the grain markets, high volatility was observed in the regimes containing the 2008 period in the livestock futures, especially in the feeder cattle market. It is of importance to keep in mind that when there is a considerable shock in the markets, whether it is on the supply side or the demand side, its effect could be on both, price levels and volatility behavior. That might explain why other shocks like the “Energy Policy act in 2005” and the 2010-2011 major droughts around grain producing areas in the globe are not easy to highlight in the identified regimes periods for each of the commodities.

More recently, is generally clear how important it is to have a globalized economy and to have faster and more efficient flow of information, yet these two factors are sometimes mistakenly conceived as bad characteristics of our markets. Some people attribute the increase of volatility and futures price levels to the participation of outside players know as speculators. However, many people would agree that this assertion is not true given the importance of the mentioned players in driving up the liquidity on the markets, which is of vital importance for market participants, whether they are hedgers or speculators. Whatever it is the reason for the markets' volatility behavior, there is a clear need to understand how volatility change. Along those lines, this study looks at the forecasting performance of three methods in predicting realized volatility in the futures prices of corn, wheat, soybeans, live cattle, feeder cattle and lean hogs. The forecasting performance is first analyzed in the full length of the data. This analysis is further complemented by analyzing the forecasting performance in each individual regime. Forecasting performance was analyzed in terms of bias, efficiency, forecast encompassing, and forecast change over time.

In terms of bias, implied volatility, historical volatility a naïve approach and a composite model were all found unbiased in predicting one week ahead realized volatility across the corn, wheat, soybeans, live cattle, feeder cattle and lean hogs commodity markets, using the full length of the data. Interestingly, we did not find any different conclusion when individual regimes were analyzed in each commodity.

Implied volatility, historical volatility a naïve approach and a composite model were all found efficient forecasters of one week realized volatility across all commodities analyzed, except for feeder cattle, when the full length of the data was analyzed. In the feeder cattle analysis using the full length of the data, implied volatility, the composite approach and the naïve approach were the only efficient forecasters. Since historical volatility was inefficient alone, we suspect that in the composite method approach, implied volatility is driving the result. We did not find any case were both implied volatility and historical volatility were inefficient by themselves, but efficient when combined. This assertion might lead to question the importance of combining implied volatility and historical volatility to create a composite forecast. This conclusion is further strengthened when we analyzed the forecast methods based on “Mean Absolute Errors”, Root Mean Squared Errors” and “Mean Absolute Percentage Errors. When analyzing individual market regimes in the grain markets, implied volatility was found inefficient in three individual regimes, historical volatility in one and the composite method in one of the individual regimes. In the livestock markets, implied volatility and the composite approach were found inefficient in two of the individual market regimes and historical volatility was found inefficient in three of the individual market regimes. If we look at the full period of time analysis of efficiency of the forecast methods, implied volatility, the naïve approach and the composite approach seem to have an advantage over historical volatility, considering it was the only forecast method that was found inefficient across all six commodities in one of the individual regimes. Remarkably from this section, we did not find evidence to support the idea of the superiority of a composite method.

To determine if implied volatility, being a forward looking measure, encompasses all the information contained in the historical volatility measure, we used the test for forecast encompassing. In a similar way this test allowed us to analyze the implied volatility versus the naïve model and historical volatility versus the naïve model. Across all commodities, implied volatility proved to encompass all the information contained in the historical volatility forecast when the full period of time was analyzed. On the other hand, historical volatility was found not to encompass all the information contained in the implied volatility forecast across all six commodities in the full period of time. This suggests that the historical volatility method provides no further information relative to the implied volatility method in forecasting one week ahead realized volatility in all six commodities. Across all commodities, implied volatility encompassed all the information contained in the naïve forecast when the full period of time was analyzed. On the other hand, the naïve forecast was found not to encompass all the information contained in the implied volatility forecast across all six commodities in the full period of time when compared to implied and historical volatility. When individual market regimes were analyzed implied volatility encompassed all the information contained in the historical volatility method in all of the regimes across commodities except for one of the regimes in corn. Combining the regimes across commodities, historical volatility did not encompass all the information contained in the implied volatility method in 14 of the market regimes. This leads us to believe that implied volatility contains the most information about realized volatility in a one week forecast horizon.

Different factors could be affecting the forecasting performance of the analyzed forecast methods over time. Therefore, is of interest to assess if the forecast performance has change over time. For this purpose the test for time change was used. The test results show that the forecast performance of the four forecast methods in the corn, wheat and soybeans markets has gotten worst over time while that of live cattle, feeder cattle and lean hogs has not changed, using the full period of the data. Our perception about this conclusion is that the market complexities have intensify over the time period analyzed, making it harder for the forecast methods to predict volatility. The behavior of realized volatility change in different time periods, but generally has gotten more aggressive after the 2000s. When the individual market regimes where analyzed results varied. Very few regimes actually showed time change in one or more forecast methods. Those include wheat, where the three forecast methods showed decreasing forecast errors in regime 7, live cattle where the composite method showed improvement in regime 9 and feeder cattle where the historical volatility method showed improvement in regime 5. In general we did not find forecast performance change in most of the identified regimes across each commodity.

6.1 Implications

Though generalizing implications across the diverse analyzed commodity markets is not an easy task, there are a few general conclusions that can be drawn from this study.

Structural breaks are present throughout the agricultural commodity markets. When analyzing the performance of forecast methods of realized volatility, it is important to keep in mind that market structures do change over time. This research identified market structural breaks in each of the analyzed commodities which differed in both number and timing across the six examined commodities. This highlights the value in breaking the data and assessing the forecasting performance accordingly.

When it comes to decision making, the availability of resources is a key factor. The data used in this study is available to general public but it requires investment. Risk managers should be aware of the importance of having a comprehensive risk management plan that uses the most adequate techniques according to each circumstance. When users have available both implied volatility data and historical volatility, the process required to combine those approaches is not difficult. However, this research shows very limited forecasting improvement by creating a linear combination of implied volatility and historical volatility as forecaster of 1 week realized volatility of the analyzed agricultural commodities. Furthermore, this study shows that implied volatility encompasses all the information contained in the historical volatility and the naïve approach measures analyzed. It is of importance to keep in mind that the historical volatility measure used in this study is a 20 days moving average. The literature review shows that a simple historical approach might be superior to other time series alternatives that involve complex mathematical models. Additionally, 20-days historical volatility is more widely available than measures that come from more complex time series approaches, therefore is a more accessible tool for risk managers.

The bottom-line for a risk manager from this study involves deciding what forecast method and in which specification is better to forecast future volatility. We recognize that the several steps taken in this study include the identification of the market regimes which requires expertise that is not available to market participants all of the time. Though we recognize the importance of the market structural breaks in our data, the question that rises is how do we identify those regimes contemporaneously? Maybe the good news is that if that expertise is not available to the decision maker, we found enough evidence to support the idea that no matter in what market regime the decision might have to be taken, implied volatility, historical volatility and the composite method could offer a decent estimate of future realized volatility in the short term based on bias and efficiency. When our analysis was complemented by estimating the mean absolute errors, the root mean squared errors and the mean absolute percentage errors we found equal superiority in the composite and implied volatility forecast methods. Furthermore, considering the extra steps required for the estimation of a composite approach, it may be preferable for a decision maker to use implied volatility as forecaster of realized volatility in the short term. These conclusion holds in the corn, wheat, soybeans, live cattle and lean hogs markets. If the expertise is available, the layers of analysis performed in this study starting with the identification of the market regimes could be updated to find out in which market regime the decision is going to be made. Alternatively, there could be some value in characterizing todays period according to similarities to the identified market regimes in this study.

6.2 Future Research

This study looked at the forecasting performance of implied volatility, historical volatility and a linear combination of both, and a naïve approach as forecasters of 1 week ahead realized volatility. It would be interesting to analyze the changes in our findings when forecasting longer time horizons. For example, for a feedlot manager it is of interest to know the volatility of the fed cattle prices 4 to 6 months ahead so that he can make the best decisions in his operation. This task would require analyzing the performance of the mentioned forecast methods in forecasting realized volatility 16-24 weeks ahead.

The current analysis was performed using weekly data. Our weekly estimate comes from the last trading day of each week. It would be of interest to know if the results change when a weekly average is used instead. Furthermore, knowing the forecasting performance of implied, historical and a linear combination of both forecast method when daily data is used instead of the weekly estimate would be of benefit for the literature.

It would also be of interest to analyze if incorporating current information into the forecast would improve its accuracy. That is, if we know that the current volatility estimate is off by 2%, would incorporating that information into the next period forecast improve its accuracy? That is an area of the realized volatility forecasting performance arena that has not been analyzed and that could shed some light towards improving accuracy of different forecast methods.

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Appendix A - Identifying Market Structural Changes

Wheat Results

Figure 6.1, Wheat Chow Test Results

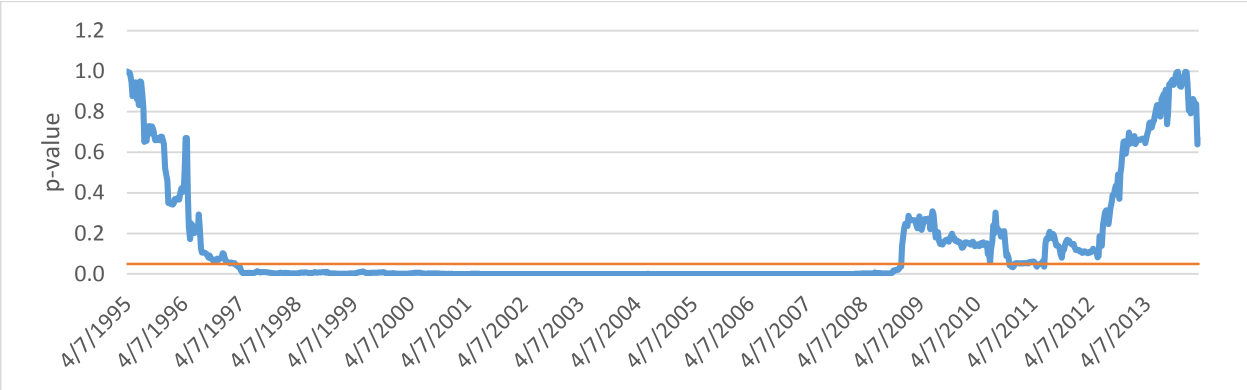

Table 6.1, Wheat UDmax F test

Number of breaks	UDmaxF	Pr > UDmaxF
20	84.62756	<.0001

Table 6.2, Wheat WDmax F test

Number of breaks	Alpha	WDmaxF	Pr > WDmaxF
20	0.1	91.285	<.0001
	0.05	94.561	<.0001
	0.025	97.571	<.0001
	0.01	100.995	<.0001

Table 6.3, Wheat supF (l+1|l) test

l	New Break	supF(l+1|l)	Pr > supF(l+1|l)
0	387	49.792	0.002
1	119	53.874	0.000
2	782	50.048	0.002
3	119	43.273	0.028
4	65	43.008	0.031
5	**65**	**43.008**	**0.031**
6	385	36.417	0.252
7	916	31.723	0.716
8	321	19.658	1.000
9	592	17.393	1.000
10	459	14.085	1.000
11	459	14.085	1.000

12	398	16.143	1.000
13	488	20.179	1.000
14	30	13.857	1.000
15	30	13.857	1.000
16	488	20.179	1.000
17	321	15.060	1.000
18	321	15.060	1.000
19	321	15.060	1.000
20	321	15.060	1.000

Table 6.4, Wheat BP break dates

Number of breaks	Break	95% Confidence Limits	
1	387	335	439
2	671	654	688
	830	816	844
3	671	657	685
	782	778	786
	830	827	833
4	119	90	148
	671	658	684
	782	778	786
	830	827	833
5	119	91	147
	671	664	678
	732	722	742
	782	779	785
	830	827	833
6	65	54	76
	119	108	130
	671	664	678
	732	722	742
	782	779	785
	830	827	833
7	65	55	75
	119	109	129
	385	342	428
	682	675	689
	732	726	738
	782	779	785
	830	827	833
8	65	55	75

	119	109	129
	385	344	426
	682	676	688
	732	726	738
	782	779	785
	830	827	833
	916	903	929
9	65	55	75
	119	110	128
	353	343	363
	400	389	411
	682	676	688
	732	726	738
	782	779	785
	830	827	833
	916	903	929
10	65	55	75
	119	110	128
	353	343	363
	400	391	409
	592	560	624
	682	676	688
	732	726	738
	782	779	785
	830	827	833
	916	903	929
11	65	56	74
	119	110	128
	353	343	363
	400	392	408
	592	561	623
	682	676	688
	732	726	738
	782	779	785
	830	828	832
	878	867	889
	926	917	935
12	65	56	74
	119	110	128
	367	350	384
	424	418	430

	469	461	477
	592	565	619
	682	676	688
	732	726	738
	782	779	785
	830	828	832
	878	868	888
	926	918	934
13	65	56	74
	119	110	128
	353	343	363
	400	393	407
	459	435	483
	564	544	584
	639	630	648
	689	684	694
	737	731	743
	784	781	787
	830	828	832
	878	868	888
	926	918	934
14	65	56	74
	119	110	128
	353	343	363
	400	393	407
	459	449	469
	505	486	524
	593	580	606
	641	634	648
	689	685	693
	737	731	743
	784	781	787
	830	828	832
	878	868	888
	926	918	934
15	65	56	74
	119	108	130
	174	115	233
	353	343	363
	400	393	407
	459	449	469

	505	487	523
	593	580	606
	641	634	648
	689	685	693
	737	731	743
	784	781	787
	830	828	832
	878	868	888
	926	918	934
16	65	56	74
	119	108	130
	202	183	221
	248	238	258
	295	285	305
	353	345	361
	400	393	407
	459	436	482
	564	545	583
	639	630	648
	689	684	694
	737	731	743
	784	782	786
	830	828	832
	878	868	888
	926	918	934
17	65	56	74
	119	108	130
	202	183	221
	248	238	258
	295	285	305
	353	345	361
	400	393	407
	459	449	469
	505	487	523
	593	580	606
	641	634	648
	689	685	693
	737	731	743
	784	782	786
	830	828	832
	878	868	888

	926	918	934
18	65	56	74
	119	108	130
	202	183	221
	248	238	258
	295	285	305
	353	345	361
	400	393	407
	459	449	469
	505	487	523
	593	580	606
	641	634	648
	689	685	693
	737	732	742
	784	782	786
	830	828	832
	878	868	888
	926	918	934
	976	951	1001
19	65	56	74
	119	109	129
	202	183	221
	248	238	258
	295	285	305
	353	345	361
	400	393	407
	448	434	462
	498	480	516
	544	519	569
	593	582	604
	641	635	647
	689	685	693
	737	732	742
	784	782	786
	830	828	832
	878	868	888
	926	918	934
	976	951	1001
20	30	24	36
	78	65	91
	126	111	141

	202	184	220
	248	238	258
	295	285	305
	353	345	361
	400	393	407
	448	434	462
	498	480	516
	544	519	569
	593	582	604
	641	635	647
	689	685	693
	737	732	742
	784	782	786
	830	828	832
	878	868	888
	926	918	934
	976	951	1001

Soybeans Results

Figure 6.2, Soybeans Chow Test Results

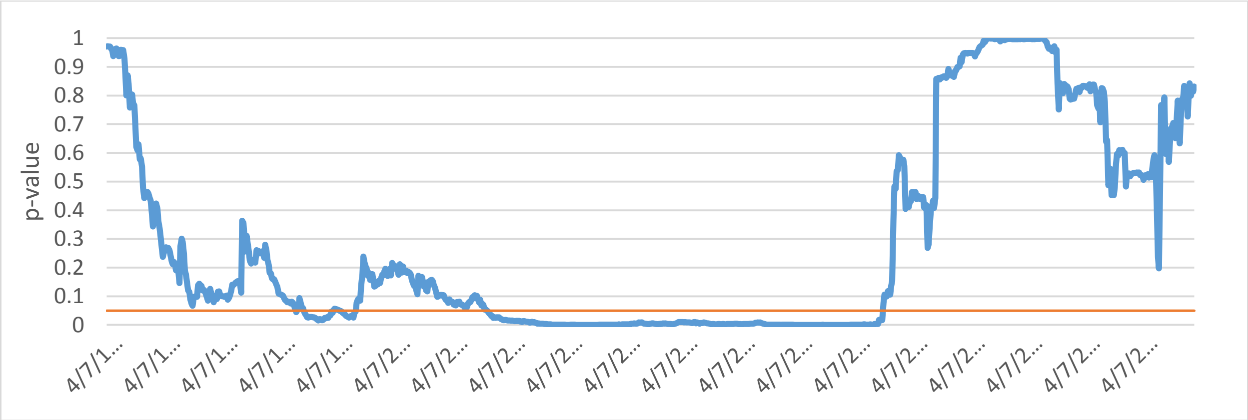

Table 6.5, Soybeans UDmax F test

Number of breaks	UDmaxF	Pr > UDmaxF
20	168.845	<.0001

Table 6.6, Soybeans WDmax F test

Number of breaks	Alpha	WDmaxF	Pr > WDmaxF
20	0.10	182.127	<.0001
	0.05	188.664	<.0001

	0.025	194.668	<.0001
	0.01	201.499	<.0001

Table 6.7, Soybeans supF (l+1|l) test

l	New Break	supF(l+1|l)	Pr > supF(l+1|l)
0	673	39.348	0.103
1	765	70.831	<.0001
2	649	59.364	<.0001
3	450	39.125	0.111
4	547	59.918	<.0001
5	967	34.375	0.427
6	624	21.134	1.000
7	624	21.134	1.000
8	330	23.425	1.000
9	330	23.425	1.000
10	30	26.167	0.998
11	30	26.167	0.998
12	30	26.167	0.998
13	330	29.677	0.899
14	30	26.167	0.998
15	30	26.167	0.998
16	30	26.167	0.998
17	793	26.394	0.997
18	793	26.394	0.997
19	793	26.394	0.997
20	793	26.394	0.997

Table 6.8, Soybeans BP break dates

Number of breaks	Break	95% Confidence Limits	
1	673	609	737
2	716	714	718
	765	763	767
3	670	667	673
	717	715	719
	765	763	767
4	450	407	493
	670	667	673
	717	715	719
	765	763	767
5	475	467	483

	547	539	555
	670	667	673
	717	715	719
	765	763	767
6	475	467	483
	547	539	555
	670	667	673
	717	715	719
	765	763	767
	967	952	982
7	475	467	483
	547	540	554
	670	667	673
	717	715	719
	765	763	767
	870	855	885
	921	908	934
8	236	229	243
	282	274	290
	475	468	482
	547	540	554
	670	667	673
	717	715	719
	765	763	767
	967	953	981
9	236	229	243
	282	274	290
	475	468	482
	547	540	554
	670	667	673
	717	715	719
	765	763	767
	870	856	884
	921	908	934
10	78	64	92
	130	115	145
	236	229	243
	282	274	290
	475	468	482
	547	540	554
	670	667	673

	717	715	719
	765	763	767
	967	954	980
11	78	65	91
	130	115	145
	236	230	242
	282	275	289
	475	468	482
	547	540	554
	670	667	673
	717	715	719
	765	763	767
	870	856	884
	921	909	933
12	78	65	91
	130	115	145
	236	230	242
	282	275	289
	475	469	481
	547	540	554
	670	668	672
	717	715	719
	765	763	767
	870	856	884
	920	911	929
	966	958	974
13	78	65	91
	130	115	145
	236	230	242
	282	275	289
	450	441	459
	496	485	507
	547	541	553
	670	668	672
	717	715	719
	765	763	767
	870	857	883
	920	911	929
	966	958	974
14	78	65	91
	130	116	144

	236	230	242
	282	277	287
	330	311	349
	450	442	458
	496	485	507
	547	542	552
	670	668	672
	717	715	719
	765	763	767
	870	857	883
	920	911	929
	966	958	974
15	78	65	91
	130	119	141
	187	169	205
	236	231	241
	282	277	287
	330	311	349
	450	442	458
	496	485	507
	547	542	552
	670	668	672
	717	715	719
	765	763	767
	870	857	883
	920	912	928
	966	958	974
16	78	66	90
	130	119	141
	187	170	204
	236	231	241
	282	277	287
	330	311	349
	450	442	458
	496	485	507
	547	542	552
	624	609	639
	670	668	672
	717	715	719
	765	763	767
	870	857	883

	920	912	928
	966	958	974
17	78	66	90
	130	119	141
	187	170	204
	236	231	241
	282	277	287
	330	311	349
	450	442	458
	496	485	507
	547	543	551
	624	609	639
	670	668	672
	717	715	719
	765	763	767
	823	800	846
	870	860	880
	920	912	928
	966	958	974
18	30	17	43
	78	68	88
	130	119	141
	187	170	204
	236	231	241
	282	277	287
	330	311	349
	450	442	458
	496	485	507
	547	543	551
	624	609	639
	670	668	672
	717	715	719
	765	763	767
	823	800	846
	870	860	880
	920	912	928
	966	958	974
19	78	66	90
	130	120	140
	187	170	204
	236	231	241

	282	277	287
	339	323	355
	389	381	397
	434	427	441
	487	483	491
	512	506	518
	574	563	585
	624	615	633
	670	668	672
	717	715	719
	765	763	767
	823	801	845
	870	860	880
	920	912	928
	966	958	974
20	30	17	43
	78	69	87
	130	120	140
	187	170	204
	236	231	241
	282	277	287
	339	323	355
	389	381	397
	434	427	441
	487	483	491
	512	506	518
	574	563	585
	624	615	633
	670	668	672
	717	715	719
	765	763	767
	823	801	845
	870	860	880
	920	912	928
	966	958	974

Live Cattle Results

Figure 6.3, Live Cattle Chow Test Results

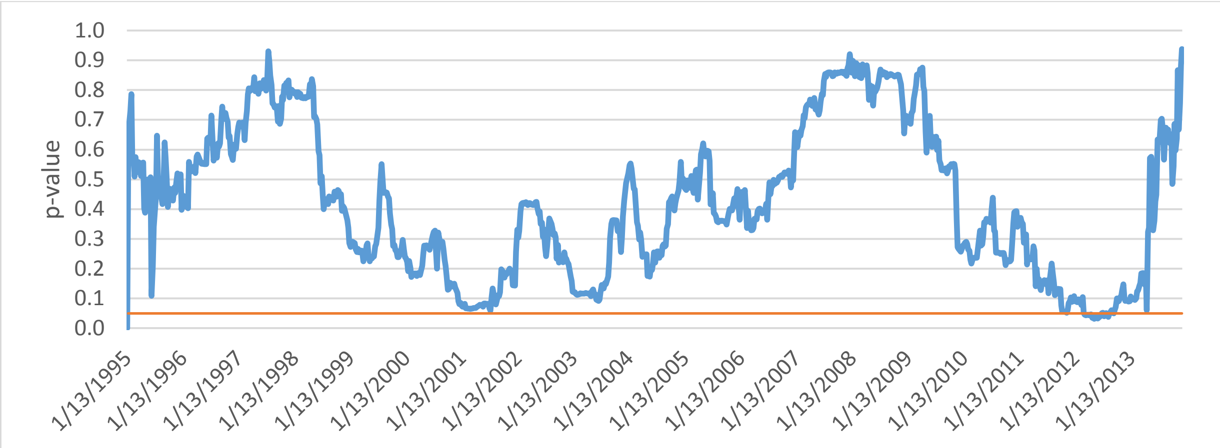

Table 6.9, Live Cattle UDmax F test

Number of Breaks	UDmaxF	Pr > UDmaxF
20	168.712	<.0001

Table 6.10, Live Cattle WDmax F test

Number of Breaks	Alpha	WDmaxF	Pr > WDmaxF
20	0.100	174.747	<.0001
	0.050	179.553	<.0001
	0.025	183.746	<.0001
	0.010	188.545	<.0001

Table 6.11, Live Cattle supF (l+1|l) test

l	New Break	supF(l+1|l)	Pr > supF(l+1|l)
0	356	19.369	1.000
1	521	39.412	0.101
2	521	30.465	0.839
3	327	29.150	0.931
4	327	29.150	0.931
5	327	29.150	0.931
6	69	20.776	1.000
7	34	21.267	1.000
8	249	21.273	1.000
9	65	50.905	0.002
10	65	50.905	0.002
11	65	50.905	0.002
12	65	50.905	0.002

13	797	13.891	1.000
14	797	13.891	1.000
15	797	13.891	1.000
16	636	11.422	1.000
17	769	16.121	1.000
18	769	16.121	1.000
19	769	16.121	1.000
20	300	8.030	1.000

Table 6.12, Live Cattle BP break dates

Number of Breaks	Break	95% Confidence Limits	
1	356	228	484
2	421	419	423
	469	467	471
3	421	419	423
	469	467	471
	521	503	539
4	421	419	423
	469	467	471
	679	672	686
	726	719	733
5	421	419	423
	469	467	471
	524	508	540
	677	671	683
	726	719	733
6	327	301	353
	421	419	423
	469	467	471
	524	509	539
	677	671	683
	726	719	733
7	69	38	100
	327	306	348
	421	419	423
	469	467	471
	524	509	539
	677	671	683
	726	720	732
8	147	134	160
	196	186	206

	327	310	344
	421	419	423
	469	467	471
	524	509	539
	677	671	683
	726	720	732
9	92	66	118
	184	171	197
	232	222	242
	326	311	341
	421	419	423
	469	467	471
	524	510	538
	677	671	683
	726	720	732
10	92	66	118
	184	171	197
	232	222	242
	326	311	341
	421	419	423
	469	467	471
	524	510	538
	677	671	683
	726	719	733
	893	852	934
11	92	67	117
	184	171	197
	232	223	241
	326	311	341
	421	419	423
	469	467	471
	524	510	538
	677	671	683
	726	720	732
	844	829	859
	893	882	904
12	92	67	117
	184	171	197
	232	223	241
	326	314	338
	374	360	388

	423	421	425
	469	467	471
	524	510	538
	677	671	683
	726	720	732
	844	829	859
	893	882	904
13	67	57	77
	113	106	120
	184	172	196
	232	223	241
	326	314	338
	374	360	388
	423	421	425
	469	467	471
	524	511	537
	677	671	683
	726	720	732
	844	830	858
	893	882	904
14	67	57	77
	113	106	120
	184	172	196
	232	223	241
	326	314	338
	374	361	387
	423	421	425
	469	467	471
	524	514	534
	588	557	619
	677	672	682
	726	720	732
	844	830	858
	893	882	904
15	45	31	59
	92	84	100
	147	139	155
	196	187	205
	249	223	275
	326	315	337
	374	361	387

	423	421	425
	469	467	471
	524	514	534
	588	557	619
	677	672	682
	726	720	732
	844	830	858
	893	883	903
16	45	32	58
	92	84	100
	147	139	155
	196	187	205
	249	224	274
	326	315	337
	374	361	387
	423	421	425
	469	467	471
	524	515	533
	588	557	619
	677	672	682
	726	720	732
	797	775	819
	844	834	854
	893	883	903
17	45	32	58
	92	84	100
	147	139	155
	196	188	204
	249	224	274
	326	315	337
	374	361	387
	423	421	425
	469	467	471
	524	515	533
	588	575	601
	636	620	652
	689	682	696
	739	729	749
	797	774	820
	844	834	854
	893	883	903

18	45	32	58
	92	84	100
	147	139	155
	196	188	204
	249	224	274
	326	315	337
	374	361	387
	423	421	425
	469	467	471
	524	515	533
	588	575	601
	636	620	652
	689	682	696
	739	730	748
	797	774	820
	844	835	853
	892	883	901
	939	913	965
19	45	32	58
	92	84	100
	147	139	155
	196	188	204
	249	224	274
	326	315	337
	374	361	387
	423	421	425
	469	467	471
	524	515	533
	588	575	601
	636	620	652
	689	682	696
	739	730	748
	797	774	820
	844	837	851
	874	866	882
	924	902	946
	971	950	992
20	45	32	58
	92	84	100
	147	139	155
	196	188	204

	249	224	274
	326	315	337
	374	361	387
	423	421	425
	469	467	471
	502	492	512
	550	539	561
	597	572	622
	654	642	666
	702	696	708
	750	737	763
	797	781	813
	844	837	851
	874	866	882
	924	902	946
	971	950	992

Feeder Cattle Results

Figure 6.4, Feeder Cattle Chow Test Results

Table 6.13, Feeder Cattle UDmax F test

Number of Breaks	UDmaxF	Pr > UDmaxF
20	75.000	<.0001

Table 6.14,Feeder Cattle WDmax F test

Number of Breaks	Alpha	WDmaxF	Pr > WDmaxF
20	0.100	80.217	<.0001
	0.050	84.140	<.0001
	0.025	87.729	<.0001

	0.010	91.982	<.0001

Table 6.15, Feeder Cattle supF (l+1|l) test

l	New Break	supF(l+1|l)	Pr > supF(l+1|l)
0	82	24.876	1.000
1	444	31.232	0.770
2	513	65.448	<.0001
3	513	65.448	<.0001
4	513	57.180	<.0001
5	513	57.180	<.0001
6	513	57.180	<.0001
7	513	57.180	<.0001
8	341	29.773	0.895
9	331	35.502	0.325
10	331	48.311	0.004
11	331	35.502	0.325
12	331	48.311	0.004
13	617	101.065	<.0001
14	617	101.065	<.0001
15	617	101.065	<.0001
16	722	16.876	1.000
17	722	16.876	1.000
18	722	16.876	1.000
19	722	16.876	1.000
20	96	15.967	1.000

Table 6.16, Feeder Cattle BP break dates

Number of Breaks	Break	95% Confidence Limits	
1	82	49	115
2	421	417	425
	470	466	474
3	228	199	257
	421	417	425
	470	466	474
4	421	417	425
	470	466	474
	698	689	707
	752	744	760
5	228	201	255
	421	417	425

	470	466	474
	698	690	706
	752	744	760
6	158	149	167
	205	197	213
	421	417	425
	470	466	474
	698	690	706
	752	745	759
7	67	64	70
	115	112	118
	213	197	229
	421	418	424
	470	466	474
	698	690	706
	752	745	759
8	67	64	70
	115	112	118
	213	197	229
	421	418	424
	470	467	473
	534	519	549
	686	678	694
	752	745	759
9	67	64	70
	115	112	118
	213	199	227
	374	365	383
	422	419	425
	470	467	473
	534	519	549
	686	678	694
	752	745	759
10	67	64	70
	115	112	118
	177	166	188
	227	218	236
	373	365	381
	422	419	425
	470	467	473
	534	519	549

	686	678	694
	752	745	759
11	67	64	70
	115	112	118
	213	200	226
	374	366	382
	422	419	425
	470	467	473
	534	520	548
	686	678	694
	752	745	759
	857	850	864
	905	897	913
12	67	64	70
	115	112	118
	177	167	187
	227	219	235
	373	365	381
	422	419	425
	470	467	473
	534	520	548
	686	679	693
	752	745	759
	857	850	864
	905	897	913
13	67	64	70
	115	112	118
	177	167	187
	227	219	235
	373	365	381
	422	419	425
	470	467	473
	534	525	543
	591	572	610
	697	689	705
	752	746	758
	857	850	864
	905	897	913
14	67	64	70
	115	112	118
	177	167	187

	227	221	233
	316	297	335
	373	367	379
	422	419	425
	470	467	473
	534	525	543
	591	572	610
	697	690	704
	752	746	758
	857	850	864
	905	898	912
15	67	64	70
	115	112	118
	177	167	187
	227	221	233
	316	297	335
	373	367	379
	422	419	425
	470	467	473
	534	525	543
	591	573	609
	697	690	704
	752	746	758
	857	850	864
	907	900	914
	958	946	970
16	67	64	70
	115	112	118
	177	167	187
	227	221	233
	316	297	335
	373	367	379
	422	419	425
	470	468	472
	534	525	543
	582	574	590
	634	616	652
	697	692	702
	752	746	758
	857	850	864
	907	900	914

	958	947	969
17	67	64	70
	115	112	118
	177	167	187
	227	221	233
	316	298	334
	373	367	379
	422	419	425
	470	468	472
	534	526	542
	582	574	590
	634	616	652
	697	692	702
	752	747	757
	801	785	817
	857	850	864
	907	900	914
	958	947	969
18	24	22	26
	69	66	72
	129	118	140
	179	171	187
	227	222	232
	316	298	334
	373	367	379
	422	419	425
	470	468	472
	534	526	542
	582	574	590
	634	617	651
	697	692	702
	752	747	757
	801	785	817
	857	850	864
	907	900	914
	958	947	969
19	24	22	26
	69	66	72
	129	118	140
	179	171	187
	227	221	233

	278	229	327
	328	315	341
	373	368	378
	422	419	425
	470	468	472
	534	526	542
	582	574	590
	634	617	651
	697	692	702
	752	747	757
	801	785	817
	857	851	863
	907	900	914
	958	947	969
20	24	22	26
	69	66	72
	129	118	140
	179	171	187
	227	221	233
	278	229	327
	328	315	341
	373	368	378
	422	419	425
	470	468	472
	518	508	528
	568	563	573
	617	611	623
	675	666	684
	722	717	727
	769	762	776
	798	777	819
	857	850	864
	907	900	914
	958	947	969

Lean Hogs Results

Figure 6.5, Lean Hogs Chow Test Results

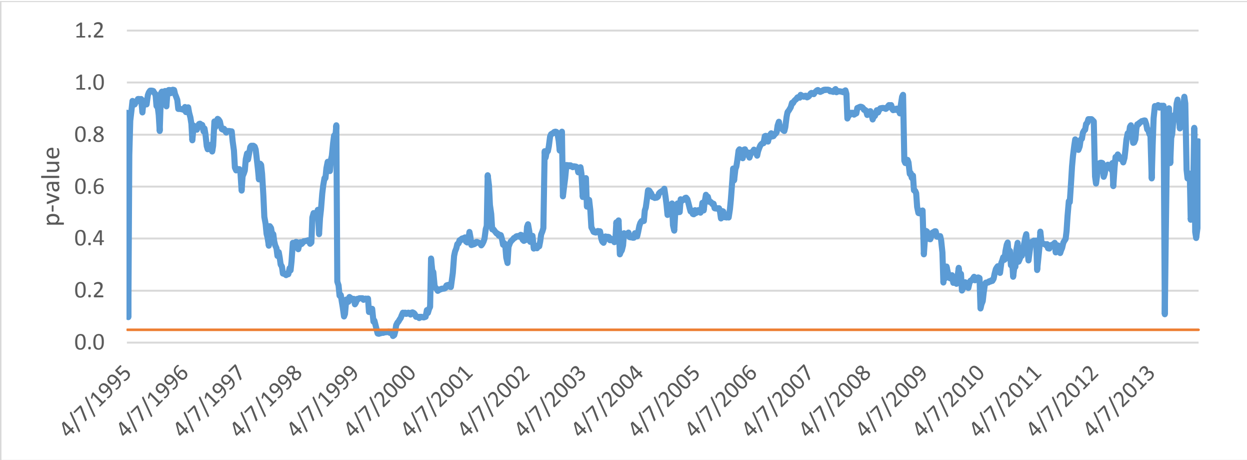

Table 6.17, Lean Hogs UDmax F test

Number of Breaks	UDmaxF	Pr > UDmaxF
20	127.964	<.0001

Table 6.18, Lean Hogs WDmax F test

Number of Breaks	Alpha	WDmaxF	Pr > WDmaxF
20	0.100	134.645	<.0001
	0.050	140.236	<.0001
	0.025	145.147	<.0001
	0.010	151.256	<.0001

Table 6.19, Lean Hogs supF (l+1|l) test

l	New Break	supF(l+1|l)	Pr > supF(l+1|l)
0	256	24.637	1.000
1	180	87.987	<.0001
2	256	27.058	0.992
3	448	26.380	0.997
4	256	28.617	0.956
5	291	58.620	<.0001
6	291	58.620	<.0001
7	291	58.620	<.0001
8	291	58.620	<.0001
9	291	58.620	<.0001
10	291	58.620	<.0001
11	291	58.620	<.0001

12	291	58.620	<.0001
13	291	58.620	<.0001
14	291	58.620	<.0001
15	291	58.620	<.0001
16	830	39.394	0.103
17	830	39.394	0.103
18	830	39.394	0.103
19	420	23.213	1.000
20	943	338.159	<.0001

Table 6.20, Lean Hogs BP break dates

Number of Breaks	Break	95% Confidence Limits	
1	256	172	340
2	158	156	160
	205	203	207
3	158	156	160
	205	202	208
	256	238	274
4	158	156	160
	205	203	207
	348	345	351
	395	392	398
5	158	156	160
	205	202	208
	256	246	266
	347	344	350
	395	392	398
6	158	156	160
	205	202	208
	256	246	266
	347	344	350
	395	392	398
	448	426	470
7	158	156	160
	205	202	208
	256	246	266
	347	345	349
	395	392	398
	868	864	872
	917	914	920
8	158	156	160

	205	202	208
	256	246	266
	347	345	349
	395	392	398
	448	428	468
	868	865	871
	917	914	920
9	158	156	160
	205	203	207
	256	247	265
	347	345	349
	395	392	398
	715	710	720
	761	757	765
	868	865	871
	917	914	920
10	158	156	160
	205	203	207
	256	247	265
	347	345	349
	395	392	398
	448	427	469
	715	710	720
	761	757	765
	868	865	871
	917	914	920
11	158	156	160
	205	203	207
	256	247	265
	347	345	349
	395	393	397
	550	545	555
	597	592	602
	713	708	718
	761	757	765
	868	865	871
	917	914	920
12	158	156	160
	205	203	207
	256	247	265
	347	345	349

	395	392	398
	449	433	465
	550	545	555
	597	592	602
	713	708	718
	761	757	765
	868	865	871
	917	914	920
13	158	156	160
	205	203	207
	256	247	265
	347	345	349
	395	392	398
	449	433	465
	550	545	555
	597	592	602
	672	662	682
	714	710	718
	761	757	765
	868	865	871
	917	914	920
14	158	156	160
	205	203	207
	256	248	264
	347	345	349
	395	392	398
	449	433	465
	550	545	555
	598	594	602
	645	641	649
	691	687	695
	749	743	755
	795	790	800
	870	867	873
	917	914	920
15	81	50	112
	158	156	160
	205	203	207
	256	248	264
	347	345	349
	395	392	398

	449	434	464
	550	545	555
	598	594	602
	645	641	649
	691	687	695
	749	743	755
	795	790	800
	870	867	873
	917	914	920
16	81	51	111
	158	156	160
	205	203	207
	252	246	258
	300	290	310
	348	346	350
	395	392	398
	449	434	464
	550	546	554
	598	594	602
	645	641	649
	691	687	695
	749	743	755
	795	790	800
	870	867	873
	917	914	920
17	48	31	65
	95	72	118
	158	156	160
	205	203	207
	252	246	258
	300	290	310
	348	346	350
	395	392	398
	449	434	464
	550	546	554
	598	594	602
	645	641	649
	691	687	695
	749	743	755
	795	790	800
	870	867	873

	917	914	920
18	48	31	65
	95	72	118
	158	156	160
	205	203	207
	252	246	258
	300	290	310
	348	346	350
	395	392	398
	448	436	460
	496	458	534
	550	545	555
	598	594	602
	645	641	649
	691	687	695
	749	743	755
	795	790	800
	870	867	873
	917	914	920
19	48	31	65
	95	72	118
	158	156	160
	205	203	207
	252	246	258
	300	290	310
	348	346	350
	395	392	398
	448	436	460
	496	459	533
	550	545	555
	598	594	602
	645	641	649
	691	687	695
	749	743	755
	795	791	799
	845	827	863
	872	870	874
	917	914	920
20	48	31	65
	95	72	118
	158	156	160

	205	203	207
	252	246	258
	300	290	310
	348	346	350
	395	392	398
	448	436	460
	496	459	533
	550	545	555
	598	594	602
	645	641	649
	691	687	695
	749	743	755
	795	791	799
	845	828	862
	872	870	874
	917	914	920
	969	918	1020

Appendix B - Forecasting Performance Analysis

Corn Results

Full Period

Table 6.21, Test for forecast bias- Corn (Full Period)

Regression	IV model	HV model	Comp model	Naïve model
Coefficient	-2.510E-10	9.240E-11	9.350E-11	5.39E-11
t Value	0	0	0	0
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.22, Test for forecast efficiency- Corn (Full Period)

	Implied Volatility	Historical Volatility	Composite	Naïve
Estimated β	4.75E-10	3.55E-09	2.89E-10	2.46E-08
t value	0	0	0	0
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho
Estimated ρ	-0.00937	0.0265	-0.015	-0.0248
t value	(-0.30)	(0.83)	(-0.47)	(-0.78)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.23, Test for forecast encompassing- Corn (Full Period)

	Preferred forecast	
	Implied Volatility	**Historical Volatility**
Estimated λ	0.0772	0.923***
t value	(0.69)	(8.31)
Result	Fail to reject Ho	Reject Ho
	Implied Volatility	**Naïve**
Estimated λ	0.00115	0.999***
t value	(0.01)	(11.02)
Result	Fail to reject Ho	Reject Ho

	Historical Volatility	Naïve
Estimated λ	0.0782	0.922***
t value	(0.60)	(7.07)
Result	Fail to reject Ho	Reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.24, Test for time change- Corn (Full Period)

	Implied Volatility	Historical Volatility	Composite	Naïve
Estimated θ	0.0000632***	0.0000554***	0.0000640***	0.0000422**
t value	(4.71)	(3.98)	(4.77)	(2.98)
Result	Reject Ho	Reject Ho	Reject Ho	Reject Ho

* p<0.05, **p<0.01, *** p<0.001

Regime 1

Table 6.25, Test for forecast bias- Corn (Regime 1)

Regression	IV model	HV model	Comp model	Naïve
Coefficient	-2.04E-10	-1.49E-10	5.00E-11	1.17E-10
t Value	(-0.00)	(-0.00)	0	0
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.26, Test for forecast efficiency- Corn (Regime 1)

	Implied Volatility	Historical Volatility	Composite	Naïve
Estimated β	-3.79E-09	-1.93E-08	1.78E-08	0.00000026
t value	(-0.00)	(-0.00)	0	0
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho
Estimated ρ	-0.103**	-0.0437	-0.106**	-0.0112
t value	(-2.68)	(-1.13)	(-2.75)	(-0.29)
Result	Reject Ho	Fail to reject Ho	Reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.27, Test for forecast encompassing- Corn (Regime 1)

	Preferred forecast	
	Implied Volatility	**Historical Volatility**
Estimated λ	0.0261	0.974***
t value	(0.20)	(7.40)
Result	Fail to reject Ho	Reject Ho
	Implied Volatility	**Naïve**
Estimated λ	-0.0433	1.043***
t value	(-0.39)	(9.32)
Result	Fail to reject Ho	Reject Ho
	Historical Volatility	**Naïve**
Estimated λ	-0.0582	1.058***
t value	(-0.30)	(5.5)
Result	Fail to reject Ho	Reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.28, Test for time change- Corn (Regime 1)

	Implied Volatility	Historical Volatility	Composite	Naïve
Estimated θ	0.0000646**	0.0000588**	0.0000654**	0.0000459*
t value	(3.11)	(2.68)	(3.14)	(2.07)
Result	Reject Ho	Reject Ho	Reject Ho	Reject Ho

* p<0.05, **p<0.01, *** p<0.001

Regime 2

Table 6.29, Test for forecast bias- Corn (Regime 2)

Regression	IV model	HV model	Comp model	Naïve
Coefficient	-1.27E-09	3.96E-10	1.73E-09	2.72E-09
t Value	(-0.00)	0	0	0
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.30, Test for forecast efficiency- Corn (Regime 2)

	Implied Volatility	Historical Volatility	Composite	Naïve
Estimated β	3.73E-08	1.14E-08	7.85E-08	9.87E-08

t value	0	0	0	0
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho
Estimated ρ	0.161	0.118	0.117	0.00281
t value	(1.01)	(0.74)	(0.74)	(0.02)
Pr > |t|	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.31, Test for forecast encompassing- Corn (Regime 2)

	Preferred forecast	
	Implied Volatility	**Historical Volatility**
Estimated λ	0.99	0.0104
t value	(1.68)	(0.02)
Result	Fail to reject Ho	Fail to reject Ho
	Implied Volatility	**Naïve**
Estimated λ	0.669	0.331
t value	(1.07)	(0.53)
Result	Fail to reject Ho	Fail to reject Ho
	Historical Volatility	**Naïve**
Estimated λ	0.268	0.732
t value	-0.55	-1.49
Result	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.32, Test for time change- Corn (Regime 2)

	Implied Volatility	**Historical Volatility**	**Composite**	**Naïve**
Estimated θ	0.00452*	0.00399	0.00403	0.00374
t value	(2.15)	(1.94)	(1.96)	(1.88)
Result	Reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Regime 3

Table 6.33, Test for forecast bias- Corn (Regime 3)

Regression	IV model	HV model	Comp model	Naïve
Coefficient	-3.20E-10	-6.99E-10	2.91E-10	3.31E-10
t Value	(-0.00)	(-0.00)	0	0
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.34, Test for forecast efficiency- Corn (Regime 3)

	Implied Volatility	Historical Volatility	Composite	Naïve
Estimated β	-2.58E-09	-0.000000166	-2.39E-08	0.000000741
t value	(-0.00)	(-0.00)	(-0.00)	0
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho
Estimated ρ	0.0657	0.0754	0.0756	0.00991
t value	(1.01)	(1.15)	(1.16)	(0.15)
Pr > |t|	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.35, Test for forecast encompassing- Corn (Regime 3)

	Preferred forecast	
	Implied Volatility	**Historical Volatility**
Estimated λ	-0.154	1.154**
t value	(-0.38)	(2.86)
Result	Fail to reject Ho	Reject Ho
	Implied Volatility	**Naïve**
Estimated λ	0.0602	0.940**
t value	(0.18)	(2.86)
Result	Fail to reject Ho	Reject Ho
	Historical Volatility	**Naïve**
Estimated λ	0.472	0.528
t value	(0.67)	(0.75)
Result	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.36, Test for time change- Corn (Regime 3)

	Implied Volatility	Historical Volatility	Composite	Naïve
Estimated θ	-0.000157	-0.0000585	-0.000144	-0.0000594
t value	(-1.31)	(-0.48)	(-1.20)	(-0.49)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Regime 4

Table 6.37, Test for forecast bias- Corn (Regime 4)

Regression	IV model	HV model	Comp model	Naïve
Coefficient	2.29E-10	-4.43E-10	1.64E-10	-1.08E-09
t Value	0	0	0	(-0.00)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.38, Test for forecast efficiency- Corn (Regime 4)

	Implied Volatility	Historical Volatility	Composite	Naïve
Estimated β	-0.000000197	-3.28E-08	1.71E-08	-0.000029
t value	0	0	0	(-0.00)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho
Estimated ρ	-0.107	-0.181	-0.182	0.0172
t value	(-0.69)	(-1.19)	(-1.20)	-0.11
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.39, Test for forecast encompassing- Corn (Regime 4)

	Preferred forecast	
	Implied Volatility	**Historical Volatility**
Estimated λ	0.995**	0.00469
t value	(2.91)	(0.01)
Result	Reject Ho	Fail to reject Ho
	Implied Volatility	**Naïve**

Estimated λ	0.0172	0.983
t value	(0.03)	(1.46)
Result	Fail to reject Ho	Fail to reject Ho
	Historical Volatility	**Naïve**
Estimated λ	0.00857	0.991**
t value	(0.03)	(3.32)
Result	Fail to reject Ho	Reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.40, Test for time change- Corn (Regime 4)

	Implied Volatility	**Historical Volatility**	**Composite**	**Naïve**
Estimated θ	-0.00137	-0.00169	-0.00169	-0.00186
t value	(-1.21)	(-1.76)	(-1.76)	(-1.63)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Wheat Results

Full Period

Table 6.41, Test for forecast bias- Wheat (Full Period)

Regression	**IV model**	**HV model**	**Comp model**	**Naive model**
Coefficient	1.55E-10	-7.22E-11	1.25E-11	9.63E-11
t Value	0	0	0	0
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.42, Test for forecast efficiency- Wheat (Full Period)

	Implied Volatility	**Historical Volatility**	**Composite**	**Naïve**
Estimated β	-1.20E-08	-1.25E-08	1.03E-09	-5.31E-08
t value	0	0	0	(-0.00)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

Estimated ρ	3.44E-02	0.0421	0.0312	-0.0153
t value	(1.09)	(1.33)	(0.99)	(-0.49)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.43, Test for forecast encompassing- Wheat (Full Period)

	Preferred forecast	
	Implied Volatility	**Historical Volatility**
Estimated λ	0.0921	0.908***
t value	(0.57)	(5.64)
Result	Fail to reject Ho	Reject Ho
	Implied Volatility	**Naïve**
Estimated λ	0.046	0.954***
t value	(0.42)	(8.65)
Result	Fail to reject Ho	Reject Ho
	Historical Volatility	**Naïve**
Estimated λ	0.111	0.889***
t value	(0.82)	(6.56)
Result	Fail to reject Ho	Reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.44, Test for time change- Wheat (Full Period)

	Implied Volatility	**Historical Volatility**	**Composite**	**Naïve**
Estimated θ	0.0000628***	0.0000573***	0.0000632***	0.0000507***
t value	(4.72)	(4.18)	(4.75)	-3.59
Result	Reject Ho	Reject Ho	Reject Ho	Reject Ho

* p<0.05, **p<0.01, *** p<0.001

Regime 1

Table 6.45, Test for forecast bias- Wheat (Regime 1)

Regression	**IV model**	**HV model**	**Comp model**	**Naïve**
Coefficient	6.84E-10	-3.89E-10	-9.49E-10	3.98E-10
t Value	0	(-0.00)	(-0.00)	0
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.46, Test for forecast efficiency- Wheat (Regime 1)

	Implied Volatility	**Historical Volatility**	**Composite**	**Naïve**
Estimated β	-3.75E-08	-4.59E-08	-1.11E-08	0.000000131
t value	(-0.00)	(-0.00)	(-0.00)	0
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho
Estimated ρ	0.0727	0.0648	0.0352	-0.0817
t value	(0.57)	(0.50)	(0.27)	(-0.64)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.47, Test for forecast encompassing- Wheat (Regime 1)

	Preferred forecast	
	Implied Volatility	**Historical Volatility**
Estimated λ	0.559	0.441
t value	(1.50)	(1.18)
Pr > |t|	Fail to reject Ho	Fail to reject Ho
	Implied Volatility	**Naïve**
Estimated λ	0.135	0.865*
t value	-0.38	-2.44
Pr > |t|	Fail to reject Ho	Reject Ho
	Historical Volatility	**Naïve**
Estimated λ	0.0873	0.913*
t value	(0.25)	(2.61)
Pr > |t|	Fail to reject Ho	Reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.48, Test for time change- Wheat (Regime 1)

	Implied Volatility	**Historical Volatility**	**Composite**	**Naïve**
Estimated θ	-0.000375	-0.000507	-0.000458	-0.000481
t value	(-0.62)	(-0.86)	(-0.78)	(-0.74)

Pr > |t|	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Regime 2

Table 6.49, Test for forecast bias- Wheat (Regime 2)

Regression	**IV model**	**HV model**	**Comp model**	**Naïve**
Coefficient	1.74E-09	1.00E-09	6.86E-10	-8.62E-10
t Value	0	0	0	(-0.00)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.50, Test for forecast efficiency- Wheat (Regime 2)

	Implied Volatility	**Historical Volatility**	**Composite**	**Naïve**
Estimated β	1.26E-08	6.21E-08	2.23E-09	9.23E-09
t value	0	0	0	0
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho
Estimated ρ	0.296*	0.487***	0.247	-0.0499
t value	(2.36)	(4.16)	(1.94)	(-0.38)
Result	Reject Ho	Reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.51, Test for forecast encompassing- Wheat (Regime 2)

	Preferred forecast	
	Implied Volatility	**Historical Volatility**
Estimated λ	-0.148	1.148***
t value	(-0.58)	(4.48)
Result	Fail to reject Ho	Reject Ho
	Implied Volatility	**Naïve**
Estimated λ	0.468	0.532*
t value	(1.90)	(2.16)
Result	Fail to reject Ho	Reject Ho

	Historical Volatility	Naïve
Estimated λ	1.008***	-0.00839
t value	(4.27)	(-0.04)
Result	Reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.52, Test for time change- Wheat (Regime 2)

	Implied Volatility	Historical Volatility	Composite	Naïve
Estimated θ	-0.00214	-0.0027	-0.00147	-0.00273*
t value	(-1.94)	(-1.92)	(-1.41)	(-2.34)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Reject Ho

* p<0.05, **p<0.01, *** p<0.001

Regime 3

Table 6.53, Test for forecast bias- Wheat (Regime 3)

Regression	IV model	HV model	Comp model	Naïve
Coefficient	-1.10E-10	6.25E-11	-7.33E-11	7.34E-11
t Value	(-0.00)	0	(-0.00)	0
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.54, Test for forecast efficiency- Wheat (Regime 3)

	Implied Volatility	Historical Volatility	Composite	Naïve
Estimated β	3.08E-09	0.000000132	8.06E-08	0.0000212
t value	0	0	0	0
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho
Estimated ρ	-0.0321	-0.0178	-0.0319	-0.000639
t value	(-0.75)	(-0.42)	(-0.75)	(-0.01)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.55, Test for forecast encompassing- Wheat (Regime 3)

	Preferred forecast	
	Implied Volatility	**Historical Volatility**
Estimated λ	-0.00402	1.004**
t value	(-0.01)	(2.94)
Result	Fail to reject Ho	Reject Ho
	Implied Volatility	**Naïve**
Estimated λ	-0.0107	1.011***
t value	(-0.04)	(3.55)
Result	Fail to reject Ho	Reject Ho
	Historical Volatility	**Naïve**
Estimated λ	-0.0178	1.018*
t value	(-0.03)	(2.00)
Result	Fail to reject Ho	Reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.56, Test for time change- Wheat (Regime 3)

	Implied Volatility	Historical Volatility	Composite	Naïve
Estimated θ	0.0000828**	0.0000794**	0.0000827**	0.0000737**
t value	(3.01)	(2.85)	(3.01)	(2.65)
Result	Reject Ho	Reject Ho	Reject Ho	Reject Ho

* p<0.05, **p<0.01, *** p<0.001

Regime 4

Table 6.57, Test for forecast bias- Wheat (Regime 4)

Regression	IV model	HV model	Comp model	Naïve
Coefficient	-1.02E-09	2.17E-09	1.16E-09	2.75E-10
t Value	(-0.00)	0	0	0
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.58, Test for forecast efficiency- Wheat (Regime 4)

	Implied Volatility	Historical Volatility	Composite	Naïve
Estimated β	-2.09E-08	2.72E-09	1.55E-08	0.000000651

t value	(-0.00)	0	0	0
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho
Estimated ρ	0.0859	0.0617	0.0792	0.0298
t value	(0.66)	(0.47)	(0.61)	(0.23)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.59, Test for forecast encompassing- Wheat (Regime 4)

	Preferred forecast	
	Implied Volatility	**Historical Volatility**
Estimated λ	0.172	0.828
t value	(0.17)	(0.81)
Result	Fail to reject Ho	Fail to reject Ho
	Implied Volatility	**Naïve**
Estimated λ	0.144	0.856
t value	(0.21)	(1.25)
Result	Fail to reject Ho	Fail to reject Ho
	Historical Volatility	**Naïve**
Estimated λ	0.179	0.821
t value	(0.21)	(0.96)
Result	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.60, Test for time change- Wheat (Regime 4)

	Implied Volatility	**Historical Volatility**	**Composite**	**Naïve**
Estimated θ	0.00131	0.000857	0.00119	0.00101
t value	(1.04)	(0.66)	(0.94)	(0.78)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Regime 5

Table 6.61, Test for forecast bias- Wheat (Regime 5)

Regression	IV model	HV model	Comp model	Naïve
Coefficient	-9.85E-10	5.96E-10	1.12E-10	1.86E-11
t Value	(-0.00)	0	0	0
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.62, Test for forecast efficiency- Wheat (Regime 5)

	Implied Volatility	Historical Volatility	Composite	Naïve
Estimated β	-0.000000194	-0.00000017	0.000000401	-2.57E-09
t value	(-0.00)	(-0.00)	0	(-0.00)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho
Estimated ρ	0.281*	0.27	0.269	0.0544
t value	(2.04)	(1.96)	(1.95)	-0.38
Result	Reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.63, Test for forecast encompassing- Wheat (Regime 5)

	Preferred forecast	
	Implied Volatility	**Historical Volatility**
Estimated λ	0.605	0.395
t value	(0.60)	(0.39)
Result	Fail to reject Ho	Fail to reject Ho
	Implied Volatility	**Naïve**
Estimated λ	0.868	0.132
t value	(1.54)	(0.23)
Result	Fail to reject Ho	Fail to reject Ho
	Historical Volatility	**Naïve**
Estimated λ	0.855	0.145
t value	(1.48)	(0.25)
Result	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.64, Test for time change- Wheat (Regime 5)

	Implied Volatility	Historical Volatility	Composite	Naïve
Estimated θ	-0.000254	-0.0000425	-0.000265	0.000239
t value	(-0.24)	(-0.04)	(-0.25)	(0.23)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Regime 6

Table 6.65, Test for forecast bias- Wheat (Regime 6)

Regression	IV model	HV model	Comp model	Naïve
Coefficient	4.95E-10	1.36E-09	-1.26E-09	-6.11E-10
t Value	0	0	(-0.00)	(-0.00)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.66, Test for forecast efficiency- Wheat (Regime 6)

	Implied Volatility	Historical Volatility	Composite	Naïve
Estimated β	3.28E-08	0.00000025	7.71E-08	0.000000127
t value	0	0	0	0
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho
Estimated ρ	-0.223	-0.181	-0.222	-0.00755
t value	(-1.30)	(-1.04)	(-1.29)	(-0.04)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.67, Test for forecast encompassing- Wheat (Regime 6)

	Preferred forecast	
	Implied Volatility	**Historical Volatility**
Estimated λ	-0.175	1.175
t value	(-0.15)	(1.00)
Result	Fail to reject Ho	Fail to reject Ho
	Implied Volatility	**Naïve**

Estimated λ	0.458	0.542
t value	(0.74)	(0.87)
Result	Fail to reject Ho	Fail to reject Ho
	Historical Volatility	**Naïve**
Estimated λ	0.819	0.181
t value	(0.89)	(0.20)
Result	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.68, Test for time change- Wheat (Regime 6)

	Implied Volatility	**Historical Volatility**	**Composite**	**Naïve**
Estimated θ	0.00407*	0.00354*	0.00393*	0.00306
t value	(2.57)	(2.13)	(2.48)	(1.78)
Result	Reject Ho	Reject Ho	Reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Regime 7

Table 6.69, Test for forecast bias- Wheat (Regime 7)

Regression	**IV model**	**HV model**	**Comp model**	**Naïve**
Coefficient	-3.47E-10	-1.02E-10	4.36E-10	-3.00E-10
t Value	(-0.00)	(-0.00)	0	(-0.00)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.70, Test for forecast efficiency- Wheat (Regime 7)

	Implied Volatility	**Historical Volatility**	**Composite**	**Naïve**
Estimated β	-1.73E-08	-6.25E-09	-6.03E-08	-0.000000173
t value	(-0.00)	(-0.00)	(-0.00)	(-0.00)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho
Estimated ρ	0.025	0.0352	0.0228	0.0311
t value	(0.33)	(0.47)	(0.30)	(0.41)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.71, Test for forecast encompassing- Wheat (Regime 7)

	Preferred forecast	
	Implied Volatility	**Historical Volatility**
Estimated λ	0.182	0.818
t value	(0.35)	(1.59)
Result	Fail to reject Ho	Fail to reject Ho
	Preferred forecast	
	Implied Volatility	**Naïve**
Estimated λ	-0.0237	1.024**
t value	(-0.08)	(3.33)
Result	Fail to reject Ho	Reject Ho
	Preferred forecast	
	Historical Volatility	**Naïve**
Estimated λ	0.00395	0.996**
t value	(0.01)	(2.93)
Result	Fail to reject Ho	Reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.72, Test for time change- Wheat (Regime 7)

	Implied Volatility	**Historical Volatility**	**Composite**	**Naïve**
Estimated θ	-0.000568**	-0.000523**	-0.000566**	-0.000416*
t value	(-3.12)	(-2.89)	(-3.11)	(-2.21)
Result	Reject Ho	Reject Ho	Reject Ho	Reject Ho

* p<0.05, **p<0.01, *** p<0.001

Soybeans Results

Full Period

Table 6.73, Test for forecast bias- Soybeans (Full Period)

Regression	**IV model**	**HV model**	**Composite**	**Naïve**
Coefficient	-3.00E-11	-4.15E-12	-7.90E-12	2.53E-10
t Value	0	0	0	0

Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.74, Test for forecast efficiency- Soybeans (Full Period)

	Implied Volatility	Historical Volatility	Composite	Naïve
Estimated β	-4.97E-09	-1.42E-09	3.53E-09	-4.12E-08
t value	0	0	0	(-0.00)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho
Estimated ρ	-0.00455	0.0107	-0.0159	-0.0273
t value	(-0.14)	(0.34)	(-0.50)	(-0.86)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.75, Test for forecast encompassing- Soybeans (Full Period)

	Preferred forecast	
	Implied Volatility	**Historical Volatility**
Estimated λ	0.167	0.833***
t value	(1.39)	(6.93)
Result	Fail to reject Ho	Reject Ho
	Implied Volatility	**Naïve**
Estimated λ	0.00428	0.996***
t value	(0)	(11)
Result	Fail to reject Ho	Reject Ho
	Historical Volatility	**Naïve**
Estimated λ	0.0568	0.943***
t value	(0)	(8)
Result	Fail to reject Ho	Reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.76, Test for time change- Soybeans (Full Period)

	Implied Volatility	Historical Volatility	Composite	Naïve
Estimated θ	0.0000430***	0.0000348**	0.0000424***	0.0000316*

t value	(3.66)	(2.89)	(3.62)	(3)
Result	Reject Ho	Reject Ho	Reject Ho	Reject Ho

* p<0.05, **p<0.01, *** p<0.001

Regime 1

Table 6.77, Test for forecast bias- Soybeans (Regime 1)

Regression	**IV model**	**HV model**	**Comp model**	**Naïve**
Coefficient	7.80E-11	5.60E-11	-2.40E-10	6.28E-11
t Value	0	0	0	0
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.78, Test for forecast efficiency- Soybeans (Regime 1)

	Implied Volatility	**Historical Volatility**	**Composite**	**Naïve**
Estimated β	-4.21E-09	2.40E-08	-1.30E-08	9.75E-08
t value	0	0	0	0
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho
Estimated ρ	0.0359	0.0661	0.0333	-0.0227
t value	(0.75)	(1.39)	(0.70)	(-0.47)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.79, Test for forecast encompassing- Soybeans (Regime 1)

	Preferred forecast	
	Implied Volatility	**Historical Volatility**
Estimated λ	0.0309	0.969***
t value	(0.16)	(5.07)
Result	Fail to reject Ho	Reject Ho
	Implied Volatility	**Naïve**
Estimated λ	0.0663	0.934***
t value	(0.40)	(5.65)
Result	Fail to reject Ho	Reject Ho

	Historical Volatility	Naïve
Estimated λ	0.31	0.690**
t value	(1.21)	(2.68)
Result	Fail to reject Ho	Reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.80, Test for time change- Soybeans (Regime 1)

	Implied Volatility	Historical Volatility	Composite	Naïve
Estimated θ	0.0000108	0.0000112	0.00001	0.0000288
t value	(0.33)	(0.33)	(0.31)	(0.85)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Regime 2

Table 6.81, Test for forecast bias- Soybeans (Regime 2)

Regression	IV model	HV model	Comp model	Naïve
Coefficient	1.04E-09	-1.01E-10	8.67E-10	-8.64E-10
t Value	0	(-0.00)	0	(-0.00)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.82, Test for forecast efficiency- Soybeans (Regime 2)

	Implied Volatility	Historical Volatility	Composite	Naïve
Estimated β	1.30E-08	-4.73E-08	2.13E-08	-0.00000379
t value	0	(-0.00)	0	(-0.00)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho
Estimated ρ	-0.115	-0.0599	-0.11	-0.00161
t value	(-1.12)	(-0.57)	(-1.07)	(-0.02)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.83, Test for forecast encompassing- Soybeans (Regime 2)

	Preferred forecast	
	Implied Volatility	**Historical Volatility**
Estimated λ	-0.0963	1.096**
t value	(-0.30)	(3.36)
Result	Fail to reject Ho	Reject Ho
	Implied Volatility	**Naïve**
Estimated λ	-0.0255	1.025***
t value	(-0.11)	(4.29)
Result	Fail to reject Ho	Reject Ho
	Historical Volatility	**Naïve**
Estimated λ	-0.0365	1.037*
t value	(-0.09)	(2.54)
Result	Fail to reject Ho	Reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.84, Test for time change- Soybeans (Regime 2)

	Implied Volatility	Historical Volatility	Composite	Naïve
Estimated θ	0.000275	0.000162	0.000266	0.000124
t value	(0.630)	(0.340)	(0.600)	(0.24)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Regime 3

Table 6.85, Test for forecast bias- Soybeans (Regime 3)

Regression	IV model	HV model	Comp model	Naïve
Coefficient	4.47E-10	-2.10E-10	3.46E-10	0
t Value	0.00	(-0.00)	0.00	0
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.86, Test for forecast efficiency- Soybeans (Regime 3)

	Implied Volatility	Historical Volatility	Composite	Naïve
Estimated β	-5.91E-08	4.35E-08	-1.88E-09	0.000000468

t value	(-0.00)	0	(-0.00)	0
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho
Estimated ρ	-0.0236	-0.0154	-0.0318	0.0435
t value	(-0.26)	(-0.17)	(-0.36)	-0.48
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.87, Test for forecast encompassing- Soybeans (Regime 3)

	Preferred forecast	
	Implied Volatility	**Historical Volatility**
Estimated λ	0.148	0.852*
t value	-0.37	-2.11
Result	Fail to reject Ho	Reject Ho
	Implied Volatility	**Naïve**
Estimated λ	-0.0483	1.048***
t value	(-0.16)	(3.45)
Result	Fail to reject Ho	Reject Ho
	Historical Volatility	**Naïve**
Estimated λ	-0.0627	1.063**
t value	(-0.16)	(2.70)
Result	Fail to reject Ho	Reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.88, Test for time change- Soybeans (Regime 3)

	Implied Volatility	**Historical Volatility**	**Composite**	**Naïve**
Estimated θ	-0.0000452	-0.0000801	-0.0000589	-0.0000633
t value	(-0.26)	(-0.45)	(-0.34)	(-0.34)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Regime 4

Table 6.89, Test for forecast bias- Soybeans (Regime 4)

Regression	IV model	HV model	Comp model	Naïve
Coefficient	4.14E-10	-3.87E-10	-2.94E-10	-1.47E-10
t Value	0.00	(-0.00)	(-0.00)	(-0.00)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.90, Test for forecast efficiency- Soybeans (Regime 4)

	Implied Volatility	Historical Volatility	Composite	Naïve
Estimated β	-0.00000358	-0.00000228	0.000000168	-0.00000368
t value	(-0.00)	(-0.00)	0	(-0.00)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho
Estimated ρ	0.0425	0.0205	0.024	-0.00271
t value	(0.36)	(0.18)	(0.21)	(-0.02)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.91, Test for forecast encompassing- Soybeans (Regime 4)

	Preferred forecast	
	Implied Volatility	**Historical Volatility**
Estimated λ	0.681	0.319
t value	(0.48)	(0.23)
Result	Fail to reject Ho	Fail to reject Ho
	Implied Volatility	**Naïve**
Estimated λ	0.557	0.443
t value	(0.26)	(0.20)
Result	Fail to reject Ho	Fail to reject Ho
	Historical Volatility	**Naïve**
Estimated λ	0.241	0.759
t value	(0.13)	(0.42)
Result	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.92, Test for time change- Soybeans (Regime 4)

	Implied Volatility	Historical Volatility	Composite	Naïve
Estimated θ	0.00103	0.00121	0.00103	0.00117
t value	(1.570)	(1.840)	(1.570)	(1.77)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Regime 5

Table 6.93, Test for forecast bias- Soybeans (Regime 5)

Regression	IV model	HV model	Comp model	Naïve
Coefficient	-3.09E-10	-4.62E-11	2.33E-10	-1.21E-10
t Value	0	0	0	(-0.00)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.94, Test for forecast efficiency- Soybeans (Regime 5)

	Implied Volatility	Historical Volatility	Composite	Naïve
Estimated β	-4.32E-08	-4.96E-08	1.21E-07	-4.98E-09
t value	0	0	0	(-0.00)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho
Estimated ρ	0.0296	0.0255	0.0118	-0.0226
t value	(0.46)	(0.40)	(0.18)	(-0.35)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.95, Test for forecast encompassing- Soybeans (Regime 5)

	Preferred forecast	
	Implied Volatility	**Historical Volatility**
Estimated λ	0.692	0.308
t value	(1.50)	(0.67)
Result	Fail to reject Ho	Fail to reject Ho
	Implied Volatility	**Naïve**

Estimated λ	0.237	0.763
t value	(0.43)	(1.38)
Result	Fail to reject Ho	Fail to reject Ho
	Historical Volatility	**Naïve**
Estimated λ	0.0909	0.909*
t value	(0.21)	(2.13)
Result	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.96, Test for time change- Soybeans (Regime 5)

	Implied Volatility	**Historical Volatility**	**Composite**	**Naïve**
Estimated θ	-0.00000523	0.0000217	0.0000151	0.000000291
t value	(-0.06)	(0.27)	(0.19)	0
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Live Cattle Results

Full Period

Table 6.97, Test for forecast bias- Live Cattle (Full Period)

Regression	**IV model**	**HV model**	**Comp model**	**Naïve**
Coefficient	-1.20E-10	1.42E-10	-1.83E-11	-1.93E-11
t Value	0	0	0	(-0.00)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.98, Test for forecast efficiency- Live Cattle (Full Period)

	Implied Volatility	**Historical Volatility**	**Composite**	**Naïve**
Estimated β	1.16E-08	1.06E-07	-1.91E-08	0.000000424
t value	0	0	0	0
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho
Estimated ρ	-0.0278	0.0324	0.00027	-0.00176

t value	(-0.88)	(1.02)	(0.01)	(-0.06)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.99, Test for forecast encompassing- Live Cattle (Full Period)

	Preferred forecast	
	Implied Volatility	**Historical Volatility**
Estimated λ	-0.109	1.109***
t value	(-1.01)	(10.25)
Result	Fail to reject Ho	Reject Ho
	Implied Volatility	**Historical Volatility**
Estimated λ	-0.0321	1.032***
t value	(-0.32)	(10.37)
Result	Fail to reject Ho	Reject Ho
	Implied Volatility	**Historical Volatility**
Estimated λ	0.293	0.707*
t value	(0.82)	(1.99)
Result	Fail to reject Ho	Reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.100, Test for time change- Live Cattle (Full Period)

	Implied Volatility	**Historical Volatility**	**Composite**	**Naïve**
Estimated θ	0.00000343	0.00000237	0.00000634	0.00000402
t value	(0.40)	(0.26)	(0.76)	(0.45)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Regime 1

Table 6.101, Test for forecast bias- Live Cattle (Regime 1)

Regression	**IV model**	**HV model**	**Comp model**	**Naïve**
Coefficient	4.04E-10	1.36E-10	2.11E-10	1.78E-10
t Value	0	0	0	0
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.102, Test for forecast efficiency- Live Cattle (Regime 1)

	Implied Volatility	Historical Volatility	Composite	Naïve
Estimated β	-5.98E-09	-0.000000443	-4.15E-08	-0.0000122
t value	(-0.00)	(-0.00)	(-0.00)	(-0.00)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho
Estimated ρ	-0.104	-0.021	-0.105	0.0193
t value	(-0.83)	(-0.17)	(-0.83)	(0.15)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.103, Test for forecast encompassing- Live Cattle (Regime 1)

	Preferred forecast	
	Implied Volatility	**Historical Volatility**
Estimated λ	0.0155	0.984*
t value	(0.04)	(2.25)
Result	Fail to reject Ho	Reject Ho
	Implied Volatility	**Naïve**
Estimated λ	-0.0949	1.095*
t value	(-0.18)	(2.11)
Result	Fail to reject Ho	Reject Ho
	Historical Volatility	**Naïve**
Estimated λ	0.0483	0.952
t value	(0.04)	(0.78)
Result	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.104, Test for time change- Live Cattle (Regime 1)

	Implied Volatility	Historical Volatility	Composite	Naïve
Estimated θ	-0.0000294	-0.000101	-0.0000331	-0.000167
t value	(-0.08)	(-0.26)	(-0.08)	(-0.44)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Regime 2

Table 6.105, Test for forecast bias- Live Cattle (Regime 2)

Regression	**IV model**	**HV model**	**Comp model**	**Naïve**
Coefficient	5.43E-10	-7.07E-10	1.96E-10	1.12E-10
t Value	0	(-0.00)	0	0
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.106, Test for forecast efficiency- Live Cattle (Regime 2)

	Implied Volatility	**Historical Volatility**	**Composite**	**Naïve**
Estimated β	4.38E-08	0.000000674	2.88E-10	0.000000237
t value	0	0	0	0
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho
Estimated ρ	0.145	0.219	-0.18	0.0526
t value	(0.56)	(0.91)	(-0.71)	(0.21)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.107, Test for forecast encompassing- Live Cattle (Regime 2)

	Preferred forecast	
	Implied Volatility	**Historical Volatility**
Estimated λ	0.158	8.42E-01
t value	(0.25)	(1.34)
Result	Fail to reject Ho	Fail to reject Ho
	Implied Volatility	**Naïve**
Estimated λ	0.0805	0.919
t value	(0.10)	(1.10)
Result	Fail to reject Ho	Fail to reject Ho
	Historical Volatility	**Naïve**

Estimated λ	0.801	0.199
t value	(0.73)	(0.18)
Result	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.108, Test for time change- Live Cattle (Regime 2)

	Implied Volatility	Historical Volatility	Composite	Naïve
Estimated θ	-0.00211	0.000142	0.000398	-0.00106
t value	(-0.77)	(0.05)	(0.16)	(-0.39)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Regime 3

Table 6.109, Test for forecast bias- Live Cattle (Regime 3)

Regression	IV model	HV model	Comp model	Naïve
Coefficient	3.38E-10	-2.85E-10	-1.82E-10	7.31E-11
t Value	0	(-0.00)	(-0.00)	0
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.110, Test for forecast efficiency- Live Cattle (Regime 3)

	Implied Volatility	Historical Volatility	Composite	Naïve
Estimated β	-0.00000151	0.00000242	-0.00000129	9.02E-08
t value	(-0.00)	0	(-0.00)	0
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho
Estimated ρ	-0.154	-0.147	-0.143	-0.00819
t value	(-1.47)	(-1.40)	(-1.36)	(-0.08)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.111, Test for forecast encompassing- Live Cattle (Regime 3)

	Preferred forecast

	Implied Volatility	Historical Volatility
Estimated λ	0.238	0.762
t value	(0.13)	(0.43)
Result	Fail to reject Ho	Fail to reject Ho
	Implied Volatility	**Naïve**
Estimated λ	0.913	0.0867
t value	(1.69)	(0.16)
Result	Fail to reject Ho	Fail to reject Ho
	Historical Volatility	**Naïve**
Estimated λ	1.026	-0.0264
t value	(1.74)	(-0.04)
Result	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.112, Test for time change- Live Cattle (Regime 3)

	Implied Volatility	Historical Volatility	Composite	Naïve
Estimated θ	-0.0000572	-0.0000488	-0.0000412	-0.00000846
t value	(-0.32)	(-0.27)	(-0.23)	(-0.05)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Regime 4

Table 6.113, Test for forecast bias- Live Cattle (Regime 4)

Regression	IV model	HV model	Comp model	Naïve
Coefficient	2.13E-10	6.50E-10	-6.79E-11	-5.04E-10
t Value	0	0	(-0.00)	(-0.00)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.114, Test for forecast efficiency- Live Cattle (Regime 4)

	Implied Volatility	Historical Volatility	Composite	Naïve
Estimated β	9.75E-08	0.000000155	-0.000000231	-0.000000151
t value	0	0	(-0.00)	(-0.00)

Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho
Estimated ρ	0.059	0.111	0.0904	0.00393
t value	(0.39)	(0.74)	(0.60)	(0.03)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.115, Test for forecast encompassing- Live Cattle (Regime 4)

	Preferred forecast	
	Implied Volatility	**Historical Volatility**
Estimated λ	0.61	0.39
t value	(0.66)	(0.42)
Result	Fail to reject Ho	Fail to reject Ho
	Implied Volatility	**Naïve**
Estimated λ	0.405	0.595
t value	(0.24)	(0.35)
Result	Fail to reject Ho	Fail to reject Ho
	Historical Volatility	**Naïve**
Estimated λ	0.346	0.654
t value	(0.35)	(0.67)
Result	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.116, Test for time change- Live Cattle (Regime 4)

	Implied Volatility	**Historical Volatility**	**Composite**	**Naïve**
Estimated θ	-0.000771	-0.000575	-0.00065	-0.000729
t value	(-0.85)	(-0.61)	(-0.72)	(-0.79)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Regime 5

Table 6.117, Test for forecast bias- Live Cattle (Regime 5)

Regression	**IV model**	**HV model**	**Comp model**	**Naïve**

Coefficient	-7.18E-11	1.96E-10	3.33E-10	1.41E-10
t Value	0	0	0	0
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.118, Test for forecast efficiency- Live Cattle (Regime 5)

	Implied Volatility	Historical Volatility	Composite	Naïve
Estimated β	0.000000907	-0.000000289	-7.82E-09	-0.000000363
t value	0	(-0.00)	(-0.00)	(-0.00)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho
Estimated ρ	-0.0698	-0.0467	-0.0547	-0.00139
t value	(-0.67)	(-0.45)	(-0.52)	(-0.01)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.119, Test for forecast encompassing- Live Cattle (Regime 5)

	Preferred forecast	
	Implied Volatility	**Historical Volatility**
Estimated λ	0.655	0.345
t value	(0.88)	(0.46)
Result	Fail to reject Ho	Fail to reject Ho
	Implied Volatility	**Naïve**
Estimated λ	0.602	0.398
t value	(0.61)	(0.40)
Result	Fail to reject Ho	Fail to reject Ho
	Historical Volatility	**Naïve**
Estimated λ	0.359	0.641
t value	(0.40)	(0.71)
Result	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.120, Test for time change- Live Cattle (Regime 5)

	Implied Volatility	Historical Volatility	Composite	Naïve
Estimated θ	0.00014	0.000187	0.000145	0.000202
t value	(0.77)	(1.04)	(0.80)	(1.12)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Regime 6

Table 6.121, Test for forecast bias- Live Cattle (Regime 6)

Regression	IV model	HV model	Comp model	Naïve
Coefficient	1.70E-10	-1.30E-10	9.24E-11	3.36E-11
t Value	0	(-0.00)	0	0
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, ***
p<0.001

Table 6.122, Test for forecast efficiency- Live Cattle (Regime 6)

	Implied Volatility	Historical Volatility	Composite	Naive
Estimated β	9.63E-08	5.31E-08	-2.79E-08	-5.33E-08
t value	0	0	(-0.00)	(-0.00)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho
Estimated ρ	0.0499	0.142	0.075	0.00718
t value	(0.48)	(1.36)	(0.72)	-0.07
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.123, Test for forecast encompassing- Live Cattle (Regime 6)

	Preferred forecast	
	Implied Volatility	**Historical Volatility**
Estimated λ	0.346	0.654
t value	(1.04)	(1.97)
Result	Fail to reject Ho	Fail to reject Ho
	Implied Volatility	**Naïve**

Estimated λ	0.0863	0.914
t value	(0.18)	(1.86)
Result	Fail to reject Ho	Fail to reject Ho
	Historical Volatility	**Naïve**
Estimated λ	0.406	0.594
t value	(0.75)	(1.10)
Result	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.124, Test for time change- Live Cattle (Regime 6)

	Implied Volatility	**Historical Volatility**	**Composite**	**Naïve**
Estimated θ	0.000116	0.00000509	0.000261	0.0000159
t value	(0.35)	(0.02)	(0.82)	(0.05)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Regime 7

Table 6.125, Test for forecast bias- Live Cattle (Regime 7)

Regression	**IV model**	**HV model**	**Comp model**	**Naïve**
Coefficient	1.79E-10	4.07E-10	-2.27E-10	-1.51E-10
t Value	0	0	(-0.00)	(-0.00)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, ***
p<0.001

Table 6.126, Test for forecast efficiency- Live Cattle (Regime 7)

	Implied Volatility	**Historical Volatility**	**Composite**	**Naïve**
Estimated β	1.76E-08	-0.000000571	3.76E-08	-0.00000179
t value	0	(-0.00)	0	(-0.00)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho
Estimated ρ	-0.0492	0.0115	0.0152	0.00558
t value	(-0.47)	(0.11)	(0.15)	-0.05

Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.127, Test for forecast encompassing- Live Cattle (Regime 7)

	Preferred forecast	
	Implied Volatility	**Historical Volatility**
Estimated λ	0.125	0.875***
t value	(0.52)	(3.62)
Result	Fail to reject Ho	Reject Ho
	Implied Volatility	**Naïve**
Estimated λ	0.0237	0.976***
t value	(0.09)	(3.71)
Result	Fail to reject Ho	Reject Ho
	Historical Volatility	**Naïve**
Estimated λ	-0.00748	1.007
t value	(-0.01)	(0.92)
Result	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.128, Test for time change- Live Cattle (Regime 7)

	Implied Volatility	**Historical Volatility**	**Composite**	**Naïve**
Estimated θ	-0.000281	-0.000649	-0.00031	-0.000678
t value	(-0.66)	(-1.45)	(-0.79)	(-1.48)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Regime 8

Table 6.129, Test for forecast bias- Live Cattle (Regime 8)

Regression	**IV model**	**HV model**	**Comp model**	**Naïve**
Coefficient	2.80E-10	7.38E-11	-3.34E-11	-3.67E-10
t Value	0	0	0	(-0.00)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, ***
p<0.001

Table 6.130, Test for forecast efficiency- Live Cattle (Regime 8)

	Implied Volatility	Historical Volatility	Composite	Naïve
Estimated β	1.15E-08	0.0000012	1.82E-08	0.0000785
t value	0	0	0	0
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho
Estimated ρ	-0.047	-0.0101	-0.0348	0.00072
t value	(-0.88)	(-0.19)	(-0.65)	(0.01)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.131, Test for forecast encompassing- Live Cattle (Regime 8)

	Preferred forecast	
	Implied Volatility	**Historical Volatility**
Estimated λ	-0.085	1.085***
t value	(-0.27)	(3.43)
Result	Fail to reject Ho	Reject Ho
	Implied Volatility	**Naïve**
Estimated λ	-0.00726	1.007***
t value	(-0.03)	(3.53)
Result	Fail to reject Ho	Reject Ho
	Historical Volatility	**Naïve**
Estimated λ	-0.028	1.028
t value	(-0.02)	(0.86)
Result	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.132, Test for time change- Live Cattle (Regime 8)

	Implied Volatility	Historical Volatility	Composite	Naïve
Estimated θ	0.0000208	0.0000151	0.0000254	0.0000189
t value	(0.55)	(0.39)	(0.68)	(0.49)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Regime 9

Table 6.133, Test for forecast bias- Live Cattle (Regime 9)

Regression	IV model	HV model	Comp model	Naïve
Coefficient	2.69E-10	3.95E-10	1.67E-10	-1.59E-10
t Value	0	0	0	(-0.00)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, ***
p<0.001

Table 6.134, Test for forecast efficiency- Live Cattle (Regime 9)

	Implied Volatility	Historical Volatility	Composite	Naïve
Estimated β	-3.19E-08	2.83E-08	3.21E-08	0.00000121
t value	0	0	0	0
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho
Estimated ρ	-0.0866	-0.0517	-0.055	0.0015
t value	(-0.98)	(-0.59)	(-0.62)	(0.02)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.135, Test for forecast encompassing- Live Cattle (Regime 9)

	Preferred forecast	
	Implied Volatility	**Historical Volatility**
Estimated λ	-0.0973	1.097*
t value	(-0.20)	(2.31)
Result	Fail to reject Ho	Reject Ho
	Implied Volatility	**Naïve**
Estimated λ	0.0745	0.925*
t value	(0.19)	(2.30)
Result	Fail to reject Ho	Reject Ho
	Historical Volatility	**Naïve**
Estimated λ	0.504	0.496
t value	(0.38)	(0.37)
Result	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.136, Test for time change- Live Cattle (Regime 9)

	Implied Volatility	Historical Volatility	Composite	Naïve
Estimated θ	-0.000223	-0.000218	-0.000221	-0.000205
t value	(-1.57)	(-1.53)	(-1.58)	(-1.44)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Feeder Cattle Results

Full Period

Table 6.137, Test for forecast bias- Feeder Cattle (Full Period)

Regression	IV model	HV model	Comp model	Naïve
Coefficient	-1.05E-11	-3.85E-12	2.40E-11	9.32E-11
t Value	0	0	0	0
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.138, Test for forecast efficiency- Feeder Cattle (Full Period)

	Implied Volatility	Historical Volatility	Composite	Naïve
Estimated β	9.35E-10	-9.83E-09	-1.19E-09	1.42E-08
t value	0	0	0	0
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho
Estimated ρ	0.0319	0.0921**	0.0342	-0.013
t value	(1.00)	(2.89)	(1.07)	(-0.41)
Result	Fail to reject Ho	Reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.139, Test for forecast encompassing- Feeder Cattle (Full Period)

	Preferred forecast	
	Implied Volatility	**Historical Volatility**
Estimated λ	-0.0523	1.052***
t value	(-0.46)	-9.36
Result	Fail to reject Ho	Reject Ho
	Implied Volatility	**Naïve**
Estimated λ	0.0706	0.929***
t value	-0.77	-10.19
Result	Fail to reject Ho	Reject Ho
	Historical Volatility	**Naïve**
Estimated λ	0.347*	0.653***
t value	-2.4	-4.5
Result	Reject Ho	Reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.140, Test for time change- Feeder Cattle (Full Period)

	Implied Volatility	Historical Volatility	Composite	Naïve
Estimated θ	0.00000811	0.00000676	0.00000791	0.00000468
t value	(1.12)	(0.89)	(1.10)	(0.61)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Regime 1

Table 6.141, Test for forecast bias- Feeder Cattle (Regime 1)

Regression	IV model	HV model	Comp model	Naïve
Coefficient	-8.12E-12	2.38E-10	2.53E-10	2.24E-10
t Value	(-0.00)	0	0	0
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.142, Test for forecast efficiency- Feeder Cattle (Regime 1)

	Implied Volatility	Historical Volatility	Composite	Naïve

Estimated β	3.33E-09	-2.25E-08	4.80E-08	-6.81E-08
t value	0	(-0.00)	0	(-0.00)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho
Estimated ρ	0.0608	0.138	0.0612	-0.00395
t value	(0.79)	(1.81)	(0.80)	(-0.05)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.143, Test for forecast encompassing- Feeder Cattle (Regime 1)

	Preferred forecast	
	Implied Volatility	**Historical Volatility**
Estimated λ	-0.0362	1.036***
t value	(-0.14)	(4.11)
Result	Fail to reject Ho	Reject Ho
	Implied Volatility	**Naïve**
Estimated λ	0.13	0.870***
t value	(0.64)	(4.27)
Result	Fail to reject Ho	Reject Ho
	Historical Volatility	**Naïve**
Estimated λ	0.456	0.544
t value	(1.42)	(1.70)
Result	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.144, Test for time change- Feeder Cattle (Regime 1)

	Implied Volatility	**Historical Volatility**	**Composite**	**Naïve**
Estimated θ	-0.000117	-0.0000771	-0.000116	-0.0000564
t value	(-1.16)	(-0.70)	(-1.16)	(-0.52)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Regime 2

Table 6.145Test for forecast bias- Feeder Cattle (Regime 2)

Regression	IV model	HV model	Comp model	Naïve
Coefficient	-8.61E-11	-3.54E-10	1.14E-10	3.35E-10
t Value	(-0.00)	(-0.00)	0	0
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.146, Test for forecast efficiency- Feeder Cattle (Regime 2)

	Implied Volatility	Historical Volatility	Composite	Naïve
Estimated β	0.000000214	-0.000000126	-4.85E-08	-0.0000137
t value	0	(-0.00)	(-0.00)	(-0.00)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho
Estimated ρ	0.018	-0.109	-0.0988	-0.00126
t value	(0.12)	(-0.72)	(-0.66)	(-0.01)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.147, Test for forecast encompassing- Feeder Cattle (Regime 2)

	Preferred forecast	
	Implied Volatility	**Historical Volatility**
Estimated λ	0.697	0.303
t value	(1.09)	(0.47)
Result	Fail to reject Ho	Fail to reject Ho
	Implied Volatility	**Naïve**
Estimated λ	-0.0105	1.01
t value	(-0.01)	(0.54)
Result	Fail to reject Ho	Fail to reject Ho
	Historical Volatility	**Naïve**
Estimated λ	0.064	0.936
t value	(0.08)	(1.12)
Result	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.148, Test for time change- Feeder Cattle (Regime 2)

	Implied Volatility	Historical Volatility	Composite	Naïve
Estimated θ	-0.000128	-0.000203	-0.000472	-0.0000947
t value	(-0.21)	(-0.32)	(-0.72)	(-0.16)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Regime 3

Table 6.149, Test for forecast bias- Feeder Cattle (Regime 3)

Regression	IV model	HV model	Comp model	Naïve
Coefficient	6.80E-11	-6.88E-11	3.24E-11	1.49E-10
t Value	0	(-0.00)	0	0
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.150, Test for forecast efficiency- Feeder Cattle (Regime 3)

	Implied Volatility	Historical Volatility	Composite	Naïve
Estimated β	-0.00000019	0.000000294	-9.59E-08	0.0000739
t value	(-0.00)	0	(-0.00)	0
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho
Estimated ρ	-0.203	-0.194	-0.203	-0.161
t value	(-1.92)	(-1.84)	(-1.92)	(-1.52)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.151, Test for forecast encompassing- Feeder Cattle (Regime 3)

	Preferred forecast	
	Implied Volatility	**Historical Volatility**
Estimated λ	0.0213	0.979
t value	(0.02)	(1.00)
Result	Fail to reject Ho	Fail to reject Ho
	Implied Volatility	**Naïve**

Estimated λ	0.0151	0.985
t value	(0.02)	(1.55)
Result	Fail to reject Ho	Fail to reject Ho
	Historical Volatility	**Naïve**
Estimated λ	0.0193	0.981
t value	(0.02)	(1.18)
Result	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.152, Test for time change- Feeder Cattle (Regime 3)

	Implied Volatility	**Historical Volatility**	**Composite**	**Naïve**
Estimated θ	-0.0000951	-0.0000798	-0.0000949	-0.0000687
t value	(-1.04)	(-0.88)	(-1.04)	(-0.76)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Regime 4

Table 6.153, Test for forecast bias- Feeder Cattle (Regime 4)

Regression	**IV model**	**HV model**	**Comp model**	**Naïve**
Coefficient	2.13E-10	1.87E-10	2.27E-10	-8.24E-11
t Value	0	0	0	(-0.00)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.154, Test for forecast efficiency- Feeder Cattle (Regime 4)

	Implied Volatility	**Historical Volatility**	**Composite**	**Naïve**
Estimated β	-0.000000181	0.000000184	1.48E-08	-3.45E-08
t value	(-0.00)	0	0	(-0.00)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho
Estimated ρ	0.206*	0.237*	0.207*	0.0116
t value	(2.03)	(2.36)	(2.04)	(0.11)
Result	Reject Ho	Reject Ho	Reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.155, Test for forecast encompassing- Feeder Cattle (Regime 4)

	Preferred forecast	
	Implied Volatility	**Historical Volatility**
Estimated λ	-0.187	1.187
t value	(-0.22)	(1.37)
Result	Fail to reject Ho	Fail to reject Ho
	Implied Volatility	**Naïve**
Estimated λ	0.847*	0.153
t value	(2.09)	(0.38)
Result	Reject Ho	Fail to reject Ho
	Historical Volatility	**Naïve**
Estimated λ	1.014*	-0.0137
t value	(2.47)	(-0.03)
Result	Reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.156, Test for time change- Feeder Cattle (Regime 4)

	Implied Volatility	Historical Volatility	Composite	Naïve
Estimated θ	0.0000929	0.0000526	0.0000996	0.000167
t value	(0.52)	(0.29)	(0.56)	(0.97)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Regime 5

Table 6.157, Test for forecast bias- Feeder Cattle (Regime 5)

Regression	IV model	HV model	Comp model	Naïve
Coefficient	1.42E-10	-1.74E-10	-1.20E-10	3.12E-10
t Value	0	(-0.00)	(-0.00)	0
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.158, Test for forecast efficiency- Feeder Cattle (Regime 5)

	Implied Volatility	Historical Volatility	Composite	Naïve
Estimated β	8.31E-09	0.000000253	-4.80E-09	-0.000000105
t value	0	0	(-0.00)	(-0.00)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho
Estimated ρ	0.0138	0.111	0.0167	-0.00123
t value	(0.22)	(1.82)	(0.27)	(-0.02)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.159, Test for forecast encompassing- Feeder Cattle (Regime 5)

	Preferred forecast	
	Implied Volatility	**Historical Volatility**
Estimated λ	-0.103	1.103***
t value	(-0.59)	(6.34)
Result	Fail to reject Ho	Reject Ho
	Implied Volatility	**Naïve**
Estimated λ	0.0181	0.982***
t value	(0.11)	(6.11)
Result	Fail to reject Ho	Reject Ho
	Implied Volatility	**Naïve**
Estimated λ	0.707	0.293
t value	(1.62)	(0.67)
Result	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.160, Test for time change- Feeder Cattle (Regime 5)

	Implied Volatility	Historical Volatility	Composite	Naïve
Estimated θ	-0.0000656	-0.000127*	-0.0000527	-0.0000987
t value	(-1.19)	(-2.09)	(-0.97)	(-1.63)
Result	Fail to reject Ho	Reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Regime 6

Table 6.161, Test for forecast bias- Feeder Cattle (Regime 6)

Regression	IV model	HV model	Comp model	Naïve
Coefficient	-7.52E-10	-5.59E-10	1.55E-10	-1.47E-10
t Value	(-0.00)	(-0.00)	0	(-0.00)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.162, Test for forecast efficiency- Feeder Cattle (Regime 6)

	Implied Volatility	Historical Volatility	Composite	Naïve
Estimated β	-1.12E-08	-4.23E-08	-0.000000101	-0.000002
t value	(-0.00)	(-0.00)	(-0.00)	(-0.00)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho
Estimated ρ	-0.148	-0.0971	-0.145	-0.00515
t value	(-1.05)	(-0.68)	(-1.02)	(-0.04)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.163, Test for forecast encompassing- Feeder Cattle (Regime 6)

	Preferred forecast	
	Implied Volatility	**Historical Volatility**
Estimated λ	0.599	0.401
t value	(0.93)	(0.62)
Result	Fail to reject Ho	Fail to reject Ho
	Implied Volatility	**Naïve**
Estimated λ	-0.0701	1.07
t value	(-0.13)	(1.93)
Result	Fail to reject Ho	Fail to reject Ho
	Historical Volatility	**Naïve**
Estimated λ	-0.0605	1.061*
t value	(-0.12)	(2.05)
Result	Fail to reject Ho	Reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.164, Test for time change- Feeder Cattle (Regime 6)

	Implied Volatility	Historical Volatility	Composite	Naïve
Estimated θ	0.000408	0.000631	0.000558	0.000329
t value	(0.62)	(1.01)	(0.88)	(0.49)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Regime 7

Table 6.165, Test for forecast bias- Feeder Cattle (Regime 7)

Regression	IV model	HV model	Comp model	Naïve
Coefficient	4.84E-11	-1.52E-10	5.33E-11	-4.18E-11
t Value	0	(-0.00)	0	(-0.00)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.166, Test for forecast efficiency- Feeder Cattle (Regime 7)

	Implied Volatility	Historical Volatility	Composite	Naïve
Estimated β	0.000000108	-0.000000239	-0.000000104	-0.000000333
t value	0	(-0.00)	(-0.00)	(-0.00)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho
Estimated ρ	0.0385	0.0289	0.0295	0.0117
t value	(0.54)	(0.41)	(0.42)	(0.17)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.167, Test for forecast encompassing- Feeder Cattle (Regime 7)

	Preferred forecast	
	Implied Volatility	**Historical Volatility**
Estimated λ	0.235	0.765

t value	(0.30)	(0.96)
Result	Fail to reject Ho	Fail to reject Ho
	Implied Volatility	**Naïve**
Estimated λ	0.152	0.848
t value	(0.22)	(1.23)
Result	Fail to reject Ho	Fail to reject Ho
	Historical Volatility	**Naïve**
Estimated λ	0.223	0.777
t value	(0.23)	(0.82)
Result	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.168, Test for time change- Feeder Cattle (Regime 7)

	Implied Volatility	**Historical Volatility**	**Composite**	**Naïve**
Estimated θ	-0.0000245	-0.00000771	-0.0000193	-0.0000161
t value	(-0.36)	(-0.11)	(-0.28)	(-0.24)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Regime 8

Table 6.169, Test for forecast bias- Feeder Cattle (Regime 8)

Regression	**IV model**	**HV model**	**Comp model**	**Naïve**
Coefficient	5.54E-11	1.80E-11	-2.27E-10	-3.71E-10
t Value	0	0	0	(-0.00)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.170, Test for forecast efficiency- Feeder Cattle (Regime 8)

	Implied Volatility	**Historical Volatility**	**Composite**	**Naïve**
Estimated β	-0.00000026	0.000049	-0.000000114	-0.000000152
t value	0	0	0	(-0.00)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

Estimated ρ	-0.0356	-0.0344	-0.0217	-0.104
t value	(-0.23)	(-0.22)	(-0.14)	(-0.66)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.171, Test for forecast encompassing- Feeder Cattle (Regime 8)

	Preferred forecast	
	Implied Volatility	**Historical Volatility**
Estimated λ	-0.0692	1.069
t value	(-0.05)	(0.81)
Result	Fail to reject Ho	Fail to reject Ho
	Implied Volatility	**Naïve**
Estimated λ	0.606	0.394
t value	(0.64)	(0.41)
Result	Fail to reject Ho	Fail to reject Ho
	Historical Volatility	**Naïve**
Estimated λ	1.032	-0.0321
t value	(0.94)	(-0.03)
Result	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.172, Test for time change- Feeder Cattle (Regime 8)

	Implied Volatility	**Historical Volatility**	**Composite**	**Naïve**
Estimated θ	-0.00075	-0.000728	-0.000706	-0.000655
t value	(-1.99)	(-1.96)	(-1.82)	(-1.67)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Lean Hogs Results

Full Period

Table 6.173, Test for forecast bias- Lean Hogs (Full Period)

Regression	IV model	HV model	Comp model	Naïve
Coefficient	1.72E-10	-2.30E-10	-1.58E-10	1.13E-11
t Value	0	0	0	0
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.174, Test for forecast efficiency- Lean Hogs (Full Period)

	Implied Volatility	Historical Volatility	Composite	Naïve
Estimated β	-4.81E-10	7.87E-08	-2.40E-09	-0.000000212
t value	(-0.00)	0	(-0.00)	(-0.00)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho
Estimated ρ	-0.00193	0.0253	0.00179	-0.00369
t value	(-0.06)	-0.79	-0.06	(-0.12)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.175, Test for forecast encompassing- Lean Hogs (Full Period)

	Preferred forecast	
	Implied Volatility	**Historical Volatility**
Estimated λ	-0.0305	1.031***
t value	(-0.18)	(6.19)
Result	Fail to reject Ho	Reject Ho
	Implied Volatility	**Naïve**
Estimated λ	0.00986	0.990***
t value	(0.07)	(6.58)
Result	Fail to reject Ho	Reject Ho
	Historical Volatility	**Naïve**
Estimated λ	0.206	0.794*
t value	(0.62)	(2.39)
Result	Fail to reject Ho	Reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.176, Test for time change- Lean Hogs (Full Period)

	Implied Volatility	Historical Volatility	Composite	Naïve
Estimated θ	-0.0000326	-0.000029	-0.0000328	-0.0000305
t value	(-1.61)	(-1.41)	(-1.62)	(-1.47)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Regime 1

Table 6.177, Test for forecast bias- Lean Hogs (Regime 1)

Regression	IV model	HV model	Comp model	Naïve
Coefficient	5.07E-10	3.96E-11	1.08E-10	4.48E-10
t Value	0	0	0	0
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.178, Test for forecast efficiency- Lean Hogs (Regime 1)

	Implied Volatility	Historical Volatility	Composite	Naïve
Estimated β	-4.57E-08	0.0000029	1.10E-08	7.91E-08
t value	(-0.00)	0	0	0
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho
Estimated ρ	-0.252*	-0.237*	-0.232*	0.00502
t value	(-2.47)	(-2.33)	(-2.26)	(0.05)
Result	Reject Ho	Reject Ho	Reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.179, Test for forecast encompassing- Lean Hogs (Regime 1)

	Preferred forecast	
	Implied Volatility	**Historical Volatility**
Estimated λ	0.0368	0.963
t value	(0.05)	(1.26)
Result	Fail to reject Ho	Fail to reject Ho
	Implied Volatility	**Naïve**

Estimated λ	0.751*	0.249
t value	(2.11)	(0.70)
Result	Reject Ho	Fail to reject Ho
	Historical Volatility	**Naïve**
Estimated λ	1.020*	-0.0197
t value	(2.37)	(-0.05)
Result	Reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.180, Test for time change- Lean Hogs (Regime 1)

	Implied Volatility	**Historical Volatility**	**Composite**	**Naïve**
Estimated θ	-0.0008	-0.000818	-0.000797	-0.000786
t value	(-1.49)	(-1.57)	(-1.49)	(-1.56)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Regime 2

Table 6.181, Test for forecast bias- Lean Hogs (Regime 2)

Regression	**IV model**	**HV model**	**Comp model**	**Naïve**
Coefficient	-3.40E-10	-1.60E-10	1.88E-10	6.60E-10
t Value	(-0.00)	(-0.00)	0	0
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.182, Test for forecast efficiency- Lean Hogs (Regime 2)

	Implied Volatility	**Historical Volatility**	**Composite**	**Naïve**
Estimated β	-9.42E-08	-0.0000012	0.000000169	-0.000000258
t value	(-0.00)	(-0.00)	0	(-0.00)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho
Estimated ρ	-0.127	-1.25E-01	-0.13	-0.0155
t value	(-1.00)	(-0.97)	(-1.02)	(-0.12)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.183, Test for forecast encompassing- Lean Hogs (Regime 2)

	Preferred forecast	
	Implied Volatility	**Historical Volatility**
Estimated λ	0.00584	0.994
t value	(0.01)	(1.42)
Result	Fail to reject Ho	Fail to reject Ho
	Implied Volatility	**Naïve**
Estimated λ	0.22	0.78
t value	(0.36)	(1.29)
Result	Fail to reject Ho	Fail to reject Ho
	Historical Volatility	**Naïve**
Estimated λ	0.812	0.188
t value	(0.73)	(0.17)
Result	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.184, Test for time change- Lean Hogs (Regime 2)

	Implied Volatility	Historical Volatility	Composite	Naïve
Estimated θ	0.00000598	0.000254	0.00000733	0.000301
t value	(0.01)	(0.31)	(0.01)	(0.37)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Regime 3

Table 6.185, Test for forecast bias- Lean Hogs (Regime 3)

Regression	IV model	HV model	Comp model	Naïve
Coefficient	8.35E-10	-3.24E-10	-1.34E-09	-7.63E-10
t Value	0	(-0.00)	(-0.00)	(-0.00)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.186, Test for forecast efficiency- Lean Hogs (Regime 3)

	Implied Volatility	Historical Volatility	Composite	Naïve
Estimated β	-3.08E-08	-4.19E-09	-2.86E-08	-4.56E-09
t value	(-0.00)	(-0.00)	(-0.00)	(-0.00)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho
Estimated ρ	0.135	0.216*	0.135	0.00271
t value	(1.25)	(2.02)	(1.25)	(0.02)
Result	Fail to reject Ho	Reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.187, Test for forecast encompassing- Lean Hogs (Regime 3)

	Preferred forecast	
	Implied Volatility	**Historical Volatility**
Estimated λ	-0.0269	1.027*
t value	(-0.06)	(2.39)
Result	Fail to reject Ho	Reject Ho
	Implied Volatility	**Naïve**
Estimated λ	0.42	0.58
t value	(1.25)	(1.73)
Result	Fail to reject Ho	Fail to reject Ho
	Historical Volatility	**Naïve**
Estimated λ	0.914*	0.0864
t value	(2.07)	(0.20)
Result	Reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.188, Test for time change- Lean Hogs (Regime 3)

	Implied Volatility	Historical Volatility	Composite	Naïve
Estimated θ	0.000458	-0.000000726	0.000467	0.0000767
t value	(0.43)	(-0.00)	(0.43)	(0.07)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Regime 4

Table 6.189, Test for forecast bias- Lean Hogs (Regime 4)

Regression	IV model	HV model	Comp model	Naïve
Coefficient	-2.31E-10	2.30E-10	-2.53E-10	-4.04E-10
t Value	(-0.00)	0	(-0.00)	(-0.00)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.190, Test for forecast efficiency- Lean Hogs (Regime 4)

	Implied Volatility	Historical Volatility	Composite	Naïve
Estimated β	-0.00000013	-9.66E-08	6.13E-08	9.18E-08
t value	(-0.00)	(-0.00)	0	0
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho
Estimated ρ	-0.116	-0.0537	-0.059	-0.00391
t value	(-1.16)	(-0.53)	(-0.58)	(-0.04)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.191, Test for forecast encompassing- Lean Hogs (Regime 4)

	Preferred forecast	
	Implied Volatility	**Historical Volatility**
Estimated λ	0.798	0.202
t value	(1.25)	(0.32)
Result	Fail to reject Ho	Fail to reject Ho
	Implied Volatility	**Naïve**
Estimated λ	0.717	0.283
t value	(0.98)	(0.39)
Result	Fail to reject Ho	Fail to reject Ho
	Historical Volatility	**Naïve**
Estimated λ	0.335	0.665
t value	(0.47)	(0.93)
Result	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.192, Test for time change- Lean Hogs (Regime 4)

	Implied Volatility	Historical Volatility	Composite	Naïve
Estimated θ	-0.000551	-0.000456	-0.00051	(0.00)
t value	(-0.82)	(-0.69)	(-0.77)	(-0.64)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Regime 5

Table 6.193, Test for forecast bias- Lean Hogs (Regime 5)

Regression	IV model	HV model	Comp model	Naïve
Coefficient	-3.63E-10	1.16E-10	3.07E-10	-1.19E-09
t Value	(-0.00)	0	0	(-0.00)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.194, Test for forecast efficiency- Lean Hogs (Regime 5)

	Implied Volatility	Historical Volatility	Composite	Naïve
Estimated β	3.61E-08	-0.000000289	-0.000000143	0.00000153
t value	0	(-0.00)	(-0.00)	0
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho
Estimated ρ	0.0242	-0.00475	0.0021	-0.00136
t value	(0.24)	(-0.05)	(0.02)	(-0.01)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.195, Test for forecast encompassing- Lean Hogs (Regime 5)

	Preferred forecast	
	Implied Volatility	**Historical Volatility**
Estimated λ	0.412	0.588
t value	(0.48)	(0.68)

Result	Fail to reject Ho	Fail to reject Ho
	Implied Volatility	**Naïve**
Estimated λ	0.0641	0.936
t value	(0.08)	(1.17)
Result	Fail to reject Ho	Fail to reject Ho
	Historical Volatility	**Naïve**
Estimated λ	-0.0158	1.016
t value	(-0.02)	(1.05)
Result	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.196, Test for time change- Lean Hogs (Regime 5)

	Implied Volatility	**Historical Volatility**	**Composite**	**Naïve**
Estimated θ	0.000249	0.000268	0.000299	0.000206
t value	(0.33)	(0.36)	(0.40)	(0.27)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Regime 6

Table 6.197, Test for forecast bias- Lean Hogs (Regime 6)

Regression	**IV model**	**HV model**	**Comp model**	**Naïve**
Coefficient	-3.69E-10	5.05E-10	-4.75E-10	2.62E-10
t Value	(-0.00)	0	(-0.00)	0
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.198, Test for forecast efficiency- Lean Hogs (Regime 6)

	Implied Volatility	**Historical Volatility**	**Composite**	**Naïve**
Estimated β	0.00000718	6.41E-08	-4.80E-08	-0.00000853
t value	0	0	(-0.00)	(-0.00)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

Estimated ρ	-0.0185	0.00256	0.00254	-0.00609
t value	(-0.26)	(0.04)	(0.04)	(-0.08)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.199, Test for forecast encompassing- Lean Hogs (Regime 6)

	Preferred forecast	
	Implied Volatility	**Historical Volatility**
Estimated λ	0.959	0.0412
t value	(0.77)	(0.03)
Result	Fail to reject Ho	Fail to reject Ho
	Implied Volatility	**Naïve**
Estimated λ	0.314	0.686
t value	(0.10)	(0.22)
Result	Fail to reject Ho	Fail to reject Ho
	Historical Volatility	**Naïve**
Estimated λ	-0.043	1.043
t value	(-0.03)	(0.80)
Result	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.200, Test for time change- Lean Hogs (Regime 6)

	Implied Volatility	**Historical Volatility**	**Composite**	**Naïve**
Estimated θ	-0.00000138	-0.0000154	-0.0000117	-0.0000124
t value	(-0.01)	(-0.08)	(-0.06)	(-0.07)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Regime 7

Table 6.201, Test for forecast bias- Lean Hogs (Regime 7)

Regression	**IV model**	**HV model**	**Comp model**	**Naïve**
Coefficient	1.77E-10	1.16E-09	8.27E-11	6.95E-10
t Value	0	0	0	0
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.202, Test for forecast efficiency- Lean Hogs (Regime 7)

	Implied Volatility	Historical Volatility	Composite	Naïve
Estimated β	0.000000883	-1.44E-08	-5.55E-08	-0.00000114
t value	0	(-0.00)	(-0.00)	(-0.00)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho
Estimated ρ	-0.0867	-0.032	-0.0458	-0.0119
t value	(-1.02)	(-0.38)	(-0.54)	(-0.14)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.203, Test for forecast encompassing- Lean Hogs (Regime 7)

	Preferred forecast	
	Implied Volatility	**Historical Volatility**
Estimated λ	0.88	0.12
t value	(1.58)	(0.22)
Result	Fail to reject Ho	Fail to reject Ho
	Implied Volatility	**Naïve**
Estimated λ	0.746	0.254
t value	(0.77)	(0.26)
Result	Fail to reject Ho	Fail to reject Ho
	Historical Volatility	**Naïve**
Estimated λ	0.118	0.882
t value	(0.19)	(1.40)
Result	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.204, Test for time change- Lean Hogs (Regime 7)

	Implied Volatility	Historical Volatility	Composite	Naïve
Estimated θ	0.000508	0.000366	0.000418	0.000469
t value	(1.35)	(0.99)	(1.14)	(1.24)

Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Regime 8

Table 6.205, Test for forecast bias- Lean Hogs (Regime 8)

Regression	**IV model**	**HV model**	**Comp model**	**Naïve**
Coefficient	1.57E-10	1.59E-10	2.79E-10	-4.35E-10
t Value	0	0	0	(-0.00)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.206, Test for forecast efficiency- Lean Hogs (Regime 8)

	Implied Volatility	**Historical Volatility**	**Composite**	**Naïve**
Estimated β	8.07E-09	0.000000201	6.58E-08	-0.00000666
t value	0	0	0	(-0.00)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho
Estimated ρ	0.0366	0.0243	0.0393	-0.0198
t value	-0.55	-0.36	-0.59	(-0.30)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.207, Test for forecast encompassing- Lean Hogs (Regime 8)

	Preferred forecast	
	Implied Volatility	**Historical Volatility**
Estimated λ	0.0224	0.978
t value	(0.04)	(1.88)
Result	Fail to reject Ho	Fail to reject Ho
	Implied Volatility	**Naïve**
Estimated λ	0.0387	0.961*
t value	(0.08)	(2.03)
Result	Fail to reject Ho	Reject Ho

	Historical Volatility	Naïve
Estimated λ	0.177	0.823
t value	(0.17)	(0.80)
Result	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001

Table 6.208, Test for time change- Lean Hogs (Regime 8)

	Implied Volatility	Historical Volatility	Composite	Naïve
Estimated θ	-0.00000836	-0.0000808	-0.0000105	-0.0000773
t value	(-0.04)	(-0.42)	(-0.06)	(-0.40)
Result	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho	Fail to reject Ho

* p<0.05, **p<0.01, *** p<0.001