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# Analyzing the Accuracy and Trading Strategy Potential of Private Analyst Projections of USDA WASDE Reports

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Analyzing the Accuracy and Trading Strategy Potential of Private Analyst Projections of USDA WASDE Reports

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Abstract

This thesis investigates the economic impact of private analyst forecasts on trading strategies in agricultural commodities markets. The primary objective is to assess whether private forecasts of world ending stocks contained in the USDA's WASDE report provide valuable information for forming profitable trading strategies. The study utilizes panel regression models to analyze the relationship between private forecast accuracy and strategic returns derived from trading strategies based on these forecasts.

The research employs unbalanced panel data spanning from January 2011 to April 2021, integrating monthly and yearly indicators to capture temporal patterns. The dataset includes observations from multiple firms, allowing for the exploration of both common behaviors and individual firm effects over time. Statistical analyses reveal that private analyst forecasts significantly influence trading outcomes, with both corn and soybean regression models demonstrating positive and highly significant coefficients for private forecast accuracy. Specifically, traders following strategies based on these forecasts could achieve returns of 6.4819% for corn and 5.1294% for soybeans, underscoring the economic value of private forecasts in agricultural commodities markets.

Additionally, market structure dynamics play a crucial role in trading strategy profitability. The analysis identifies significant relationships between market carry and inverse market conditions and strategic returns. Carry markets, characterized by higher futures prices for deferred contracts, yield higher returns, while inverse markets, where deferred contracts trade at lower prices, also provide profitable opportunities, albeit with different dynamics. These findings suggest that understanding market structure is essential for optimizing trading strategies based on private forecasts.

Moreover, the persistence of forecasting performance among analysts is explored using Fisher Exact and Chi-Squared Tests. Contrary to expectations, the results indicate no statistically significant association between an analyst's performance in consecutive periods for corn, soybeans, and wheat. This implies that past forecasting accuracy does not reliably predict future performance, challenging the notion of consistent forecasting superiority or inferiority among analysts over time.

The implications of these findings are important for traders, market participants, and policymakers. Incorporating private analyst forecasts into decision-making processes can enhance trading strategies and mitigate price risk in agricultural commodities markets. However, caution is advised against relying solely on past performance as an indicator of future forecasting success.

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1. Introduction

Agriculture is an often forgotten yet vitally important aspect of everyone's day-to-day lives. Farming is essential, it allows the global population to survive and gives civilizations the potential to thrive. Agricultural commodities are important because they not only feed humans but also feed the livestock we consume and can be used in fuel production. About 20% of the world's population (1.3 billion people) work in agriculture worldwide, contributing approximately $3 trillion to the U.S. economy alone (Pines, insert year).

The U.S. agricultural marketing system relies on accurate and timely information about the world supply and demand of these commodities. Once a month, the Interagency Commodity Estimates Committees (ICECs) prepare and release a report that forecasts the supply and demand of many different agricultural commodities. This report is called the World Agricultural Supply and Demand Estimates (WASDE). The ICECs are chaired by USDA World Agricultural Outlook Board analysts and representatives from the Agricultural Marketing Service (AMS), Economic Research Service (ERS), Farm Service Agency (FSA), and the Foreign Agricultural Service (FAS). The WASDE report covers the supply and use of U.S. and world wheat, rice, coarse grains, oilseeds, and cotton, as well as the U.S.'s supply and use of sugar, meat, poultry, eggs, and milk. (USDA, n.d.)

ICECs use information from many different sources to compile these reports. The National Agricultural Statistics Service (NASS) is the primary source of information regarding U.S. crop and livestock production/stocks. However, information is also derived from foreign government reports, satellite imagery, and weather data. Agricultural trade data comes from reports such as the USDA Census of Agriculture and country-specific information reported by the FAS. Additionally, the ERS gathers and analyzes information on domestic use, prices, and agricultural

policy from many government agencies ("WASDE FAQS," n.d.). Between all three of these major information sources, there is a significant amount of data to aggregate. All the gathered information is reviewed by ICEC members who have diverse expertise and perspectives in many areas of agriculture, and then, the WASDE report is compiled.

The WASDE report is critical to agribusiness, as it supplies important forecasts about the prices, as well as supply and demand, of commodities to firms across the Agri-supply chain. The prices of commodities change on a day-to-day basis, which can make it difficult to elicit the appropriate time to market goods, making the WASDE critical to producer, and firm, success. Given the importance of the WASDE in guiding marketing and risk management decisions in the agricultural supply chain, many private analyst firms release forecasts of estimates reported by the WASDE several days before it is released.

The timing and accuracy of these reports are vitally important, as these private forecasts provide a benchmark for firms that are going to be buying or selling commodities (Milacek & Brorsen, 2017). When firms have access to information about prices, acres harvested, and predicted yield, they can shift their position in the market to have a more favorable outcome. Agricultural firms across the supply chain are willing to subscribe and pay for this private information, as they believe it helps them better manage their risks and returns. These firms are aware that market prices (futures and cash prices) tend to respond to new supply and demand information contained in WASDE reports and so having advanced warning of potential price movements – through access to the private analyst forecasts – is a useful marketing and risk management tool.

This study has two primary objectives. The first objective is to investigate whether private forecasts have economic value. This is determined by the profitability of trading

strategies based on private analyst projections of world ending stocks. The hypothesis for this objective is that accurately predicting the direction of WES changes can enable traders to strategically position themselves in the futures markets, thereby generating profitable returns. The second objective of this study is to examine the persistence of forecasting performance among analysts over time. The second objective hypothesizes that previous forecast accuracy does not predict future accuracy.

This study uses a truncated panel regression framework to estimate the profitability of trading strategies based on private analyst projections of world-ending stocks. By analyzing the directional changes in these forecasts relative to the official WASDE reports, we aim to discern whether such forecasts have predictive power regarding futures price movements. Specifically, we hypothesize that accurately predicting the direction of ending stock changes can enable traders to strategically position themselves in the futures markets, thereby generating profitable returns. This panel data analysis, which leverages both cross-sectional and time-series dimensions, offers a robust methodology for exploring the relationships between private analyst forecasts, market dynamics, and trading returns. This approach allows us to account for heterogeneity across firms and time-varying effects, providing a comprehensive understanding of the factors influencing trading outcomes.

In addition to assessing the economic value of private analyst forecasts, this study examines the persistence of forecasting performance among analysts over time. Employing the Fisher Exact Test and Chi-Squared Test, we investigate whether past forecasting accuracy reliably predicts future performance. Understanding the consistency of forecasts provided by independent analysts is crucial for traders seeking to identify reliable sources of information in the volatile world of agricultural commodity markets. By analyzing data from multiple

commodities (i.e. corn, soybeans, and wheat) and employing rigorous econometric techniques, this research contributes to both academic literature and practical decision-making in agricultural commodities trading. Our findings shed light on the efficacy of private analyst forecasts, inform trading strategies, and offer insights into the dynamics of supply and demand forecasting in agricultural markets. Ultimately, this study aims to enhance market efficiency and facilitate more informed decision-making in the global agricultural commodities landscape.

*Background Information*

Commodity futures markets have always played a robust role in the world of agricultural commodities. These markets are complex and can be very confusing if one does not know much about them. When an agricultural business buys grain from a producer or grain merchandising firm, they typically hedge their cash purchase with futures contracts. The most significant advantage of using a futures hedge is minimizing price risk. Price risk analysis is crucial for a firm to ensure businesses are getting an optimal price for their purchases. Commodity prices are dependent on supply and demand and can vary from region to region across the country.

Futures markets are highly complex. They involve the farmers and ranchers, processors, distributors, packagers, wholesalers, and retailers. Futures trading in the U.S. originated when the Chicago Board of Trade (CBOT) was created in the mid-19th century (Mintert and Welch, 2021). Buyers and sellers of commodities both aim to eliminate the risk associated with the possibility of prices rising or falling. This is where futures markets come into play. Sellers want to limit the price risk associated with owning inventories of grain, and buyers want to establish a price for these commodities before they are to be delivered.

These buyers and sellers will enter into a futures contract to achieve these goals. A futures contract is a binding agreement between a buyer and a seller to deliver or accept delivery

of a specific commodity at a specific price on a specific date. Each futures contract is standardized by identifying the delivery month, the quantity and quality of the commodity, the delivery location, and the payment terms (Mintert and Welch, 2021). According to Mintert and Welch, futures markets provide:

- Rules of conduct that traders must follow or risk expulsion
- An organized marketplace with established trading hours by which traders must abide
- Standardized trading through rigid contract specifications, which ensure that the commodity being traded in every contract is virtually identical
- A focal point for the collection and dissemination of information about the commodity's supply and demand, which helps ensure all traders have equal access to information
- A mechanism for settling disputes among traders without resorting to the costly and often slow U.S. court system
- Guaranteed settlement of contractual and financial obligations via the exchange clearinghouse

Futures contracts allow buyers and sellers to establish a price for future delivery through hedging, where hedging is defined as taking an equal but opposite position in cash and futures. For example, a farmer could sell a corn futures contract in August for delivery in March with the intent of physically delivering the equivalent amount of cash corn in his/her local market in February and offsetting their short March futures position by buying it back before March delivery time. In this case, the farmer will receive the March futures price originally established in August adjusted for the basis (i.e. the difference between cash price and futures price) when the position is offset, and the cash corn is delivered to a buyer/grain elevator in the local cash market. A futures contract is measured by the number of units (bushels, hundredweight, etc.) in

each contract times the current price (Mintert and Welch, 2021). For commodity grain, such as corn and soybeans, one contract equals 5,000 bushels. So, if the current price per bushel of corn is $2.40, one contract would be equal to a $12,000 cash value.

A futures contract price reflects today's opinion of what a commodity will be worth when the futures contract expires (Mintert and Welch, 2021). Futures contract prices can also be used as a source of price forecasts. Historical data can be used to predict future prices for a particular grade (quality) and location of a commodity. Having a basic understanding of how futures markets operate is essential to be able to understand how price forecasting works.

Once a month, the United States Department of Agriculture (USDA) releases a report called the World Agricultural Supply and Demand Estimate (WASDE). The WASDE forecasting cycle for the corn marketing year (September through August) starts in May preceding the marketing year and continues for 18 months until November following the marketing year. WASDE reports are released between the 9th and the 12th of each month at 3pm EST until April 1994, at 8:30am EST from May 1994-December 2012, and at 12pm EST from January 2013 to present. These reports, released by the World Agricultural Outlook Board (WAOB) combine supply and use information from all available sources, including National Agricultural Statistical Service (NASS), Foreign Agriculture Service (FAS), Economic Research Service (ERS), Farm Service Agency (FSA), and Agricultural Marketing Service (AMS), and present it in a balance sheet format that shows resulting changes in ending stocks and price. Separate balance sheets are maintained for over 90 countries to produce estimates for both U.S. and World supply and use for major crops and livestock. When WASDE reports are released simultaneously with other reports (such as Crop Production) they include the latest information from these reports (Isengildina-Massa et.al, 2021). The WASDE report has been known to shift commodity prices

right before and right after it is released because, as its name suggests, it contains key supply and demand information about commodities (Milacek and Brorsen, 2017). Since this report is only released once a month, it is helpful to predict what likely current and forward-looking supply and demand information will be included. This way, a business can make decisions about buying or selling grain in advance or taking appropriate hedges in futures to mitigate price risk associated with new supply and demand information contained in the actual report. WASDE reports contain supply and demand information for major grain and oilseed commodities produced in most countries around the world. For each commodity, ending stocks, which is the key supply-side information considered to move prices, are aggregated across countries to estimate world ending stocks. Low (high) ending stocks reflect tight (abundant) supplies of a commodity and are associated with higher (lower) prices. As already noted, a large literature (Isengildina-Massa et.al, 2021) has shown that future prices react to new information about U.S. ending stocks contained in WASDE reports. Given this, it is expected that surprises to world stocks, calculated as the percentage difference between WASDE and the average private analyst forecasts of world stocks, would also be expected to move futures prices. Positive (negative) surprises would lead to lower (higher) prices. The larger the shock the greater the price response. Importantly for this thesis, the accuracy of private analyst projections of world ending stocks is economically relevant to agricultural firms.

## 2. Literature Review

The United States Department of Agriculture (USDA) plays a crucial role in providing forecasts and information that shape agricultural markets. Previous studies comparing the accuracy of USDA forecasts with private counterparts reveal interesting insights into market dynamics. Isengildina-Massa et al. (2020) found that USDA forecasts generally outperform private forecasts, with smaller errors observed over time. Specifically, they note that while both USDA and private forecast accuracies have improved over time, the USDA's accuracy has shown greater improvement. More specifically, Egelkraut et al. (2003) examined the accuracy of USDA's corn and soybean production forecasts relative to the private forecasts released by Conrad Leslie and Sparks Companies. This study found that the relative accuracy of USDA forecasts varied by crop and month. Their results suggest that for corn, USDA forecasts appeared more accurate than private forecasts, especially later in the forecasting cycle. For soybeans, private forecasts appeared more accurate than USDAs in the beginning of the forecasting cycle (August and September), but USDA forecasts were dominant for October and November. These studies underscore the USDA's pivotal role in providing reliable information to market participants, as well as their accuracy compared to their private counterparts.

The release of USDA reports, particularly the World Agricultural Supply and Demand Estimates (WASDE), significantly impacts market uncertainty and trading behaviors. Isengildina-Massa et al. (2008) demonstrate that WASDE reports reduce market uncertainty in corn and soybean markets, particularly when there is disagreement among industry expectations before the reports. This industry expectation can be attributed to private forecasters. Private forecasters typically release their estimates a few days before the USDA reports. These private estimates have traditionally been used as a proxy for market expectations of government reports

(e.g., Colling and Irwin, 1990; Grunewald, McNulty, and Biere, 1993; Garcia et al., 1997; Egelkraut et al., 2003). The decrease in uncertainty following USDA reports persists for up to five days after the report release and is even more pronounced when there has been a greater disagreement among industry expectations before the USDA reports.

Due to these challenges, intraday data allowed for the measure that the strongest price reactions to the releases were found immediately after markets opened and persisted for about ten minutes. Some subtle reactions in the last trading session before the release suggest that traders adjusted their market exposure in anticipation of the release (Isengildina-Massa et al., 2008). Additionally, McKenzie (2008) highlights the significance of advanced knowledge of USDA reports in adjusting market expectations, further emphasizing the pivotal role of these reports in shaping market behaviors and trading strategies

USDA reports not only influence market uncertainty but also play a crucial role in risk management and market efficiency. Studies by McKenzie and Singh (2011) emphasize the importance of hedging stored grain over USDA report days to mitigate potential losses due to large price movements. Furthermore, Abbot, Boussios, and Lowenberg-DeBoer (2016) estimate the value of WASDE reports and their components, revealing significant value to market participants. Specifically, their results show significant value to market participants from the WASDE reports, roughly $301 million or 0.55% of overall corn market value. The results also show significant value for each forecasted component of the reports: area ($145 million), yield ($188 million), production ($299 million), demand/stocks ($300 million) and exports ($320 million).” These findings underscore the practical importance of USDA reports in informing risk management strategies and enhancing market efficiency (McKenzie & Singh, 2011; Abbot et al., 2016).

Understanding the accuracy and impact of USDA reports has significant implications for market participants, including agricultural producers and traders. Literature shows that agricultural producers have identified price and income risk as one of their greatest sources of worry (e.g., Patrick and Ullerich, 1996; Norvell and Lattz,1999). Isengildina-Massa et al. (2020) highlight the importance of recognizing the relative accuracy advantage of USDA forecasts over private forecasts, particularly for informed decision-making in agricultural markets. Moreover, Milacek and Brorsen (2017) demonstrate the potential trading returns from using WASDE report predictions, emphasizing the practical relevance of USDA information for market participants (Isengildina-Massa et al., 2020; Milacek & Brorsen, 2017).

Previous literature has not examined the value of private information on trading strategies. Our study adds to the existing literature by examining market participants' reactions to both public and private information releases. These reactions are vital to the success of agribusiness firms, who demand robust and accurate results from their reports. While the WASDE is likely the most accurate report, not all firms have the opportunity to wait until it is released to take positions in the market.

## 3. Data

The data for this study was sourced from the Bloomberg News Service. Since early 2010, most WASDE reports have been accompanied by a survey conducted and published by Bloomberg. The analysis data was collected from this survey and includes the date and time of publishing, the name of the firm, and their forecast of the world-ending stocks estimate contained in the upcoming WASDE report. Monthly reports spanning from February of 2010 to March of 2021 were included in this study, totaling 124 reports which amounts to 2,089 observations of estimates made by 73 unique analysis firms. This research compares and contrasts the monthly forecasts of 73 different analysts to determine their accuracy, thereby aiding customers in identifying the most reliable analysts. However, it is important to note that not all analysts release reports every month. The following list includes the name of each firm along with the total number of reports they have released in our time frame.

*Table 1: Analyst and Number of Reports Released*

| Analyst | Number of Reports | Analyst | Number of Reports |
|---|---|---|---|
| AC Trading Inc | 64 | Lakefront | 14 |
| ABN Amro | 28 | Linn Group | 24 |
| ADM Investor | 112 | Love Consulting | 2 |
| Advanced Market Concepts | 99 | Macquarie Bank | 3 |
| AgMarket.Net | 17 | MaxYield Cooperative | 7 |
| AgriSource | 2 | McKeany-Flavell | 85 |
| AgriVisor | 67 | MidCo Commodities | 8 |
| Allendale | 104 | Midwest Market Solutions | 21 |
| Alpari US | 7 | Morgan Stanley | 2 |
| Bennett Consulting | 20 | North American Risk Management | 3 |
| Brock Associates | 14 | NewEdge | 2 |
| Brugler | 46 | North American Risk Management | 6 |
| CHS Hedging | 64 | Northstar | 117 |
| Citigroup | 17 | Penson | 7 |
| Commodity Information | 3 | PFG Best Inc | 21 |
| Daniels Trading | 6 | Pira Energy | 5 |
| Doane | 86 | Price Futures Group | 4 |
| ED & F Man Capital | 80 | Prime Ag Consultants | 94 |
| EFG Group | 85 | Prudential Bache | 14 |
| Farm Direction | 5 | Rabobank | 4 |
| Farm Futures | 98 | Rice Dairy LLC | 3 |
| FINTEC Group | 13 | Risk MC | 28 |
| Fortis Clearing | 3 | Roach Ag | 9 |
| Futures International | 86 | Societe Generale | 7 |
| Global Commodity Analytics | 8 | Stewart Peterson | 109 |
| Grain Cycles | 14 | StoneX | 4 |
| Grain Service | 6 | Straits Financial LLC | 1 |
| Hightower | 14 | U.S. Commodities | 53 |
| Hueber Report | 57 | Walsh Trading | 7 |
| INTL FCStone | 56 | Water St. Advisory | 36 |
| Jefferies Bache | 45 | Western Milling | 44 |
| JPMorgan & Chase Co | 5 | Zaner Group | 79 |
| Kropf & Love | 16 | | |

The summary statistics for the panel regression data highlight the central tendencies and variability of the prediction variables and their magnitudes of errors. These summary statistics are presented below, in Table 2. The variable Corn (Soybean) Private Forecast shows that 61% of the observations involved a prediction, whereas Corn (Soybean) Private Forecast Inverse confirms the inverse relationship with 39% of the observations. The mean values of Corn (Soybean) Carry Market (0.003) and Corn (Soybean) Inverse Market (0.009) indicate that both positive and negative prediction errors are, on average, small, though Corn (Soybean) Inverse Market shows slightly higher variability. The variable Difference in Corn (Soybean) Prediction, which measures the difference in corn (soybean) predictions, has a negative mean of -0.015, suggesting a slight overall bias towards underestimation, with a moderate spread of values. These statistics provide a quantitative overview of prediction behaviors and error magnitudes, which are critical for understanding the performance and reliability of the predictive models used in the analysis.

*Table 2: Summary Statistics for Corn and Soybean Panel*

| Statistic | N | Mean | St. Dev. | Min | Max |
|---|---|---|---|---|---|
| Corn Private Forecast | 2,028 | 0.610 | 0.488 | 0 | 1 |
| Corn Carry Market | 2,028 | 0.003 | 0.047 | -0.198 | 0.653 |
| Corn Private Forecast Inverse | 2,028 | 0.390 | 0.488 | 0 | 1 |
| Corn Inverse Market | 2,028 | 0.009 | 0.063 | -0.449 | 0.673 |
| Difference in Corn Predictions | 2,028 | -0.015 | 0.047 | -0.244 | 0.317 |
| Soybean Private Forecast | 2,071 | 0.650 | 0.477 | 0 | 1 |
| Soybean Carry Market | 2,028 | 0.000 | 0.028 | -0.235 | 0.193 |
| Soybean Private Forecast Inverse | 2,028 | 0.350 | 0.477 | 0 | 1 |
| Soybean Inverse Market | 2,028 | 0.002 | 0.033 | -0.737 | 0.324 |
| Difference in Soybean Predictions | 2,071 | -0.020 | 0.083 | -0.828 | 0.716 |

Table 3, as shown below, presents an overview of the variables that will be utilized in our Fisher Exact and Chi-Squared tests. The dataset includes 2,101 observations for the WASDE (World Agricultural Supply and Demand Estimates) reports on corn, soybeans, and wheat ending stocks. The mean value for WASDE corn is 202.943 million bushels with a standard deviation of

78.250, ranging from 111.890 to 2,184.000 million bushels. For WASDE soybeans, the mean is 82.955 million bushels with a standard deviation of 16.580, and values range between 53.100 and 115.330 million bushels. WASDE wheat has a mean of 235.489 million bushels, a standard deviation of 45.493, and ranges from 172.380 to 321.450 million bushels. Private estimates show similar patterns with slightly different means and standard deviations. Notably, the absolute error metrics indicate the accuracy of private forecasts compared to WASDE reports. The mean absolute error for corn is 0.032 with a standard deviation of 0.085, while soybeans have a mean of 0.027 and a standard deviation of 0.034. Wheat shows the lowest mean absolute error at 0.018 with a standard deviation of 0.036. These statistics highlight the variability and accuracy in the private forecasts relative to the official WASDE estimates.

*Table 3: Summary Statistics of Variables Used in Fisher Exact and Chi-Squared Tests*

| Statistic | N | Mean | St. Dev. | Min | Max |
|---|---|---|---|---|---|
| WASDE Corn Estimate | 2,101 | 202.943 | 78.250 | 111.890 | 2,184.000 |
| WASDE Soybean Estimate | 2,101 | 82.955 | 16.580 | 53.100 | 115.330 |
| WASDE Wheat Estimate | 2,101 | 235.489 | 45.493 | 172.380 | 321.450 |
| Private Corn Estimate | 2,047 | 199.674 | 64.556 | 105.000 | 365.000 |
| Private Soybean Estimate | 2,091 | 82.841 | 17.023 | 42.000 | 201.400 |
| Private Wheat Estimate | 2,063 | 232.647 | 45.580 | 68.000 | 325.500 |
| Corn Absolute Error (WASDE-Private) | 2,031 | 0.032 | 0.085 | 0.000 | 2.037 |
| Soybean Absolute Error (WASDE-Private) | 2,074 | 0.027 | 0.034 | 0.000 | 0.737 |
| Wheat Absolute Error (WASDE-Private) | 2,046 | 0.018 | 0.036 | 0.000 | 1.317 |

## 4. Methods

### *Unbalanced Panel Regression*

A primary objective of this research is to assess whether private analyst forecasts have economic value. With this in mind, we use panel regression models to determine if trading strategies formed on analysts' projections of world-ending stocks generate profitable returns. Hypothetical long and short futures trades based on the analyst ending stocks projections are established after the analyst projections are released and lifted after the WASDE report is released. If an analyst forecast indicates higher ending stocks in comparison to the previous month's WASDE report – an indication of higher supply – prices should theoretically fall and taking a short futures position to capture that price fall should be profitable. Conversely, if an analyst forecast indicates lower ending stocks in comparison to the previous month's WASDE report, a long futures position should be profitable. Of particular interest is whether the accuracy of the projected direction of ending stocks by analysts is associated with profitable returns (based on price direction) to the trading strategies. We measure the accuracy of private analyst forecasts in terms of the ex post observed direction of ending stocks gleamed from WASDE projections over the same period.

Panel data, also known as longitudinal data, contains observations about different cross sections across time, thus combining the features of both time series and cross-sectional data. This dataset includes observations collected at regular intervals, akin to time series data, and spans across multiple firms, similar to cross-sectional data. The use of panel data is particularly advantageous as it allows us to model both the common behaviors shared by firms and the unique behaviors of individual firms. This dual capability provides a richer dataset with greater variability and efficiency than either time series or cross-sectional data alone. By leveraging

panel data, we can detect and measure the statistical effects that are otherwise unobservable in pure time series or cross-sectional analyses and minimize estimation biases that may arise from aggregating groups into a single time series. While our dataset is unbalanced, with some firms having missing observations at certain times, it still significantly enhances our analysis. A major distinction between panel data models and time series models is that the former accommodates heterogeneity across firms, introducing individual-specific effects. This allows for more nuanced modeling where parameters can vary across firms, captured through fixed effects and random effects models. These heterogeneous models are essential in understanding the diverse characteristics and behaviors of each firm in our study.

Various variables were generated to enhance the analytical framework. Monthly and yearly indicators were extracted from the date variables to capture temporal patterns. Adjustments for spread effects were conducted using calculated spreads and treasury bill rates. Spread adjustments were incorporated into the datasets to account for their influence on market dynamics. Spreads take the form of carry market structures (where deferred contracts trade at higher prices than nearby contracts) and inverted market structures (where deferred contracts trade at lower prices than nearby contracts). The rationale to account for these differing market structures is to control for period of low or high stock/supplies. Futures prices tend to be more volatile in low stock environments and hence may increase the risk and uncertainty associated with trading strategies and accurately predicting price movements. Our adjusted spread measure is designed to capture the ability of traders to profit from long and short futures strategies under these two different market conditions The following equation was used to calculate cost of carry based on Geman and Ohana (2009):

$$(1)\ adjusted\ spread = \frac{futures\ 13M - futures\ 1M\ (1 + rate\ 1y)}{futures 1M}$$

Where futures 1M and futures 13M denote the first month and 13th month futures prices, respectively. Rate 1y represents the one-year T-bill interest rate. In our unbalanced panel regression model, we use the adjusted spread calculation to create two binary variables: one representing carries and one representing inverses.

The merged datasets were then transformed into panel data format. This conversion facilitated the application of panel data analysis techniques, allowing for the exploration of individual firm-level effects over time. Specific dates associated with missing private time observations were identified and subsequently removed from the datasets to prevent bias in the analysis (a total of 151 corn observations and 108 soybean observations were removed). Wheat was not analyzed. And there were only a few observations in 2010, so that year is omitted from the analysis, and we estimate the panel model over the January 2011 to April 2021 period.

First, we define private analyst forecast accuracy in terms of the month-to-month directional change in ending stocks projections:

$$(2)\ ac^{i}_{m,j} = 1\ if\left(pr^{i}_{m,j} - wa_{m-1,j}\right) * \left(wa_{m,j} - wa_{m-1,j}\right) > 0$$

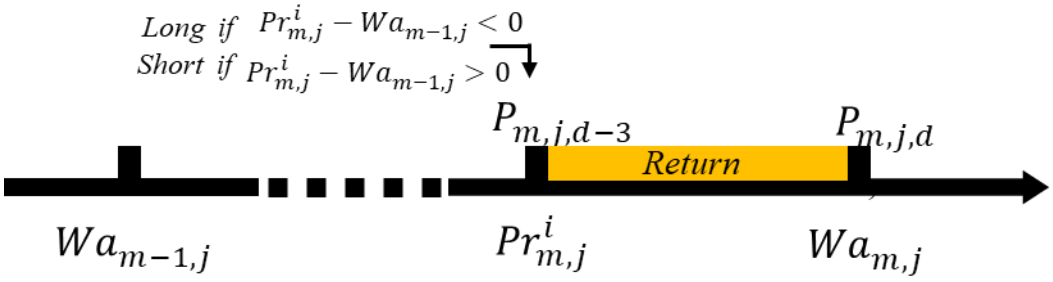
$$(3)\ ac^{i}_{m,j} = 0\ if\left(pr^{i}_{m,j} - wa_{m-1,j}\right) * \left(wa_{m,j} - wa_{m-1,j}\right) < 0$$

Where $ac^{i}_{m,j}$ represents accuracy across private analyst forecasts for month *m* by commodity *j* (corn and soybeans). The private analyst forecast is deemed to be accurate if the projected directional change in ending stocks is the same as the directional change in ending stocks

revealed in consecutive WASDE reports over the same period. The terms $pr_{m,j}^{i}$ and $wa_{m,j}^{i}$ are each analyst *i*'s forecast and the WASDE forecast respectively for month *m* by commodity *j*. Note, from a trading strategy perspective directional accuracy is more important than accuracy in terms of magnitude of the level difference in private and WASDE projections, although we use this latter definition of accuracy in the consistent performer analysis section (Fisher exact tests). Accurately predicting directional change in ending stocks and hence theoretical price direction allows a trader to establish long or short futures positions to profit from anticipated futures price changes.

Next, we illustrate how a hypothetical trade could use the directional change in ending stocks projected by private analysts to establish long and short trading strategies. In figure () the timeline for a specific trading strategy is shown along with whether the trader should go long or short based upon the projected directional change in ending stocks. Private analyst projections are released by Bloomberg newswire service 3 days prior to the official WASDE release date. If private analyst ending stocks projections, $pr_{m,j}^{i}$, are higher than the previous month WASDE projections ($wa_{m-1,j}$), a trader would go short futures on that day and lift the position by buying back (going long futures) on the subsequent WASDE release day ($wa_{m,j}$). Analogously, a long futures trade would be enacted when $pr_{m,j}^{i}$ are lower than $wa_{m-1,j}$.

*Figure 1: Trading Strategy*




The strategic returns based on each private analyst *i*'s projections in relation to WASDE projections are then labeled $sr^i_{m,j}$ and categorized in terms of long or short returns, where returns are defined as the log differences between closing prices of nearby futures contracts on WASDE release days and closing prices on the release of private analyst forecasts (3 days prior to WASDE release).

$$(4)\ sr^i_{m,j} = \begin{cases} \log(p_{m,j,d}) - \log(p_{m,j,d-3})\ if\ long\ when\ pr^i_{m,j} - wa_{m-1,j} < 0 \\ \log(p_{m,j,d-3}) - \log(p_{m,j,d})\ if\ short\ when\ pr^i_{m,j} - wa_{m-1,j} > 0 \end{cases}$$

Traders who base their future trading strategy on this directional projection rule will earn significantly positive returns if the private analyst forecasts are accurate and if prices react in a consistent manner with ending stocks changes (i.e. higher stocks result in lower prices and vice versa).

To test this hypothesis, we estimate panel regression models, where strategic return $sr^i_{m,j}$ are regressed on our private forecast accuracy variable $ac_{m,j}$ The model is based on an unbalanced panel dataset because private analyst firms do not make projections every month. We estimate an

unbalanced panel fixed effect model which also includes adjusted spread measures and monthly seasonal dummies as well as our analyst prediction accuracy variable to explain strategic returns:

$$(5)\ sr^{i}_{m,j} = \vartheta^{i}_{a,j} + \beta ac^{i}_{m,j} + \gamma_1 coc_{m,j} + \sum_{n=1}^{11} \lambda_{n,j} D_{n,j} + \tau^{i}_{m.j}$$

The term ($coc_{m,j}$) represents our adjusted spread measure (carry or inverse), $D_{n,j}$ are monthly dummy variables from January to November, $\vartheta^{i}_{a,j}$ is the fixed effect term that controls for variation in returns based on individual analyst projections, and $\tau^{i}_{m,j}$ is the error term.

The coefficient, $\beta$, for the private forecast accuracy variable is of key interest. If it is significantly positive, a hypothetical trader following a long or short trading strategy based on private forecast accuracy, would earn a profitable return. The term $\vartheta^{i}_{a,j}$ is the fixed effect variable and accounts for specific analyst effects and represents the average return across analyst projection-based trading strategies.

*Fisher Exact Test and Chi-Squared Test*

After running the regressions that examine the analyst group as a whole, a natural question to ask is whether there is one analyst who is better than the others. To address this, we employed a Fisher Exact Test to assess the statistical significance between winning (losing) groups in period *t* and winning (losing) groups in period *t+1*. This method was previously used by Irwin, Good, and Martines-Filho (2006) to compare the persistent superior performance of agricultural market advisory services across crop years. The objective of this approach is to identify whether or not an analyst's performance this month can predict their performance the

following month, relative to all other analysts. This method aims to uncover the persistence of analyst's performance over time.

The Fisher Exact Test is a nonparametric test similar to the Chi-Squared Test but it is more robust to outliers and small sample sizes. Both tests aim to determine if there is statistical dependence between groups or categories. For instance, if a group of students smoke, are they more likely to also drink alcohol? In our context, if an analyst is a good forecaster (in the top 50% of the group) in one month, is it more likely that the same firm will also be a good forecaster in the following month?

The goal is to determine whether or not we can pick an analyst to follow based on their performance in the previous period. If knowing which firms perform best in one month helps statistically predict which firms will perform best the next month, as detected by the Fisher Exact Test, this indicates persistent superior (or inferior) forecasting performance by some firms.

Formally, our null hypothesis is that there is no dependence between winners (losers) in period $t$ and winners (losers) in period $t+1$. Therefore, rejecting the null hypothesis provides statistical evidence of dependence, indicating persistent or predictable forecasting skill by an analyst.

To further validate our findings, we also performed Chi-Squared Tests on the same data. The Chi-Squared Test is another method used to determine if there is a significant association between categorical variables. This test was applied to verify the results obtained from the Fisher Exact Test, ensuring the robustness of our conclusions.

The first step in our procedure involved generating contingency tables for each unique observation period, excluding the first period to allow for a previous period comparison. This was accomplished by using functions that categorized analysts' performance into 'win' or 'lose' based on their absolute error rankings. Specifically, an analyst was classified as a 'win' if their cumulative distribution rank of absolute error was less than or equal to 0.5 for that period. The data was filtered to only include consecutive periods for each analyst, ensuring the analysis focused on performance consistency.

Next, Fisher's Exact Tests were performed on these contingency tables to calculate the p-value and odds ratio. This step was crucial in determining the likelihood that an analyst's performance ('win' or 'lose') in period *t-1* predicts their performance in period *t*. Each test's results were recorded and summarized to evaluate statistical dependence across periods.

In parallel, we conducted Chi-Squared Tests on the same contingency tables. This provided an additional layer of validation for our results, allowing us to compare the findings from Fisher's Exact Test with those from the Chi-Squared Test. The Chi-Squared Test results included the Chi-Squared statistic and p-value, which indicate whether there is a significant association between performance across periods.

Finally, the results from both the Fisher's Exact Test and the Chi-Squared Test were compiled into comprehensive datasets. These datasets detailed the odds ratios and p-values for the Fisher's Exact Test, as well as the chi-squared statistics and p-values for the Chi-Squared Test.

## 5. Results

### *Corn Regression Results*

The regression focusing on the corn returns dataset yields several significant insights into the factors influencing returns (Table 2). The coefficient for the private forecast accuracy variable is both positive and highly significant ($\beta = 6.482$, $p < 0.01$), indicating that a hypothetical trader following a long or short trading strategy based on average private forecast accuracy would earn a 6.482% return on investment (ROI). This result highlights that private analyst forecasts, on average, have economic value and that the average of all analyst projections of ending stocks could be used to form profitable trading strategies or strategically place futures hedges for firms seeking to manage price risk. The market carry variable is also positive and highly significant ($\gamma_c = 2.7048$, $p < 0.01$), while the market inverse variable is negative and highly significant ($\gamma_i = -1.9111$, $p < 0.01$). This suggests that the type of market structure impacts the strategic returns, and in carry (inverse) markets higher (lower) strategic returns would be earned. The model had an $R^2$ of 0.104 indicating that 10.4% of the variability in corn returns is explained by the model, with an adjusted R-squared of 0.057 reflecting the degrees of freedom adjustment. The highly significant F-statistic (12.779, $p < 0.01$) indicates that the overall model is robust, and the included variables collectively contribute to explaining the variation in corn returns.

### *Soybean Regression Results*

Regression results for the trading strategy applied to soybeans are also presented in Table 4. Similarly to corn, the regression results for soybeans showed greater returns when using the

trading strategy. Specifically, using the trading strategy resulted in a 5.129% profitable soybean return. This suggests that traders who went long when private forecasts were lower than the previous WASDE and went short when private forecasts were higher than the previous WASDE would have earned significantly higher returns than those who did not.The cost of the carry variable shows a significant negative relationship ($\beta = -2.880$, $p < 0.01$), indicating that the higher carrying costs are associated with lower returns. This suggests that carrying costs negatively impact the profitability of the trading strategy for soybeans.The negative soybean spread variable has a significant positive coefficient ($\beta = 2.838$, $p < 0.01$), implying that when the spread is negative, which indicates an inverse market, the returns from the trading strategy are higher. The F-statistic (12.969, $p < 0.01$) indicates that the model is statistically significant and better explains the variation in soybean returns than an intercept-only model.

*Table 4: Corn and Soybean Regression Results*

| | (1) | (2) |
|---|---|---|
| | Corn Returns | Soybeans Returns |
| Private forecast accuracy | 6.4819*** | 5.1294*** |
| | (0.6557) | (0.5784) |
| Carry market | 2.7048*** | -2.8801*** |
| | (0.8902) | (0.4761) |
| Inverse market | -1.9111*** | 2.8375*** |
| | (0.6340) | (0.5307) |
| Observations | 1,621 | 1,655 |
| Month dummies | Yes | Yes |
| Fixed effect | Yes | Yes |
| Adjusted R2 | 0.057 | 0.0568 |

*Fisher Exact and Chi-Squared Results*

To determine whether an analyst's performance in a previous period could predict their performance in the subsequent period, we applied the Fisher Exact Test to the contingency tables generated for corn, soybeans, and wheat. The results of these tests are summarized in Table 5.

For corn, both the Fisher's Exact Test and the Chi-Squared Test results consistently indicated no significant association between an analyst's performance in consecutive periods. The p-values from the Fisher's Exact Test were consistently above the 0.05 significance level,

and the odds ratios did not show any meaningful patterns of dependence. Similarly, the Chi-Squared Test results showed p-values greater than 0.05 and chi-squared statistics that did not reach the threshold necessary to reject the null hypothesis of independence. These findings collectively suggest that past performance does not predict future performance for corn analysis, indicating no persistent superior or inferior forecasting skill of world inventory ending stocks for corn.

The results for soybeans mirrored those for corn. The Fisher's Exact Test yielded p-values above 0.05, indicating no statistically significant dependence between performance in consecutive periods. The odds ratios did not demonstrate consistent trends. Complementary, the Chi-Squared Test results also showed p-values greater than 0.05 and the chi-squared statistics did not indicate any significant associations. Together, these results suggest that an analyst's performance in one period does not predict their performance in the next period for world inventory ending stocks of soybeans, implying no consistent forecasting skill among soybean analysts.

For wheat, both the Fisher's Exact Test and the Chi-Squared Test results indicated no significant relationship between an analyst's performance in consecutive periods. The Fisher's Exact Test p=values were consistently above 0.05, and the odds ratio did not show any significant patterns. Similarly, the Chi-Squared Test results produced p-values above 0.05 and the chi-squared statistics did not support rejecting the null hypothesis of independence. These findings suggest that there is no statistical evidence of persistent forecasting performance among wheat analysts, reinforcing the conclusions that past performance does not reliably predict future performance.

There were two instances where the Fisher's Exact Test yielded an "inf" (infinite) result. For corn, this occurred because the analysts exhibited perfect win-win or lose-lose streaks, indicating that all analysts consistently performed in the same category across periods. This perfect consistency led to an infinite odds ratio, although it is an isolated case and not reflective of the overall trend. For wheat, the "inf" result was due to streaks that were nearly perfect, combined with a small number of analysts. These special cases, while noteworthy, do not alter the overall conclusion that past performance does not reliably predict future performance for the majority of the data.

*Table 5: Summary of Fisher and Chi-squared Test Results*

| | | Number of Significant Results ($p<0.05$) | | |
|---|---|---|---|---|
| Test | Total | Corn | Soybeans | Wheat |
| Fisher | 121 | 6 | 3 | 2 |
| Chi-Squared | 121 | 3 | 2 | 2 |

## 6. Conclusion and Discussion

In this study, we set out to assess the economic impact of private analyst forecasts of world-ending stocks and investigate the persistence of forecasting performance among analysts over time. Through panel regression analysis and statistical tests, we have uncovered valuable insights into the dynamics of agricultural commodities markets and the efficacy of private analyst forecasts. These results show…

### *Economic Value of Private Analyst Forecasts*

Our findings indicate that private analyst forecasts hold significant economic value, as evidenced by the positive and highly significant coefficients of the private forecast accuracy variable in both the corn and soybean regression models. Traders following trading strategies based on average private forecast accuracy would have earned profitable returns, underscoring the utility of private analyst forecasts in informing trading decisions. These results support the notion that private analyst projections of world ending stocks contain valuable information that can be leveraged to anticipate future price movements and mitigate price risk in agricultural commodities markets.

### *Persistence of Forecasting Performance*

Our analysis of the persistence of forecasting performance among analysts reveals intriguing insights. Contrary to expectations, the Fisher Exact Test and the Chi-Squared Test results consistently indicate no significant association between an analyst's performance in consecutive periods for corn, soybeans, and wheat. These findings suggest that past forecasting accuracy does not reliably predict future performance, implying a lack of persistent superior or inferior forecasting skills among analysts. While there were isolated instances of perfect win-win

or lose-lose streaks, these cases do not alter the overall conclusion that forecasting performance among analysts is not consistently predictive.

*Implications and Future Directions*

The implications of our findings are multifaceted. For traders and market participants, the results underscore the importance of incorporating private analyst forecasts into trading strategies, as they provide valuable insights into future price movements. However, it is crucial to consider market structure dynamics and exercise caution in interpreting past forecasting performance as a reliable indicator of future performance.

Additionally, the lack of persistent forecasting performance among analysts raises questions about the underlying factors influencing forecasting accuracy. Further investigation into the drivers of forecasting performance, such as analyst characteristics, information sources, and forecasting methods, could provide valuable insights into improving the accuracy and reliability of private analyst forecasts.

In conclusion, this study contributes to the literature on agricultural commodities markets by providing empirical evidence of the economic value of private analyst forecasts and examining the persistence of forecasting performance among analysts. By informing trading strategies and shedding light on the dynamics of forecast accuracy, our findings have practical implications for traders, market participants, and policymakers alike, ultimately contributing to more informed decision-making in agricultural commodities markets.

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8. Appendix

*Table 6: Fisher Exact Test Results*

| | Corn | | Soybeans | | Wheat | |
|---|---|---|---|---|---|---|
| Date | Odds Ratio | P Value | Odds Ratio | P Value | Odds Ratio | P Value |
| 4/9/2010 | 0.552 | 1 | 0.322 | 1 | 0 | 0.429 |
| 5/11/2010 | Inf | 0.100 | 0.322 | 1 | 0.322 | 1 |
| 8/12/2010 | 3.106 | 1 | 0 | 1 | Inf | 0.400 |
| 9/10/2010 | 16.603 | 0.080 | 2.700 | 0.567 | 0.155 | 0.242 |
| 10/8/2010 | 1 | 1 | 1.414 | 1 | 0.552 | 1 |
| 11/9/2010 | 16.603 | 0.080 | 2.316 | 1 | 0.530 | 1 |
| 12/10/2010 | 0.765 | 1 | 2.104 | 0.619 | 0.765 | 1 |
| 1/12/2011 | 0.405 | 0.592 | 0.405 | 0.592 | 1.304 | 1 |
| 2/9/2011 | 2.974 | 0.545 | 2.700 | 0.567 | 2.700 | 0.567 |
| 3/10/2011 | 1 | 1 | 2.700 | 0.567 | 2.070 | 1 |
| 4/8/2011 | 2.602 | 1 | 1 | 1 | 2.602 | 1 |
| 5/11/2011 | 0.483 | 1 | 0.414 | 1 | 0.203 | 0.524 |
| 6/9/2011 | 0.322 | 1 | 0.552 | 1 | 3.106 | 1 |
| 7/12/2011 | 4.450 | 0.486 | 3.106 | 1 | 4.450 | 0.486 |
| 8/11/2011 | 0.384 | 1 | 1.414 | 1 | 1 | 1 |
| 9/12/2011 | 2.070 | 1 | 0.266 | 0.524 | 0.483 | 1 |
| 10/12/2011 | 0.692 | 1 | 1 | 1 | 2.700 | 0.567 |
| 11/9/2011 | 4.354 | 0.286 | 0.530 | 1 | 2.324 | 0.592 |
| 12/9/2011 | 1 | 1 | 0.230 | 0.545 | 1 | 1 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 1/12/2012 | 0.483 | 1 | 1 | 1 | 0.203 | 0.524 |
| 2/9/2012 | 2.070 | 1 | 0.203 | 0.524 | 1 | 1 |
| 3/9/2012 | 16.603 | 0.080 | 3.529 | 0.567 | 1.886 | 1 |
| 4/10/2012 | 0.620 | 1 | 0.763 | 1 | 0.763 | 1 |
| 5/10/2012 | 5.166 | 0.266 | 3.044 | 0.592 | 3.044 | 0.592 |
| 6/12/2012 | 1.792 | 1 | 0.586 | 1 | 0.765 | 1 |
| 7/11/2012 | 0 | 0.015 | 1.299 | 1 | 0.155 | 0.242 |
| 8/10/2012 | 1.414 | 1 | 1 | 1 | 0.552 | 1 |
| 9/12/2012 | 2.070 | 1 | 0.483 | 1 | 10.907 | 0.206 |
| 10/11/2012 | 0 | 0.048 | 1.433 | 1 | 0.540 | 1 |
| 11/9/2012 | 0.483 | 1 | 0.692 | 1 | 2.700 | 0.567 |
| 12/11/2012 | 2.070 | 1 | 10.907 | 0.206 | 2.070 | 1 |
| 2/8/2013 | 0.175 | 0.266 | 2.324 | 0.592 | 1.304 | 1 |
| 3/8/2013 | 1.304 | 1 | 6.789 | 0.266 | 1.304 | 1 |
| 4/10/2013 | 0.329 | 0.592 | 6.397 | 0.132 | 0.685 | 1 |
| 5/10/2013 | 1.886 | 1 | 1 | 1 | 4.341 | 0.545 |
| 6/12/2013 | 2.324 | 0.592 | 1.183 | 1 | 0.365 | 0.576 |
| 7/11/2013 | 2.974 | 0.545 | 0.692 | 1 | 6.069 | 0.242 |
| 8/12/2013 | 0 | 0.444 | 1.433 | 1 | 0.266 | 0.524 |
| 9/12/2013 | 0.092 | 0.206 | 1 | 1 | 0.414 | 1 |
| 11/8/2013 | 1.304 | 1 | 1 | 1 | 1 | 1 |
| 12/10/2013 | 0.765 | 1 | 0.224 | 0.315 | 0.181 | 0.287 |
| 1/10/2014 | 5.166 | 0.266 | 0.688 | 1 | 0 | 0.231 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 2/10/2014 | 5.166 | 0.266 | 2.324 | 0.592 | 1.892 | 1 |
| 3/10/2014 | 1.185 | 1 | 0.620 | 1 | 1.231 | 1 |
| 4/9/2014 | 1 | 1 | 2.599 | 0.619 | 3.091 | 0.347 |
| 5/9/2014 | 0.586 | 1 | 1.705 | 1 | 0.586 | 1 |
| 6/11/2014 | 4.354 | 0.286 | 1 | 1 | 0.527 | 1 |
| 8/12/2014 | 0.102 | 0.103 | 1.705 | 1 | 0.405 | 0.592 |
| 9/11/2014 | 0.586 | 1 | 0.765 | 1 | 1.705 | 1 |
| 10/10/2014 | 0.186 | 0.286 | 0.266 | 0.315 | 0.586 | 1 |
| 11/10/2014 | 1.705 | 1 | 2.104 | 0.619 | 0.558 | 1 |
| 12/10/2014 | 1.299 | 1 | 1 | 1 | 0.478 | 1 |
| 1/12/2015 | 1 | 1 | 1.304 | 1 | 1.229 | 1 |
| 2/10/2015 | 1.705 | 1 | 0.266 | 0.315 | 2.104 | 0.619 |
| 3/10/2015 | 0.266 | 0.315 | 0.385 | 0.619 | 0.385 | 0.619 |
| 4/9/2015 | 0.295 | 0.559 | 1 | 1 | 1.229 | 1 |
| 5/12/2015 | 0.175 | 0.266 | 1.304 | 1 | 1 | 1 |
| 6/10/2015 | 1 | 1 | 0.186 | 0.286 | 0.405 | 0.592 |
| 7/10/2015 | 1 | 1 | 1.304 | 1 | 3.529 | 0.567 |
| 8/12/2015 | 1.234 | 1 | 1.558 | 1 | 3.583 | 0.342 |
| 9/11/2015 | 0.053 | 0.015 | 1.524 | 1 | 1.524 | 1 |
| 10/9/2015 | 8.828 | 0.057 | 0.656 | 1 | 1 | 1 |
| 12/9/2015 | 0.385 | 0.619 | 3.091 | 0.347 | 2.104 | 0.619 |
| 3/9/2016 | 0 | 0.061 | 3.533 | 0.523 | 0.692 | 1 |
| 4/12/2016 | 0.060 | 0.080 | 0.295 | 0.559 | 1.304 | 1 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 5/10/2016 | 0.586 | 1 | 6.397 | 0.132 | 0.426 | 0.608 |
| 6/10/2016 | 0.405 | 0.592 | 1 | 1 | 1.705 | 1 |
| 7/12/2016 | 16.603 | 0.080 | 1.304 | 1 | 1 | 1 |
| 8/12/2016 | 0.765 | 1 | 0.385 | 0.619 | 2.599 | 0.619 |
| 9/12/2016 | 0 | 0.077 | 6.397 | 0.132 | 1.231 | 1 |
| 10/12/2016 | 0.302 | 0.569 | 0.266 | 0.315 | 6.397 | 0.132 |
| 11/9/2016 | 0.586 | 1 | 7.614 | 0.132 | 1.614 | 1 |
| 12/9/2016 | 0.586 | 1 | 0.765 | 1 | 6.397 | 0.132 |
| 1/12/2017 | 0.072 | 0.041 | 6.397 | 0.132 | 2.104 | 0.619 |
| 2/9/2017 | 4.032 | 0.559 | 4.676 | 0.282 | 0.181 | 0.287 |
| 3/9/2017 | 0.809 | 1 | 2.749 | 0.370 | 0.354 | 0.370 |
| 4/11/2017 | 11.647 | 0.023 | 7.027 | 0.070 | 4.557 | 0.170 |
| 5/10/2017 | 0.283 | 0.567 | 1 | 1 | 0.060 | 0.080 |
| 6/9/2017 | 0.692 | 1 | 2.700 | 0.567 | 13.453 | 0.080 |
| 7/12/2017 | 1 | 1 | 1.229 | 1 | 1 | 1 |
| 8/10/2017 | 0.405 | 0.592 | 0.558 | 1 | 4.354 | 0.286 |
| 9/12/2017 | 3.529 | 0.567 | 1.304 | 1 | 1 | 1 |
| 10/12/2017 | 0.188 | 0.153 | 0.353 | 0.588 | 1.234 | 1 |
| 11/9/2017 | 0.422 | 0.637 | 1.558 | 1 | 2.222 | 0.630 |
| 12/12/2017 | 1.918 | 0.637 | 11.109 | 0.050 | 3.237 | 0.335 |
| 1/12/2018 | 1.692 | 0.644 | 1 | 1 | 8.828 | 0.057 |
| 2/8/2018 | 0.075 | 0.050 | 1 | 1 | 0.905 | 1 |
| 3/8/2018 | 2.372 | 0.637 | 0.272 | 0.347 | 1.374 | 1 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 4/10/2018 | 0.273 | 0.580 | 0.523 | 1 | 7.876 | 0.119 |
| 5/10/2018 | 0.385 | 0.619 | 0.765 | 1 | 2.104 | 0.619 |
| 6/12/2018 | 2.599 | 0.619 | 0.426 | 0.608 | 0.765 | 1 |
| 7/12/2018 | 0.306 | 0.350 | 1.805 | 0.650 | 0.519 | 0.650 |
| 8/10/2018 | 0.656 | 1 | 10.238 | 0.057 | 0.642 | 1 |
| 9/12/2018 | 1.703 | 0.670 | 5.631 | 0.086 | 30.288 | 0.002 |
| 10/11/2018 | 1 | 1 | 4.949 | 0.179 | 1.376 | 1 |
| 11/8/2018 | 2.158 | 0.656 | 1.470 | 1 | 1 | 1 |
| 12/11/2018 | 0.680 | 1 | 13.054 | 0.022 | 4.949 | 0.179 |
| 2/8/2019 | 0.426 | 0.608 | 1.155 | 1 | 0.426 | 0.608 |
| 3/8/2019 | 3.619 | 0.315 | 0.119 | 0.119 | 0.189 | 0.282 |
| 4/9/2019 | 0.272 | 0.347 | 1.696 | 1 | 0.520 | 0.638 |
| 5/10/2019 | 1.231 | 1 | 3.619 | 0.315 | 0.685 | 1 |
| 6/11/2019 | 0.188 | 0.153 | 1.234 | 1 | 0.763 | 1 |
| 7/11/2019 | 0.502 | 0.637 | 1.234 | 1 | 0.620 | 1 |
| 8/12/2019 | 0.656 | 1 | 3.680 | 0.347 | 0.289 | 0.335 |
| 9/12/2019 | 6.177 | 0.153 | 0.162 | 0.153 | 0.656 | 1 |
| 10/10/2019 | 0.809 | 1 | 4.267 | 0.179 | 0.243 | 0.188 |
| 11/8/2019 | 3.680 | 0.347 | 0.502 | 0.637 | 18.438 | 0.015 |
| 12/10/2019 | 1 | 1 | 1.907 | 0.622 | 1.614 | 1 |
| 1/10/2020 | 1.805 | 0.650 | 11.647 | 0.023 | 3.680 | 0.347 |
| 2/11/2020 | 0.272 | 0.347 | 0.656 | 1 | 1.524 | 1 |
| 3/10/2020 | 4.474 | 0.315 | 7.614 | 0.132 | 1 | 1 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 4/9/2020 | 1.231 | 1 | 2.128 | 0.608 | 0.765 | 1 |
| 5/12/2020 | 1.304 | 1 | 0.688 | 1 | 7.955 | 0.242 |
| 6/11/2020 | 0.405 | 0.592 | 0.295 | 0.559 | 3.529 | 0.567 |
| 8/12/2020 | 1 | 1 | 0.272 | 0.347 | 1 | 1 |
| 9/11/2020 | 1 | 1 | 0.642 | 1 | 1.466 | 1 |
| 10/9/2020 | 0.656 | 1 | 2.372 | 0.637 | 3.680 | 0.347 |
| 11/10/2020 | 0.243 | 0.188 | 2.372 | 0.637 | 1 | 1 |
| 12/10/2020 | 0.502 | 0.637 | 1.234 | 1 | 0.502 | 0.637 |
| 1/12/2021 | 2.501 | 0.615 | 1.462 | 1 | 2.465 | 0.596 |
| 3/9/2021 | 1.231 | 1 | 1.231 | 1 | 1.684 | 1 |

*Table 7: Chi-Squared Test Results*

| | Corn | | Soybeans | | Wheat | |
|---|---|---|---|---|---|---|
| Date | X Squared | P Value | X Squared | P Value | X Squared | P Value |
| 4/9/2010 | 9.59E-32 | 1 | 0 | 1 | 0.365 | 0.546 |
| 5/11/2010 | 2.667 | 0.102 | 0 | 1 | 0 | 1 |
| 8/12/2010 | 0 | 1 | 0 | 1 | 0.750 | 0.386 |
| 9/10/2010 | 3 | 0.083 | 0.076 | 0.782 | 0.883 | 0.347 |
| 10/8/2010 | 0 | 1 | 1.44E-32 | 1 | 9.59E-32 | 1 |
| 11/9/2010 | 3 | 0.083 | 0 | 1 | 0 | 1 |
| 12/10/2010 | 0 | 1 | 0.059 | 0.809 | 0 | 1 |
| 1/12/2011 | 0.090 | 0.764 | 0.090 | 0.764 | 0 | 1 |
| 2/9/2011 | 0.034 | 0.853 | 0.076 | 0.782 | 0.076 | 0.782 |
| 3/10/2011 | 0 | 1 | 0.076 | 0.782 | 0 | 1 |
| 4/8/2011 | 0 | 1 | 0 | 1 | 0 | 1 |
| 5/11/2011 | 0 | 1 | 0 | 1 | 0.417 | 0.519 |
| 6/9/2011 | 0 | 1 | 9.59E-32 | 1 | 0 | 1 |
| 7/12/2011 | 0.109 | 0.741 | 0 | 1 | 0.109 | 0.741 |
| 8/11/2011 | 0 | 1 | 1.44E-32 | 1 | 0 | 1 |
| 9/12/2011 | 0 | 1 | 0.141 | 0.708 | 0 | 1 |
| 10/12/2011 | 0 | 1 | 0 | 1 | 0.076 | 0.782 |
| 11/9/2011 | 0.665 | 0.415 | 0 | 1 | 0.048 | 0.826 |
| 12/9/2011 | 0 | 1 | 0.375 | 0.540 | 0 | 1 |
| 1/12/2012 | 0 | 1 | 0 | 1 | 0.417 | 0.519 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 2/9/2012 | 0 | 1 | 0.417 | 0.519 | 0 | 1 |
| 3/9/2012 | 3 | 0.083 | 0.333 | 0.564 | 0 | 1 |
| 4/10/2012 | 0 | 1 | 0 | 1 | 0 | 1 |
| 5/10/2012 | 0.621 | 0.431 | 0.292 | 0.589 | 0.292 | 0.589 |
| 6/12/2012 | 0 | 1 | 0 | 1 | 0 | 1 |
| 7/11/2012 | 4.648 | 0.031 | 2.71E-32 | 1 | 0.883 | 0.347 |
| 8/10/2012 | 1.44E-32 | 1 | 0 | 1 | 9.59E-32 | 1 |
| 9/12/2012 | 0 | 1 | 0 | 1 | 1.600 | 0.206 |
| 10/11/2012 | 2.976 | 0.085 | 0 | 1 | 3.33E-32 | 1 |
| 11/9/2012 | 0 | 1 | 0 | 1 | 0.076 | 0.782 |
| 12/11/2012 | 0 | 1 | 1.600 | 0.206 | 0 | 1 |
| 2/8/2013 | 0.853 | 0.356 | 0.048 | 0.826 | 0 | 1 |
| 3/8/2013 | 0 | 1 | 1.244 | 0.265 | 0 | 1 |
| 4/10/2013 | 0.292 | 0.589 | 1.637 | 0.201 | 1.58E-31 | 1 |
| 5/10/2013 | 0 | 1 | 0 | 1 | 0.375 | 0.540 |
| 6/12/2013 | 0.048 | 0.826 | 9.92E-32 | 1 | 0.043 | 0.836 |
| 7/11/2013 | 0.034 | 0.853 | 0 | 1 | 0.737 | 0.391 |
| 8/12/2013 | 0.394 | 0.530 | 0 | 1 | 0.141 | 0.708 |
| 9/12/2013 | 1.6 | 0.206 | 0 | 1 | 0 | 1 |
| 11/8/2013 | 0 | 1 | 0 | 1 | 0 | 1 |
| 12/10/2013 | 0 | 1 | 1.016 | 0.313 | 0.938 | 0.333 |
| 1/10/2014 | 0.621 | 0.431 | 0 | 1 | 0.783 | 0.376 |
| 2/10/2014 | 0.621 | 0.431 | 0.048 | 0.826 | 4.32E-32 | 1 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 3/10/2014 | 7.20E-32 | 1 | 0 | 1 | 0 | 1 |
| 4/9/2014 | 0 | 1 | 0.250 | 0.617 | 0.512 | 0.474 |
| 5/9/2014 | 0 | 1 | 0 | 1 | 0 | 1 |
| 6/11/2014 | 0.665 | 0.415 | 0 | 1 | 7.94E-32 | 1 |
| 8/12/2014 | 2.006 | 0.157 | 0 | 1 | 0.090 | 0.764 |
| 9/11/2014 | 0 | 1 | 0 | 1 | 0 | 1 |
| 10/10/2014 | 1.143 | 0.285 | 0.633 | 0.426 | 0 | 1 |
| 11/10/2014 | 0 | 1 | 0.059 | 0.809 | 0 | 1 |
| 12/10/2014 | 2.71E-32 | 1 | 0 | 1 | 2.91E-31 | 1 |
| 1/12/2015 | 0 | 1 | 0 | 1 | 8.82E-32 | 1 |
| 2/10/2015 | 0 | 1 | 0.633 | 0.426 | 0.059 | 0.809 |
| 3/10/2015 | 0.633 | 0.426 | 0.250 | 0.617 | 0.250 | 0.617 |
| 4/9/2015 | 0.174 | 0.676 | 0 | 1 | 8.82E-32 | 1 |
| 5/12/2015 | 0.853 | 0.356 | 0 | 1 | 0 | 1 |
| 6/10/2015 | 0 | 1 | 1.143 | 0.285 | 0.090 | 0.764 |
| 7/10/2015 | 0 | 1 | 0 | 1 | 0.333 | 0.564 |
| 8/12/2015 | 0 | 1 | 0 | 1 | 0.813 | 0.367 |
| 9/11/2015 | 4.861 | 0.027 | 0 | 1 | 0 | 1 |
| 10/9/2015 | 2.854 | 0.091 | 0 | 1 | 0 | 1 |
| 12/9/2015 | 0.250 | 0.617 | 0.512 | 0.474 | 0.059 | 0.809 |
| 3/9/2016 | 2.753 | 0.097 | 0.114 | 0.735 | 0 | 1 |
| 4/12/2016 | 3 | 0.083 | 0.174 | 0.676 | 0 | 1 |
| 5/10/2016 | 0 | 1 | 1.637 | 0.201 | 0.100 | 0.751 |

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|---|---|---|---|---|---|---|
| 6/10/2016 | 0.090 | 0.764 | 0 | 1 | 0 | 1 |
| 7/12/2016 | 3 | 0.083 | 0 | 1 | 0 | 1 |
| 8/12/2016 | 0 | 1 | 0.250 | 0.617 | 0.250 | 0.617 |
| 9/12/2016 | 2.558 | 0.110 | 1.637 | 0.201 | 0 | 1 |
| 10/12/2016 | 0.184 | 0.668 | 0.633 | 0.426 | 1.637 | 0.201 |
| 11/9/2016 | 0 | 1 | 2.250 | 0.134 | 0 | 1 |
| 12/9/2016 | 0 | 1 | 0 | 1 | 1.637 | 0.201 |
| 1/12/2017 | 3.359 | 0.067 | 1.637 | 0.201 | 0.059 | 0.809 |
| 2/9/2017 | 0.350 | 0.554 | 0.549 | 0.459 | 0.938 | 0.333 |
| 3/9/2017 | 0 | 1 | 0.437 | 0.508 | 0.493 | 0.483 |
| 4/11/2017 | 4.237 | 0.040 | 2.534 | 0.111 | 1.272 | 0.259 |
| 5/10/2017 | 0.333 | 0.564 | 0 | 1 | 3.000 | 0.083 |
| 6/9/2017 | 0 | 1 | 0.076 | 0.782 | 2.228 | 0.136 |
| 7/12/2017 | 0 | 1 | 8.82E-32 | 1 | 0 | 1 |
| 8/10/2017 | 0.090 | 0.764 | 0 | 1 | 0.665 | 0.415 |
| 9/12/2017 | 0.333 | 0.564 | 0 | 1 | 0 | 1 |
| 10/12/2017 | 1.516 | 0.218 | 0.100 | 0.751 | 0 | 1 |
| 11/9/2017 | 0.225 | 0.635 | 0 | 1 | 0.143 | 0.705 |
| 12/12/2017 | 0.041 | 0.839 | 2.906 | 0.088 | 0.473 | 0.492 |
| 1/12/2018 | 0.001 | 0.976 | 0 | 1 | 2.854 | 0.091 |
| 2/8/2018 | 3.740 | 0.053 | 0 | 1 | 1.14E-31 | 1 |
| 3/8/2018 | 0.225 | 0.635 | 0.889 | 0.346 | 1.33E-31 | 1 |
| 4/10/2018 | 0.313 | 0.576 | 6.60E-32 | 1 | 1.641 | 0.200 |

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|---|---|---|---|---|---|---|
| 5/10/2018 | 0.250 | 0.617 | 0 | 1 | 0.059 | 0.809 |
| 6/12/2018 | 0.250 | 0.617 | 0.100 | 0.751 | 0 | 1 |
| 7/12/2018 | 0.604 | 0.437 | 0.031 | 0.861 | 0.073 | 0.788 |
| 8/10/2018 | 0 | 1 | 3.556 | 0.059 | 0 | 1 |
| 9/12/2018 | 0.036 | 0.850 | 2.312 | 0.128 | 8.054 | 0.005 |
| 10/11/2018 | 0 | 1 | 1.800 | 0.180 | 1.11E-31 | 1 |
| 11/8/2018 | 0.200 | 0.655 | 0 | 1 | 0 | 1 |
| 12/11/2018 | 0 | 1 | 4.900 | 0.027 | 1.800 | 0.180 |
| 2/8/2019 | 0.100 | 0.751 | 9.90E-32 | 1 | 0.100 | 0.751 |
| 3/8/2019 | 0.547 | 0.460 | 1.886 | 0.170 | 0.837 | 0.360 |
| 4/9/2019 | 0.889 | 0.346 | 0 | 1 | 0.028 | 0.867 |
| 5/10/2019 | 0 | 1 | 0.547 | 0.460 | 1.58E-31 | 1 |
| 6/11/2019 | 1.516 | 0.218 | 0 | 1 | 0 | 1 |
| 7/11/2019 | 0.066 | 0.797 | 0 | 1 | 0 | 1 |
| 8/12/2019 | 0 | 1 | 0.889 | 0.346 | 0.615 | 0.433 |
| 9/12/2019 | 2.025 | 0.155 | 2.025 | 0.155 | 0 | 1 |
| 10/10/2019 | 0 | 1 | 1.295 | 0.255 | 1.015 | 0.314 |
| 11/8/2019 | 0.889 | 0.346 | 0.066 | 0.797 | 4.743 | 0.029 |
| 12/10/2019 | 0 | 1 | 0.012 | 0.914 | 0 | 1 |
| 1/10/2020 | 0.031 | 0.861 | 4.237 | 0.040 | 0.889 | 0.346 |
| 2/11/2020 | 0.889 | 0.346 | 0 | 1 | 0 | 1 |
| 3/10/2020 | 1.016 | 0.313 | 2.250 | 0.134 | 0 | 1 |
| 4/9/2020 | 0 | 1 | 0.033 | 0.855 | 0 | 1 |

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|---|---|---|---|---|---|---|
| 5/12/2020 | 0 | 1 | 0 | 1 | 1.371 | 0.242 |
| 6/11/2020 | 0.090 | 0.764 | 0.174 | 0.676 | 0.333 | 0.564 |
| 8/12/2020 | 0 | 1 | 0.889 | 0.346 | 0 | 1 |
| 9/11/2020 | 0 | 1 | 0 | 1 | 0 | 1 |
| 10/9/2020 | 0 | 1 | 0.225 | 0.635 | 0.889 | 0.346 |
| 11/10/2020 | 1.015 | 0.314 | 0.225 | 0.635 | 0 | 1 |
| 12/10/2020 | 0.066 | 0.797 | 0 | 1 | 0.066 | 0.797 |
| 1/12/2021 | 0.198 | 0.657 | 0 | 1 | 0.115 | 0.734 |
| 3/9/2021 | 0 | 1 | 0 | 1 | 7.47E-32 | 1 |