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The 2019 Government Shutdown Increased Uncertainty in Major Agricultural Commodity Markets.

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The 2019 Government Shutdown Increased Uncertainty in Major Agricultural Commodity Markets.

Abstract

In January 2019, a government shutdown prevented the U.S. Department of Agriculture from publishing information about the situation and outlook for major U.S. agricultural commodities. We show that, as a result, Chicago Mercantile Exchange Board of Trade markets for corn and soybeans experienced heightened market uncertainty, elevating the cost of hedging. We use historical options data to estimate that the shutdown and publication delay increased the price of hedging, according to two different approaches. We estimate that, on the first day of trading following the normally scheduled USDA publication time, the additional commodity market uncertainty caused by the government shutdown increased the price of hedging ATM corn and soybean options by additional 2.95% (95% CI: 2.93% - 2.97%) and 1.66% (95% CI: 1.64% - 1.68%), respectively for corn and soybeans, using an approach that assumes a normal January report impact. Using a different counterfactual approach—assuming that the IV reduction following the February 2019 publication would have been experienced in January, we find that the increase in hedging costs due to missing information was actually about 11.4% (95% CI: 10.9% - 11.79%) higher for corn and 4.3% (95% CI: 4.1% - 4.42%) higher for soybeans.

Keywords: WASDE, Implied Volatility, USDA reports, Options, GARCH, Moneyness.

1 Introduction

For decades, USDA has published information about the market situation for a wide range of domestic commodities, and has estimated the elements of supply and demand for major agricultural

commodities both in the United States and around the world. USDA publishes these reports free of charge in order to align market expectations, resolve uncertainty, and improve efficiency and economic activity in these markets. The most prominent examples of USDA reports include the World Agriculture Supply and Demand Estimates (WASDE), Grain Stocks, Crop Progress, Feed Outlook, Oil Crops Outlook, Crop Production, Acreage and Prospective Plantings (APP).

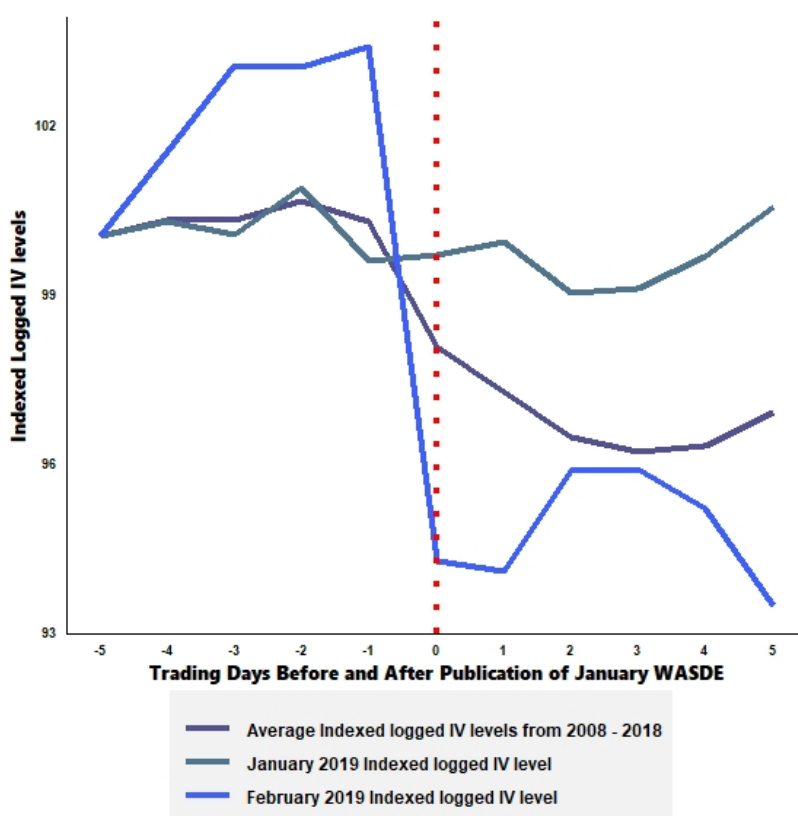
Market participants like farmers, elevators, commercial grain firms, and end users rely on agricultural commodity futures and options markets to manage their business risks. Options strategies can limit potential losses, or provide additional income, depending on the side they take—writer or purchaser. Information provided by USDA reports is closely followed by market participants and observers to make informed supply management and speculative decisions: realigning expectations about commodity market conditions, re-allocating resources, and maximizing their profitability. A growing empirical literature shows that these reports provide the market with important information, impacting prices and implied volatilities (IV) at announcement time (see, e.g., Sumner and Mueller, 1989; McNew and Espinosa, 1994; Isengildina-Massa et al., 2008a and 2008b; Adjemian, 2012 and 2018; Ying, Chen and Dorfman, 2019).

Indeed, recent work has shown that missing USDA reports may elevate uncertainty levels in agricultural markets. During an appropriations lapse in 2013, USDA suspended its October World Agriculture Supply and Demand Estimates (WASDE) report. Adjemian et al. (2018) concluded that corn and soybean markets did not experience normally expected changes in prices and reductions in implied volatility (IV) around the release of the USDA information. As a result, market participants had less information with which to plan or conduct their operations, and likely faced increased hedging costs. A natural extension of that work is to study the government shutdown in January 2019, which likewise forced USDA to suspend its publication of a variety of reports, including its normally-scheduled WASDE, Crop Production, and Grain Storage releases. Once the 2019 shutdown ended, USDA published that information on February 8th—about a month later than

normal (USDA, 2019).

Figure 1(a) compares the average pre-2019 path of log IV for CBOT corn in a 5-day window around the release of a January report against the actual log IV observed around (1) the originally-scheduled release date during the 2019 shutdown, and (2) the February 2019 report—the first that USDA published after the shutdown. The dotted line marks the normal, scheduled USDA WASDE and/or Grain Stock report release day.

Figure 1: **CBOT CORN: Indexed Logged IV Levels**



The lines are the time series of indexed logged CBOT corn IV levels. The red dotted line marks the day when the historic January USDA reports were released, the day when missing January 2019 USDA reports were *scheduled* for release, and the day when February 2019 USDA reports were released.

In general, USDA January announcements produce a sharp decline in CBOT corn implied volatility. Similarly, a sharp decline is also observed following the release of February 2019 report. However, in January 2019, no such decline is observed, indicating that USDA's failure to publish a report led to a higher level of uncertainty in the market than would have otherwise been observed. Similar patterns are also exhibited by CBOT soybeans (see figure A1 in Appendix). In this paper, we estimate the degree to which missing government information elevated uncertainty in major domestic commodity markets, and the impact it had on market participants.

Several important factors differentiate the 2013 and 2019 government shutdowns. The 2013 shutdown prevented the publication of an October report during a relatively tranquil crop year. But the 2019 shutdown curtailed the release of a January report, and USDA publications during that time are viewed by some participants as among the most important. They provide the initial "final" production estimates for the forecasting cycle in the form of an annual summary and include one of the Department's quarterly reports of inventories, highly anticipated by traders since it signals crop disappearance and on- and off-farm stocks levels at the State level. It is likely that public budgetary pressures will increase in the future, so understanding how markets are affected by missing government information is an important area of study for both participants and policy makers..

Adjemian et al. (2018) suggest that the price of hedging is higher in the absence of the WASDE report. We quantify the additional hedging cost for at-the-money (ATM) options caused by missing public news.¹ We also contribute to the literature by providing a full portrait of the impact of missing government information across the implied volatility surface. To construct the counterfactual for the estimated changes in IV if the January 2019 reports had been published on time, we use two measures: (1) the average change in IV around the release of pre-2019 January reports, and (2) the actual observed change in IV following the release of the next published report (i.e., in February 2019). We use the option *vega*, a measure of how much the price of an option changes conditional

¹An option is said to be at-the-money if its strike price is (nearly) equivalent to the price of the underlying security. These options only have time value and are usually the most highly traded.

on a 1% change in implied volatility, to estimate the likely changes in options prices that might have had occurred if the missing reports were published as originally scheduled. Given that the report was not released that month, we estimate the additional cost of hedging each futures contract on the first trading day that would have been affected by the news, providing a lower bound for the per-contract impact to potential hedgers in the market due to the government shutdown.

Risk-averse commodity market participants with short positions (i.e., those with an interest in selling the underlying commodity) can buy put options on futures contracts to hedge against the risk that prices fall; the price of the option is referred to as a *premium*. A put holder has the right to exercise the option—meaning that s/he can short a futures contract to the option writer at the strike price. This becomes profitable as the futures price falls below the strike price, since an arbitrage can be earned by simultaneously taking a long at the lower market price: selling high and buying low. If futures prices rise, or at least do not fall below the specified strike price, a put option would not become profitable. Since they provide the perspective of a short hedger, we use put options to evaluate the additional cost of hedging due to publication curtailment of the January 2019 WASDE report.² We control for the general market uncertainty caused by the government shutdown (and other phenomena in the world, including the ongoing trade war) using the Chicago Board Options Exchange Volatility Index (VIX), as well as standard trend, seasonality, and day-of-the-week effects.

We estimate that, on the first day of trading following the normally scheduled USDA publication time, the additional commodity market uncertainty caused by the government shutdown increased the price of hedging ATM corn and soybean puts by additional 2.95% (95% CI: 2.93% - 2.97%) and 1.66% (95% CI: 1.64% - 1.68%), respectively for corn and soybeans, using an approach that assumes a normal January report impact. Using a different counterfactual approach—assuming that the IV reduction following the February 2019 publication would have been experienced in

²We generate nearly identical results when we calculate these cost increases using ATM calls.

January, we find that the increase in hedging costs due to missing information was actually about 11.4% (95% CI: 10.9% - 11.79%) higher for corn and 4.3% (95% CI: 4.1% - 4.42%) higher for soybeans. We find significant, but lower increases for deep out-of-the-money or in-the-money options for these commodities.

2 BACKGROUND

Every month USDA publishes a series of comprehensive reports defining the current situation and projections for supply and demand fundamentals in agricultural commodity markets. The World Agricultural Supply and Demand Estimates (WASDE) report provides a detailed balance sheet of variables for the agricultural commodity markets. WASDE is prepared by combining insights from several USDA agencies represented in the Interagency Commodity Estimates Committees (ICECs), chaired by the USDA World Agricultural Outlook Board (WAOB). ICECs relies on Foreign Agricultural Service (FAS) reports for overseas commodity market developments, the National Agricultural Statistics Service (NASS) for agricultural commodity and livestock projections, the Economic Research Service (ERS) for regional assessments, the Agricultural Marketing Service (AMS) and the Farm Service Agency (FSA) for market information and impacts of domestic policies. ICEC committees generate consensus forecasts based on all these data sources. Since it contains highly market sensitive information, WASDE is prepared under secure lock-up conditions, and is released to all users simultaneously each month (Vogel and Bange, 1999).

Uncertainty about these fundamentals naturally decreases as the harvest comes in, and USDA updates its projections. While the May WASDE report contains the first projections for the new marketing year, the first survey-based corn and soybean production forecasts are included in the August report (Vogel and Bange, 1999). January reports contain the final annual projections each year. Between February and April, USDA makes only minor changes to its reports. NASS also issues Grain Stock reports, providing an extensive analysis of the on- and off-farm stock positions

for major agricultural crops. Grain Stocks reports are released four times a year (January, March, June, September). Moreover, the January Grain Stocks report and WASDE report are released concurrently. (Adjemian et al, 2018)

Many researchers have found USDA reports affect market expectations of prices and uncertainty. Sumner and Mueller (1989) show that market prices change following the release of USDA harvest forecasts. McNew and Espinosa (1994) report reductions in market uncertainty following report release. Isengildina-Massa et al. (2008a, 2008b) show that corn and soybean markets react to announcement days, reflected in increased futures return variance, and reduced options IV. Adjemian (2012) show that agricultural commodity futures markets rapidly incorporate new information, confirming the persistence of impact across contract positions. Following report release, futures markets experience heightened intraday trading volumes and volatility that dissipate in a few minutes (Adjemian and Irwin, 2018).

Over the last decade, private market advisory alternatives have grown and so has the accuracy of their projections. Xiao et al. (2014) finds that the accuracy of private forecasts is highest for wheat and lowest for soybeans. Recent literature suggests that, even in the presence of private forecasts, USDA reports are informative (Ying, Chen and Dorfman, 2019; Karali et al., 2019). Karali et al. (2019) observed significant futures commodity price movements in response to market surprises, even for the reports most likely affected by the availability of private sources of information. As freely-available products of the federal government, USDA commodity reports are public goods, and they have a strong track record of forecast reliability. Private forecasts, on the contrary, are not freely accessible. Even in the presence of private sources of information, many USDA reports remain highly valued and trusted by end users.

3 DATA

We use Bloomberg historical ATM options implied volatility data for each individual CBOT corn and soybean contract from 1995 to 2019. Corn contracts deliver in March, May, July, September and December, while soybean futures do so in January, March, May, July, August, September and November. To form a continuous series of close-to-close changes in implied volatility for each commodity, we roll over from the nearby to the next deferred contract 15 days prior to the contract expiration month. We match this change in implied volatility with historical *WASDE* and *Grain Stocks* report announcements; these data are maintained by the Cornell University Library. For both commodities, figures A2 and A3 in the appendix compare kernel density plots based on the IVs observed on USDA announcement days relative to other days. Bloomberg historical ATM options implied volatility data are not available by *moneyness*, or the ratio of the strike price of the option in question to the ATM strike levels. Therefore, to study the impact of missing information by moneyness levels, we extract Bloomberg data on 30-day implied volatility by moneyness, for corn and soybeans from 2005 to 2019 (those data are not available from 1995-2004, so the time periods of analysis do not match exactly). The 30-Day IV refers to the forecasted daily implied volatility for the coming 30 days. These are the closest data available next to contract-level IVs. In this way, it is similar to the way the VIX is constructed, since that measure represents the forecasted daily implied volatility associated with the SP 500 index over the next thirty days. These two features make it the next best data-set available for our analysis. The table below provides summary statistics for each of the series used in our analysis

USDA published a total of 398 WASDE and Grain Stocks reports (298 WASDE, 100 Grain Stocks reports) on 373 announcement days from January, 1995 - February, 2019. On 25 of those announcement days, WASDE and Grain Stocks reports were released concurrently. In order to control for general market uncertainty and investor sentiment, we collect CBOE Volatility Index (VIX) data. We draw options vegas from Datastream, a database maintained by Thomson Reuters.

Table 1: CBOT Corn and Soybeans: Change in Daily IV

	Time	Moneyness	Statistic	Mean	Median	Std. Dev.	Skewness
Corn	1995-2019	At the Money	ΔIV	-0.0006	-0.0004	0.028	0.62
			$ \Delta IV $	0.0173	0.0113	0.022	6.11
	2005-2019	90% Mon-eyness	ΔIV	$-2.8e^{-5}$	-0.0023	0.036	-2.6
			$ \Delta IV $	0.021	0.013	0.029	5.47
		95% Mon-eyness	ΔIV	$-3.4e^{-5}$	0.0007	0.032	-1.5
			$ \Delta IV $	0.02	0.014	0.025	5.8
		At the Money	ΔIV	$-2.35e^{-5}$	0.0004	0.031	-1.06
			$ \Delta IV $	0.019	0.0137	0.024	7.27
		105% Moneyness	ΔIV	$-8.1e^{-5}$	0.001	0.033	-1.58
			$ \Delta IV $	0.019	0.013	0.026	7.4
		110% Moneyness	ΔIV	$-1.5e^{-5}$	0.002	0.034	-2.25
			$ \Delta IV $	0.02	0.013	0.027	6.18
Soybean	1995-2019	At the Money	ΔIV	-0.00036	-0.0004	0.026	-0.066
			$ \Delta IV $	0.018	0.0125	0.02	4.22
	2005-2019	90% Mon-eyness	ΔIV	$-7.8e^{-5}$	0.002	0.031	-1.9
			$ \Delta IV $	0.02	0.013	0.024	4.6
		95% Mon-eyness	ΔIV	-0.0001	0.0003	0.027	-0.19
			$ \Delta IV $	0.018	0.0135	0.02	3.65
		At the money	ΔIV	-0.0001	-0.0002	0.025	0.13
			$ \Delta IV $	0.018	0.014	0.017	2.88
		105% Moneyness	ΔIV	-0.0001	0.0007	0.03	1.04
			$ \Delta IV $	0.018	0.013	0.024	11.46
		110% Moneyness	ΔIV	$-7.9e^{-5}$	0.0013	0.031	-0.17
			$ \Delta IV $	0.018	0.013	0.025	8.57

Note: ΔIV is computed as the daily difference between the logged IVs. There are a total of 6133 and 6115 observations for corn and soybeans respectively from 1995 to 2019. From 2005 to 2019, there are 3494 observations for corn and 3441 observations for soybeans.

4 METHODOLOGY

In this paper we estimate how implied volatility for major agricultural futures contracts changed following USDA report announcements, and calculate the daily change in implied volatility as:

$$\Delta IV_{i,t} = \log(IV_{i,t}) - \log(IV_{i,t-1}) \quad (1)$$

where the commodity (corn or soybeans) is indexed by i and the trading day is indexed by t . The logarithmic transformation helps to normalize the data, and differencing ensures stationarity. Our basic regression model is specified as:

$$\begin{aligned} \Delta IV_{i,t} = & \beta_0 + \beta_1 \Delta IV_{i,t-1} + \beta_2 D_{WASDE} + \beta_3 D_{Grain\ Stocks} \\ & + \beta_4 D_{Pre-2019\ Jan\ WASDE} \\ & + \beta_5 D_{Pre-2019\ Feb\ WASDE} \\ & + \beta_6 D_{Jan19\ WASDE} + \beta_7 D_{Feb19\ WASDE} \\ & + \beta_8 \Delta VIX_t + \beta_9 Vol_{i,t} + \beta_M \times M + \epsilon_{i,t} \end{aligned} \quad (2)$$

where VIX refers to CBOE's Volatility Index, Vol is the futures trading volume for commodity i on day t . M is a vector of other regressors including month and day-of-week dummies and time trends. We specifically include dummies for WASDE and Grain-stock report release days (D_{WASDE} & $D_{Grain\ Stocks}$), for all trading days that include WASDE and Grain stock reports released in the month of January and February ($D_{Pre-2019\ Jan\ WASDE}$ & $D_{Pre-2019\ Feb\ WASDE}$), for the missing January 2019 reports ($D_{Jan19\ WASDE}$) and for the reports released in the following month ($D_{Feb19\ WASDE}$).

Because the residuals from (2) are characterized by auto-correlation and heteroskedasticity (as discussed in detail in the next section), we also estimate GARCH Models. Our GARCH(1,1) model

with ARMA (1,1) specification is as follows:

$$\begin{aligned}
\Delta IV_{i,t} = & \beta_0 + \beta_1 \Delta IV_{i,t-1} + \beta_2 D_{WASDE} + \beta_3 D_{Grain\ Stocks} \\
& + \beta_4 D_{Pre-2019\ Jan\ WASDE} \\
& + \beta_5 D_{Pre-2019\ Feb\ WASDE} \\
& + \beta_6 D_{Jan19\ WASDE} + \beta_7 D_{Feb19\ WASDE} \\
& + \beta_8 \Delta VIX_d + \epsilon_{i,t} + \epsilon_{i,t-1} \\
\epsilon_{i,t} = & \sigma_{i,t} Z_{i,t} \\
\sigma_{i,t}^2 = & \omega + \alpha \epsilon_{i,t-1}^2 + \beta \sigma_{i,t-1}^2 + \gamma_R R \\
Z_{i,t} \sim & N(0, 1)
\end{aligned} \tag{3}$$

ω , α and β are GARCH parameters. R is the vector of same regressors that are added to the mean equation. $Z_{i,t}$ is a random variable with a standard normal distribution.

In order to estimate the counterfactual change in IV that would have occurred had the January 2019 reports been published on time, we construct two proxy measures:

- the normal change exhibited by the IV series in response to pre-2019 January reports
 $= \beta_2 + \beta_3 + \beta_4$
- The actual observed change in IV following the release of the next published report (i.e., February 2019), compared to the impact of a pre-2019 February release
 $= \beta_7 - \beta_5$

To investigate the impact of the missing reports along the IV surface, for each commodity we construct a 5x1 IV vector of daily changes in the 30-day IV, for 90%, 95%, 100%, 105% and 110% moneyiness, as our dependent variable and estimate a dynamic conditional correlation (DCC) GARCH model to generate the marginal effects of the missing report on the price of hedging. We take this approach because, for each IV vector the underlying commodity is the same. Since

each series is influenced by same supply-demand dynamics, like weather shocks and general level of uncertainty in the markets, there is high correlation among each component in the vector. A DCC GARCH model is flexible to those relationships while accounting for serial correlation and conditional heteroskedasticity.

5 RESULTS

5.1 Using 1995-2019 Data

Table 2 summarizes the results of the CBOT corn market IV models we estimate to measure the impact of missing government data. Model (1) presents the OLS regression results with no month and day-of-week effects. After controlling for other factors, it associates historic (1995-2018) January WASDE and Grain-stock reports (reported in the table as counterfactual 1) with a highly statistically significant decline in daily IV of about 4%. Historic February WASDE reports have no significant effect on IV, while the release of the February 2019 WASDE report carried a substantial IV decline, after controlling for other factors. Therefore, under counterfactual 2, the impact of missing information is even larger: about 14%. Model (2) controls for additional month and day-of-week effects, but produces no significant change in any of the coefficients; indicating that the results are robust to these effects. However, both models (1) and (2) suffer from auto-correlation (as observed from LM and LBP test statistic in the table). We therefore estimate a standard GARCH(1,1) and exponential GARCH (1,1) model with ARMA (1,1) process, respectively referred to as models (3) and (4). Both make only minor changes to the counterfactual estimates, which remain highly statistically significant. Model (4) exhibits the lowest Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) values, so is preferred according to our specification tests. As a result, we report headline point estimates and confidence intervals from this model, and refer to it as preferred. Still, the similarity of our findings across model specifications signifies the robustness of our results.

Table 3 provides the same results for CBOT soybeans. To correct for serial correlation in OLS regression models (1) and (2), we estimate sGARCH (2,1) and eGARCH(2,1) models with ARMA(3,1) processes.³ Across model specifications, we estimate the counterfactual 1 impact on IV in the range of negative 2.6% - 3.0%, and counterfactual 2 as a daily decline in IV of between 5.1% - 5.4%. As in the case of corn, our eGARCH model is preferred according to both AIC and BIC.

³Although other specifications with different lags produced substantively similar results, we proceeded with sGARCH (2,1) and eGARCH(2,1) models, each following and ARMA(3,1) process because each satisfied our diagnostic tests.

Table 2: Factors that Affect the Daily Change in Log Implied Volatility for CBOT Corn, 1995-2019

		<i>Regression Models</i>			
		OLS		sGARCH ¹	eGARCH ¹
		(1)	(2)	(3)	(4)
(A)	Lagged change in Daily Log IV	-0.089** (0.037)	-0.087** (0.0372)	0.963*** (0.0055)	0.953*** (0.0084)
(B)	Generic Grain Stock Announcement	-0.025*** (0.004)	-0.024*** (0.004)	-0.023*** (0.0042)	-0.02*** (0.0012)
(C)	Generic WASDE Announcement	-0.036*** (0.003)	-0.034*** (0.0029)	-0.0297*** (0.0025)	-0.0252*** (0.0016)
(D)	Pre-2019 January WASDE/Grain Stock	0.022** (0.01)	0.024** (0.0099)	0.0155* (0.0088)	0.0095*** (0.00098)
(E)	Pre-2019 February WASDE	0.006 (0.0081)	0.008 (0.008)	0.0004 (0.0087)	-0.002 (0.0077)
(F)	January 2019 WASDE	0.005 (0.0027)	0.003 (0.0018)	0.0065*** (0.0022)	0.0048*** (0.0011)
(G)	February 2019 WASDE/Grain Stock Announcement	-0.134*** (0.0086)	-0.131*** (0.0085)	-0.12*** (0.013)	-0.12*** (0.0093)
(H)	Daily change in VIX	0.044*** (0.013)	0.034*** (0.013)	0.046*** (0.0175)	0.049*** (0.0005)
Week Dummies? ²		No	Yes	No	No
Month Dummies? ²		No	Yes	No	No
<i>Impact Of Missing WASDE</i>					
Counterfactual 1 ³		-0.03918*** (0.0087)	-0.0349*** (0.0084)	-0.0373*** (0.0077)	-0.0365*** (0.0025)
Counterfactual 2 ⁴		-0.1394*** (0.016)	-0.1394*** (0.0157)	-0.12*** (0.0197)	-0.12*** (0.0158)
<i>Test Statistics</i>					
AIC		-27065.81	-27097.15	-4.6935	-4.7151
BIC		-26978.43	-26915.67	-4.6716	-4.6921
LM Test ⁵		72.705***	99.236***	0.576	0.565
LBP Test (Lag 9)		44.521***	54.611***	7.6*	6.6

Note: Robust standard errors are reported in parentheses. Counterfactual 1 = (B) + (C) + (D), and Counterfactual 2 = (G) - (E). Standard errors for both are calculated using the Delta Method.

¹ Variables A to H were included in both mean and variance equations in the GARCH specification.

² Week and month dummies were initially added to the GARCH Models. However, their coefficients were insignificant and hence were subsequently dropped from the final models.

³ Based on Historic January reports.

⁴ Based on February 2019 report.

⁵ For OLS models, the Breusch-Pagan test statistic is reported. For GARCH Models, weighted ARCH LM results (at lag 7) are presented.

*p<0.1; **p<0.05; ***p<0.01

Table 3: Modeling the Daily Change in Log Implied Volatility for CBOT Soybeans, 1995-2019

		<i>Regression Models</i>			
		OLS		sGARCH ¹	eGARCH ¹
		(1)	(2)	(3)	(4)
(A)	Lagged change in Daily Log IV	-0.064** (0.039)	-0.059 (0.0385)	0.736*** (0.0935)	0.707*** (0.0207)
(B)	Generic Grain Stock Announcement	-0.03*** (0.0043)	-0.031*** (0.0043)	-0.031*** (0.0046)	-0.03*** (0.0015)
(C)	Generic WASDE Announcement	-0.032*** (0.0025)	-0.0315*** (0.0025)	-0.0298*** (0.00249)	-0.0258*** (0.0012)
(D)	Pre-2019 January WASDE/Grain Stock	0.032*** (0.008)	0.037*** (0.008)	0.03*** (0.0077)	0.026*** (0.0012)
(E)	Pre-2019 February WASDE	0.015** (0.007)	0.0165** (0.007)	0.012** (0.0059)	0.011* (0.0058)
(F)	January 2019 WASDE	0.0092 (0.0097)	0.0108 (0.0105)	0.01 (0.04)	0.0103 (0.0095)
(G)	February 2019 WASDE/Grain Stock Announcement	-0.036*** (0.0078)	-0.037*** (0.0078)	-0.038*** (0.0083)	-0.043*** (0.006)
(H)	Daily change in VIX	0.026** (0.012)	0.0189 (0.012)	0.039*** (0.011)	0.033*** (0.0079)
Week Dummies? ²		No	Yes	No	No
Month Dummies? ²		No	Yes	No	No
<i>Impact Of Missing WASDE</i>					
Counterfactual 1 ³		-0.0306*** (0.0063)	-0.0257*** (0.0062)	-0.0305*** (0.0058)	-0.0295*** (0.0029)
Counterfactual 2 ⁴		-0.0514*** (0.014)	-0.054*** (0.014)	-0.051*** (0.013)	-0.054*** (0.012)
<i>Test Statistics</i>					
AIC		-27496.01	-27497.44	-4.7201	-4.7501
BIC		-27408.67	-27316.04	-4.6948	-4.7226
LM Test ⁵		73.475***	97.081***	5.806	5.369
LBP Test (Lag 11)		33.603***	44.927***	6.023	6.329

Note: Robust standard errors are reported in parenthesis. Counterfactual 1 = (B) + (C) + (D), and Counterfactual 2 = (G) - (E). Standard errors for both are calculated using the Delta Method.

¹ Variables A to H were included in both mean and variance equations in the GARCH specification.

² Week and month dummies were initially added to the GARCH Models. However, their coefficients were insignificant and hence were subsequently dropped from the final models.

³ Based on Historic January reports.

⁴ Based on February 2019 report.

⁵ For OLS models, Breush Pagan Test statistic is reported. For GARCH Models, weighted ARCH LM results (at lag 8) are presented.

*p<0.1; **p<0.05; ***p<0.01

Following the results in tables 2 and 3, we approximate the counterfactual price of ATM corn and soybean put options due to publication curtailment of the January 2019 WASDE report. We estimate that, on the first day of trading following the normally scheduled USDA publication time, the additional commodity market uncertainty caused by the government shutdown increased the price of hedging ATM corn and soybean puts by additional 2.95% per contract per bushel (95% CI: 2.93% - 2.97%) and 1.66% per contract per bushel (95% CI: 1.64% - 1.68%), respectively for corn and soybeans, using an approach that assumes a normal January report impact. Using a different counterfactual approach—assuming that the IV reduction following the February 2019 publication would have been experienced in January, we find that the increase in hedging costs due to missing information was actually about 11.4% per contract per bushel (95% CI: 10.9% - 11.79%) higher for corn and 4.3% per contract per bushel (95% CI: 4.1% - 4.42%) higher for soybeans. We find significant, but lower increases for deep out-of-the-money or in-the-money options for these commodities. Overall, ATM put options display the maximum increase. Further, as the markets progress closer to the release of February WASDE reports, the increase in options premia, due to missing government reports, gradually decreases.

5.2 ANALYSIS BY OPTION MONEYNES

Options can be characterized by their moneyness levels, or the ratio of the strike price of the option in question to the ATM strike. An option is said to be at-the-money if its strike price is (nearly) equivalent to the price of the underlying security. These options only have time value. In-the money options possess both intrinsic value (or monetary value), since they can be exercised profitably immediately, and time value, since they have the possibility of becoming even more profitable with the passage of time. Out-of-the money options have no intrinsic value, but do possess time value. Trading volume of an option depends, to some extent, on the moneyness levels. ATM options are usually the most highly traded. Implied volatility surfaces in commodity markets are generally skewed, and the impact of news may be affected by option moneyness. That is, deep out-of-the-money (OTM) or in-the-money (ITM) options, meaning those with strike prices associated with

a very low or high probability of being executed, may be affected differently by news than ATM options. As defined in section 3, we use the data on 30-day implied volatility at moneyness levels of 90%, 95%, 100%, 105%, and 110%, for each commodity (from 2005 to 2019). The 30-Day IV refers to the forecasted daily implied volatility for the coming 30 days. It is similar to the way the VIX is constructed, since that measure represents the forecasted daily implied volatility associated with the SP 500 index over the next thirty days. It is different from the IV values used for analysis in the previous section (There we use daily implied volatility.) We estimate a multivariate dynamic conditional correlation (DCC) GARCH model (DCC(1,1) eGARCH(1,1) ARMA (1,1)).⁴ To gauge the impact of the government shutdown and subsequent missing January 2019 reports, for each moneyness level, we extract the average change in IV around the release of pre-2019 January reports and use a cubic spline to generate a counterfactual IV level that would have been observed, had the reports been published on time.

Figure 2 provides the point-estimate results and the 95 % confidence bands for counterfactual 1 for both corns and soybeans along the implied volatility surface. ATM corn contracts experience the largest impact of government news (-7.4%, 95% CI: 4.5% - 10.3%), with smaller impacts estimated at other levels of option moneyness. Further, confidence intervals are narrower for deep out-of-the-money or in-the-money options and wider for other moneyness levels. Soybeans offer a smaller variation in marginal effects across different moneyness levels, but near the money options still display the maximum impact. Similar to corn, confidence intervals for soybeans are narrower towards both the ends of moneyness levels. Overall, for both the commodities, marginal effects closely follow a convex function. ATM options are generally among the most heavily traded, so they are highly sensitive to changes in market uncertainty (Isengildina-Massa et al., 2008a). Compared to the results observed in section 5.1, we observe higher point estimates for ATM options for corn as well as soybeans. We believe that the point estimates might be upward biased because of

⁴We conduct a formal test for the relevance of DCC GARCH against a constant conditional correlation (CCC) GARCH model. For both the commodities, we reject the null hypothesis at 1% significance level, confirming the relevance of DCC GARCH model for our analysis.

data unavailability (on IV surface) from 1995-2004.

Figure 2: **IMPACT OF MISSING JANUARY 2019 REPORTS: Marginal Effects across Moneyiness Levels (Based on Counterfactual 1)**

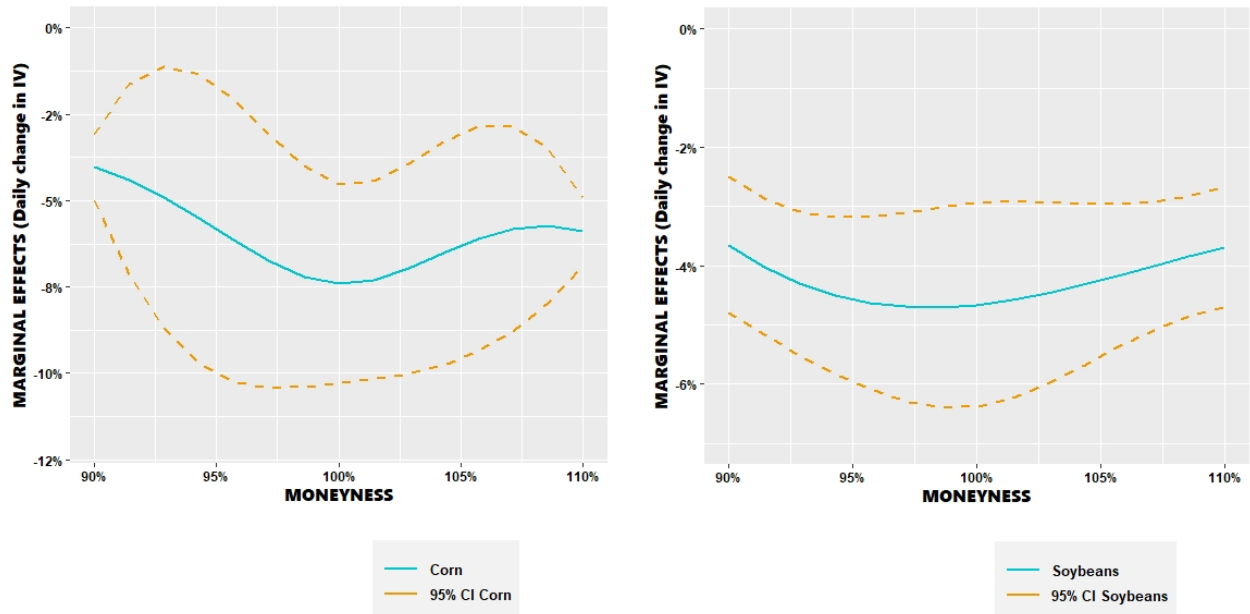


Figure 3: **IMPACT OF MISSING JANUARY 2019 REPORTS: Marginal Effects across Moneyness Levels (Based on Counterfactual 2)**

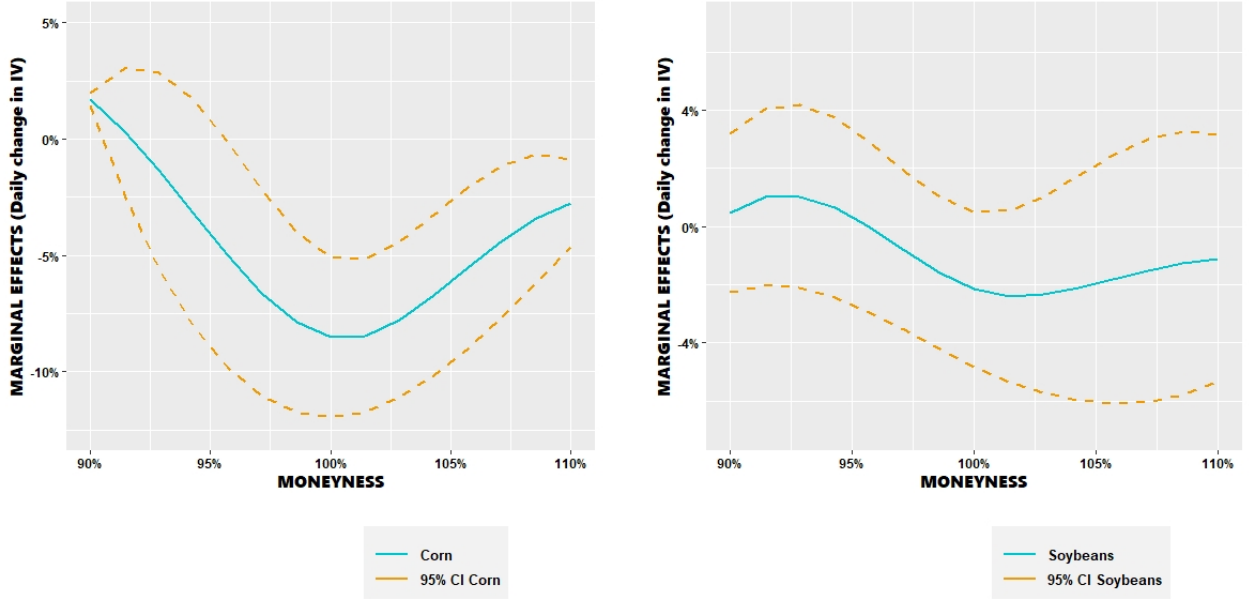


Figure 3 provides the same results for counterfactual 2 for both the commodities along the implied volatility surface. Near the money corn and soybean contracts experience the largest impact of government news, with smaller impacts estimated at other levels of option moneyness. However, specifically in the case of soybeans, some of the marginal effects are positive at the mean, but these point estimates are statistically insignificant. Compared to the results observed in section 5.1, we observe lower point estimates for ATM options for corn as well as soybeans, although they point in the same direction. .

Even though we use 30-day IV data instead of contract-specific historical IV data, we still observe highly significant and negative point impacts for ATM corn and soybean contracts for both counterfactuals. This is in line with the results observed in tables 1 and 2. Figures 2 and 3 portray a volatility smile (i.e. convexity with respect to moneyness level) in the impact of missing information, similar to the empirical regularity observed in many derivatives markets whereby IV itself is convex with respect to moneyness level.

Based on the marginal effects from figure 2 and 3 and the actual IVs observed on each of these days across the moneyness surface, we calculate the counterfactual IVs that would have been observed on January 11th 2019, if the missing reports had been published. Figures 3 and 4 report our mean-level results for corn and soybeans, respectively. We estimate that, had January 2019 WASDE and Grain Stocks reports been published on time, each market would have experienced notable declines across the IV surface.

Figure 4: **Impact of Missing 2019 Reports on CBOT Corn IV: 11th January, 2019**

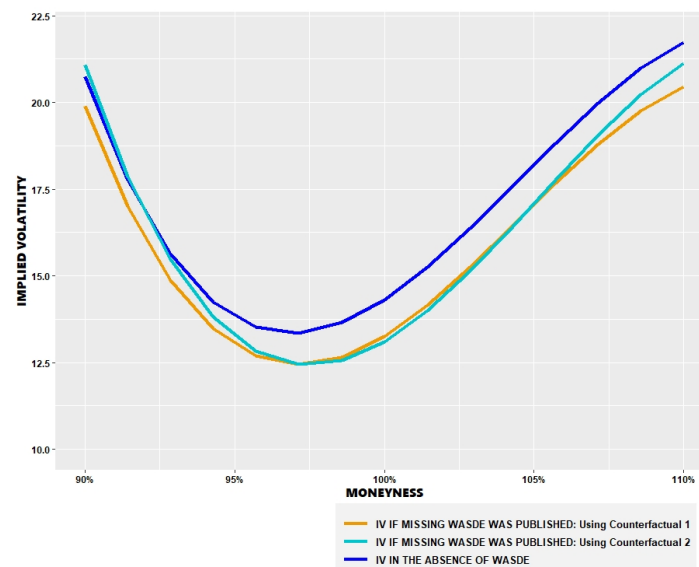
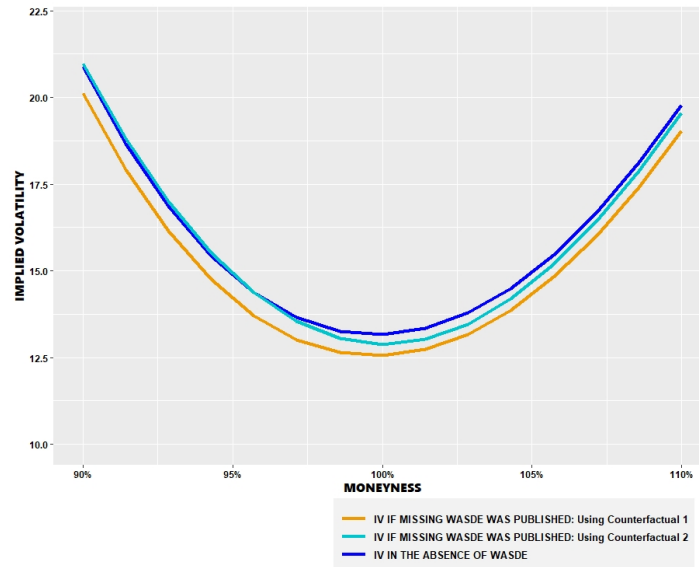


Figure 5: **Impact of Missing 2019 Reports on CBOT Soybeans IV: 11th January, 2019**



6 CONCLUSION and POLICY IMPLICATIONS

The 2019 government shutdown delayed USDA’s publication of its end-of-year January crop and stocks reports. We show that corn and soybean markets did not experience normal reductions in uncertainty around the release of important government crop news. Uncertainty is an important factor in determining options premia; more uncertainty raises premia, all else equal. We estimate that, on the first day of trading following the normally scheduled USDA publication time, the additional commodity market uncertainty caused by the government shutdown increased the price of hedging ATM corn and soybean options by additional 2.95% (95% CI: 2.93% - 2.97%) and 1.66% (95% CI: 1.64% - 1.68%), respectively for corn and soybeans, using an approach that assumes a normal January report impact. To put this in context, those effects raised the per contract hedging costs involved in the purchase of ATM corn and soybean put options on January 11, 2019 by about \$12.73 and \$13.48, respectively. Using a different counterfactual approach—assuming that the IV reduction following the February 2019 publication would have been experienced in January, we find that the increase in hedging costs due to missing information was actually about 11.4% (95%

CI:10.9% - 11.79%) higher for corn and 4.3% (95% CI: 4.1% - 4.42%) higher for soybeans, implying an increase in per contract ATM hedging costs of \$45.37 and \$33.85, respectively, on January 11, 2019. According to historical IV surface data, ATM options experience the largest effects of missing information, at least in percentage terms. However, these options are usually the most highly traded, so our results offer important insights not only for traders and market participants, but also for decision makers who face budget constraints regarding the collection and provision of information about supply and demand fundamentals for agricultural commodities.

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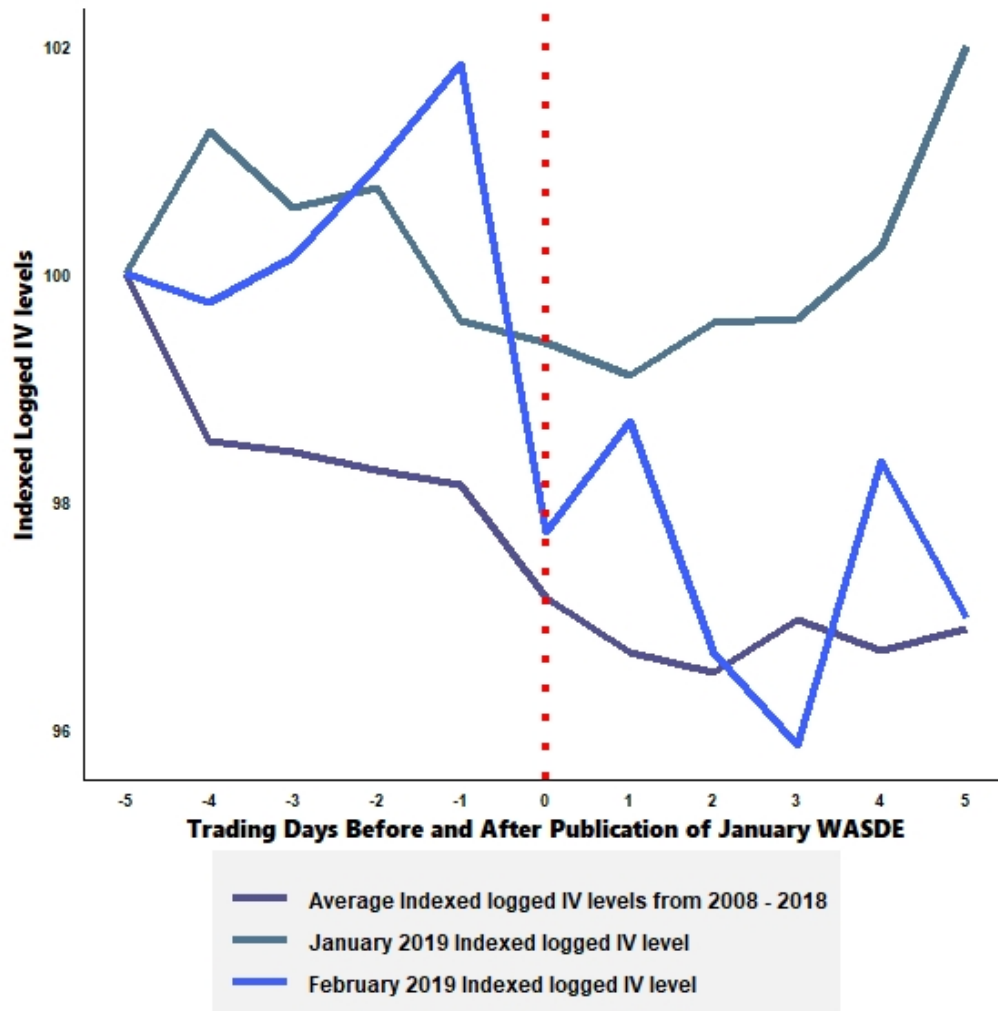
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8 APPENDIX

Figure A1: CBOT SOYBEANS: Indexed Logged IV Levels.



The blue lines are the time series of the indexed logged CBOT soybean IV levels in a 5-day window around the normal release of a January report averaged from 2008 - 2018. The red dotted line marks the day when the historic January USDA reports were released, the day when missing January 2019 USDA reports were *scheduled* for release and the day when February 2019 USDA reports were released.

Figure A2: **Corn: Kernel Density Plot**

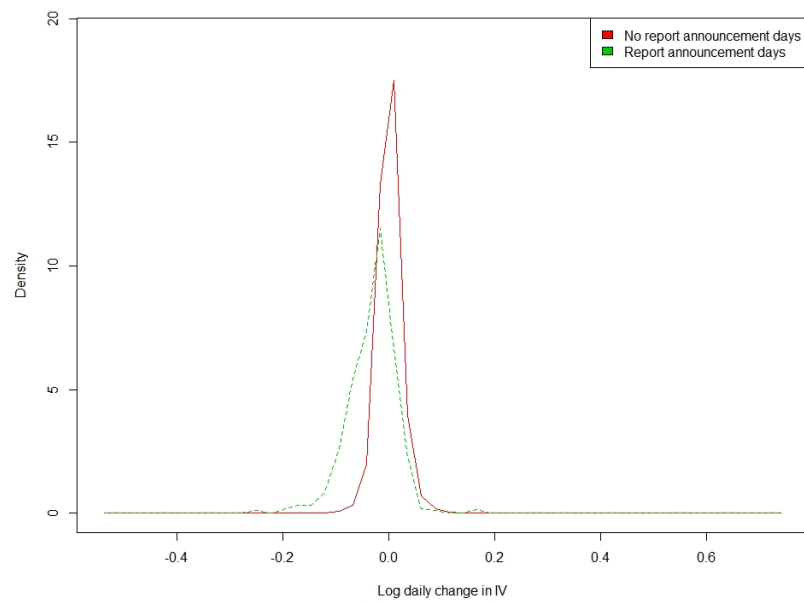


Figure A3: **Soybeans: Kernel Density Plot**

