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Are USDA reports still news to changing crop markets?

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ABSTRACT

This study investigates whether major USDA reports still provide important news to changing crop markets. The news component of each report, or market "surprise," is measured as a difference between the USDA estimate and its private expectation in corn, soybeans, and wheat markets. Changes in the relevance of USDA information are assessed by examining changes in the magnitude of market surprises and shifts in the futures price reaction to these surprises, which isolates the impact of each report. The stable size of market surprises over time suggests that competition from alternative data sources has not reduced the news component of USDA crop reports. Increasing price reaction to most reports, including those facing competition from alternative information sources, suggests that value of public information may be enhanced in uncertain markets affected by structural changes.

1. Introduction

The landscape of agricultural commodity markets has changed dramatically over the last several decades. Policy changes have had an especially significant impact on crop markets due to the introduction of the U.S. biofuel mandates in 2005 and the subsequent use of crops for energy production (Carter et al., 2017). As Fig. 1 demonstrates, this led to sharp changes in crop prices starting in late 2006. The break was so sharp that it ushered in "a new era" of crop prices (Irwin and Good, 2009). For example, the average futures price across pre- and post-2007 sub-periods increased from $2.46/bu. to $4.75/bu. for corn, $5.99/bu. to $11.16/bu. for soybeans, $3.42/bu. to $6.27/bu. for winter wheat, and $3.79/bu. to $7.04/bu. for spring wheat, increases ranging from 83% to 93%. Similar changes were also observed in the volatility of crop prices, reflecting increased market instability.

Structural change in agricultural commodity markets in the mid-2000s was not limited to biofuels policy. In fact, Irwin and Sanders (2012) argued that "…the first decade of the 21st century has perhaps witnessed more structural change in commodity futures markets than all previous decades combined." The authors highlight three major forms of structural change: (i) a dramatic shift in 2006–2008 from a primarily telephone/open outcry trading platform to computer/electronic order matching platform; (ii) improved market access stemming from the combination of a revolutionary improvement in communication tools (software and hardware) and the rise of electronic trading that allowed much easier and direct access to the markets; and (iii) the entry of new "financial" participants in the commodity futures arena, widely referred to as "financialization."

Physical crop markets have also undergone substantial changes in the last decade, with new crop varieties made possible by rapid strides in biotechnology that offer higher yields but may be more susceptible to drought conditions (Lobell et al., 2014). Furthermore, the surge in communication technology, computing power, storage and remote sensing, commonly referred to as "big data" (Sonka, 2014), resulted in the emergence and growth of private information sources that provide increasing competition to information traditionally provided by the U.S. Department of Agriculture (USDA).

The USDA continues to spend millions of dollars to collect and disseminate market information to the public. The Office of Management and Budget reports that out of "$6.6 billion in total direct

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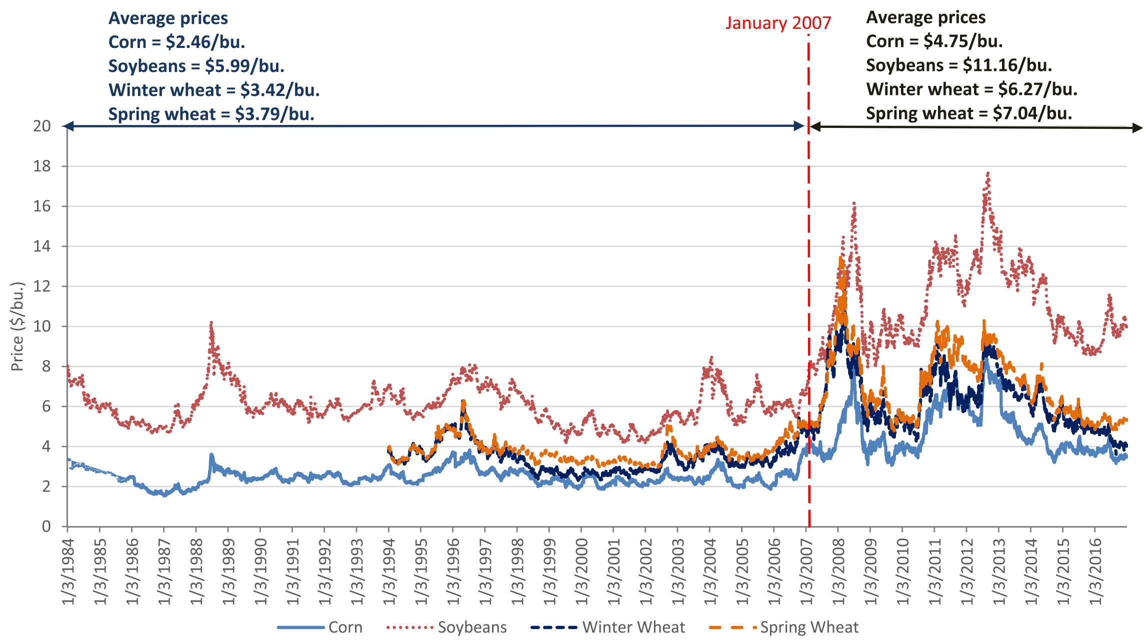

Fig. 1. New crop futures prices.
Note: Sample period is 1984/85–2016/17 marketing years for corn and soybeans and 1994/95–2016/17 marketing years for winter and spring wheat.

funding for major statistical programs across all Federal agencies in 2012, USDA accounted for about $521 million or 7.8% of the total." (C-FARE, 2013, p. 4) Over 30% of these funds are allocated to National Agricultural Statistical Service (NASS), an agency primarily responsible for data collection and dissemination. The justification for this investment in USDA's data products is that in many cases public data are necessary because they facilitate the efficient functioning of the markets, reduce information asymmetries and inform the policy and program formation, operation and evaluation processes (C-FARE, 2013). However, the ongoing structural changes in agricultural commodity markets as well as the emergence of alternative private information sources call the relevance of public data into question especially in the times of budget shortfalls.

An extensive literature provides ample evidence that USDA crop reports have moved markets for decades (e.g., Colling and Irwin, 1990; Fortenbery and Sumner, 1993; Baur and Orazem, 1994; Isengildina-Massa et al., 2008; McKenzie, 2008; Adjemian, 2012; Lehecka et al., 2014; Dorfman and Karali, 2015).[1] However, less is known about changes in impact over time. Some evidence of diminished market impact starting in the mid-1980s has been reported (Fortenbery and Sumner, 1993), but other evidence indicates no change or even an increasing impact after the mid-1980s (Garcia et al., 1997; Isengildina-Massa et al., 2008). Two recent studies estimating changes in market impacts (Isengildina-Massa et al., 2016; Ying et al., 2017) suggest that some USDA crop reports are still informative and influential in crop futures markets, but there are some reports whose impact appears to be declining.

This discussion indicates that the available evidence on the changing market impact of USDA crop reports is limited. In addition, previous studies have important limitations. First, most studies focus on the price impact of only one type of USDA report in one or two markets. This prevents comparison of market impacts across major USDA acreage, production, and stock reports and across markets, which may be important because various reports and markets could respond to structural changes differently. Second, price impact is most frequently measured in the literature using a dummy variable (or its equivalent) on report release days, which makes it impossible to separate the impact of reports released on the same day. This "clustering" is a non-trivial problem. For example, almost all Crop Production Annual Summary and Prospective Plantings reports since 1985 were released on the same day as quarterly Grain Stocks reports. Therefore, the dummy variables used to measure price impact pick up the combined impact of all reports released on the same day.

The purpose of our study is to investigate whether USDA crop reports are still news to the changing crop markets using direct measures of market news that avoid identification and clustering issues. We address limitations in previous studies by directly measuring the market "news" or "surprise" component of the reports and then estimating changes in the price impact based on the news component. This allows the price impact of a given USDA report to be uniquely identified and overcomes the clustering issue. We construct the most comprehensive set of market expectations in the literature to date in order to compute the market surprise as the difference between USDA and private analysts' forecasts, The data set includes expectations for all major USDA crop reports including Prospective Plantings, Acreage, Winter Wheat Seedings, Crop Production, Crop Production Annual Summary, and Grain Stocks, for corn, soybeans, winter wheat, and spring wheat for the sample period 1984/85 through 2016/17 marketing years. In view of the multiple sources of structural change affecting agricultural commodity markets in the mid-2000s, the sample is divided into pre- and post-2007 sub-periods to assess possible changes in the price impact of USDA information.

Structural changes in commodity markets resulted in increased market uncertainty and higher competition from private information sources. While greater market uncertainty may make USDA information more valuable, competition from private information sources may replace some of the USDA data products and make them irrelevant. These changes in impact may affect market surprises in USDA information, potentially resulting in different price reactions. We test these hypotheses by first assessing the equality in absolute surprises across time.

[1] A few studies provide empirical estimates of the direct welfare benefits of public crop forecasts (Hayami and Peterson, 1972; Freebairn, 1976; Bradford and Kelejian, 1978; Abbott et al., 2016; Gouel, 2017). In these studies, a theoretical supply/demand structure for a market is proposed, parameter estimates are obtained, and then social welfare is estimated under different information or expectation assumptions. The estimation results suggest the social welfare value of USDA forecasts has substantially exceeded the cost.

Furthermore, since commodity price reactions to information shocks are not independent, changes in price reactions across time are evaluated in a dynamic conditional correlation multivariate generalized autoregressive conditional heteroskedasticity framework with exogenous factors in the conditional variance equations (DCC MGARCH-X). Our modelling framework is novel, as it takes into account co-movements and cross-commodity information effects, disentangles the individual price impacts of acreage, production, and stock reports due to the availability of expectations data, and measures the impact of report releases on price volatility. Our findings demonstrate that the value of USDA reports has not diminished. The first set of results shows no systematic decline in market surprises of USDA crop reports. Thus, the USDA forecasts generally carry new information beyond private information sources, even in more recent years. The second set of results demonstrates that price movements continue to occur in response to market surprises, even for those USDA reports that are most likely to be affected by competition from the private information sources.

2. Data

This study examines the informational value of USDA's key crop reports that are prepared and issued by NASS over 1984/85 through 2016/17 marketing years. The annual forecasting cycle for crops starts with Winter Wheat Seedings reports in early January followed by Prospective Plantings reports in March. Winter Wheat Seedings reports contain seeded area estimates based primarily on surveys conducted during the first two weeks of December.[2] Annual Prospective Plantings reports contain survey-based estimates of producers' planting intentions as of March 1st and are typically released at the end of March. Good and Irwin (2011) provide a thorough review of the survey procedures used by the USDA. Additional expected supply information is disclosed in Acreage reports. These reports provide updated survey information on planted and/or harvested acreages for those commodities included in Prospective Plantings reports and are released at the end of every June. Harvested acreage is finalized in the Crop Production Annual Summary report released in January, and represents the final USDA estimate for both Prospective Plantings and Acreage.

Crop Production reports include information from Acreage reports and other sources, and contain forecasts of marketing year yield and production for major crops consistent with their growing cycles. These reports are typically released between the 9th and 15th of each month.[3] For corn and soybeans, the production forecasts are typically released from August through November. Production forecasts for wheat are released from May through August for winter wheat, and from July through August for spring wheat. Production forecasts released before January represent an update of the previous forecast describing a marketing year total production, which is finalized in January in the Crop Production Annual Summary report. For more information on the preparation of Crop Production reports, see Irwin et al. (2014).

Grain Stocks reports track available supply throughout the marketing year, which is a function of annual production and the pace of use, and are issued by NASS quarterly (January, March, June, and September). These reports describe stocks of multiple crops, including corn, soybeans, and wheat, as well as the number and capacity of on- and off-farm storage facilities, and are used by the market as important indicators of the pace of usage within the marketing year relative to projections.

[2] The title of the report was Winter Wheat and Rye Seedings from 1964 to 1999, changed to Winter Wheat Seedings from 2000 to 2016 and to Winter Wheat and Canola Seedings in 2017. This annual report is simultaneously released with the Crop Production Annual Summary report during our sample period.

[3] Starting in 1985, Crop Production and WASDE reports were released simultaneously.

Table 1
USDA reports and private expectations, 1984/85–2016/17 marketing years.

Reports	Corn	Soybeans	Winter wheat	Spring wheat
Winter wheat seedings			Jan	
Prospective plantings	Mar	Mar		Mar (1989)
Acreage	Jun	Jun		Jun (1994)
Crop production	Aug-Nov	Aug-Nov	May-Aug	Jul-Aug
Crop production annual summary	Jan	Jan		
Grain stocks	Jan, Mar, Jun, Sep	Jan, Mar, Jun, Sep	Jan, Mar, Jun, Sep	Jan, Mar, Jun, Sep

Note: Numbers in parentheses describe the starting date for private expectations data if not available for the entire sample period. For both winter and spring wheat, Grain Stocks refer to all wheat category.

Table 2
Futures contracts used in new crop price series.

	Corn	Soybeans	Winter wheat	Spring wheat
Calendar Month	(CBOT)	(CBOT)	(CBOT)	(MGEX)
January_t	Mar_t	Mar_t	Mar_t	Mar_t
February_t	Dec_t	Nov_t	Jul_t	Sep_t
March_t	Dec_t	Nov_t	Jul_t	Sep_t
April_t	Dec_t	Nov_t	Jul_t	Sep_t
May_t	Dec_t	Nov_t	Jul_t	Sep_t
June_t	Dec_t	Nov_t	Jul_t	Sep_t
July_t	Dec_t	Nov_t	Sep_t	Sep_t
August_t	Dec_t	Nov_t	Sep_t	Sep_t
September_t	Dec_t	Nov_t	Dec_t	Dec_t
October_t	Dec_t	Nov_t	Dec_t	Dec_t
November_t	Dec_t	Jan_{t+1}	Dec_t	Dec_t
December_t	Mar_{t+1}	Jan_{t+1}	Mar_{t+1}	Mar_{t+1}

Note: The subscript, t or t + 1, refers to the year of the futures contract expiration date relative to the year t of the daily price being computed. The primary new crop futures contracts are December for corn, November for soybeans, July for winter wheat, and September for spring wheat.

Industry analysts' estimates, which are usually released a few days before the USDA reports, have been traditionally used as a proxy for market expectations of government reports (e.g., Colling and Irwin, 1990; Grunewald et al., 1993; Garcia et al., 1997; Egelkraut et al., 2003). We follow the same approach and construct private expectations series illustrated in Table 1 using the following sources: Winter Wheat Seedings, Prospective Plantings, and Acreage report expectations for corn, soybeans, and wheat are obtained from Knight Ridder/Dow Jones through 2015; 2016 expectations are from Thomson Reuters. Private analysts' estimates for corn and soybean Crop Production reports use an average of forecasts by Conrad Leslie and Informa Economics (formerly Sparks Companies, Inc.) during 1984–2000; the average between the Informa Economics estimate and the average analyst estimate reported by the Dow Jones Newswire survey for 2001–2005; the average of the Dow Jones survey for 2006–2012; and the average of the Bloomberg survey during 2013–2016.[4] Private expectations for wheat Crop Production reports are based on the average analysts' forecasts reported by Knight-Ridder/Dow Jones Newswire.

We use daily price data of new crop futures contracts. Corn, soybeans, and soft red winter wheat futures contracts are traded at the Chicago Board of Trade (CBOT), and hard red spring wheat contracts are traded at the Minneapolis Grain Exchange (MGEX). Table 2 lists the specific contract maturities used in each calendar month for these new crop futures price series. Specifically, the primary new crop futures contracts are December for corn, November for soybeans, July for winter wheat, and September for spring wheat.

[4] See Good and Irwin (2006) for further details on the pre-release analysts' forecasts for corn and soybeans.

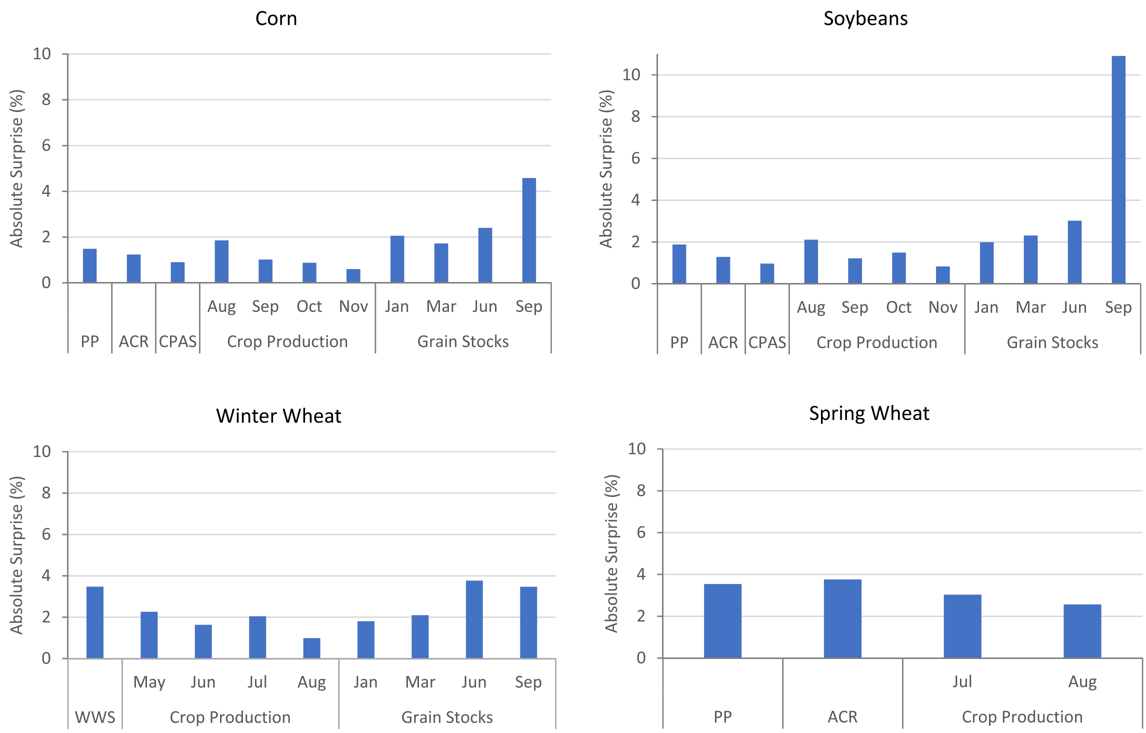

Fig. 2. Average absolute market surprises.
Note: Sample period is 1984/85–2016/17 marketing years for corn and soybeans and 1994/95–2016/17 marketing years for winter and spring wheat. PP = Prospective Plantings, ACR = Acreage, CPAS = Crop Production Annual Summary, and WWS = Winter Wheat Seedings report.

3. Changes in the news component of USDA reports

Market surprise reflects the additional, new information contained in the USDA reports beyond private analysts' expectation. Our study defines market surprise as the percentage difference between the USDA estimate, q_t^U, and the average private analysts' estimate, q_t^P, on day t for a given report as follows:

$$S_t = 100 \times (\ln q_t^U - \ln q_t^P). \quad (1)$$

The absolute magnitudes of market surprises across commodities for various reports are shown in Fig. 2. Among Prospective Plantings reports, the largest surprises are found in spring wheat and the smallest in corn. Average absolute surprises in the Acreage report for spring wheat and in the Winter Wheat Seedings report for winter wheat are more than twice as large as in corn and soybeans. Among Crop Production reports, the largest surprise tends to be associated with the first report (August for corn and soybeans, May for winter wheat, and July for spring wheat). While not dramatically larger, it is interesting to note that Crop Production surprises in wheat tend to be larger than in corn or soybeans. Crop Production Annual Summary surprises in corn and soybeans tend to be slightly larger than the last Crop Production report surprise and comparable in average absolute magnitude of around 1%. Furthermore, for corn and soybeans, the largest market surprises are associated with Grain Stocks surprises, particularly with September surprises that are several orders of magnitude greater than the surprises for any other report for these commodities. For wheat Grain Stocks reports, the largest surprises are associated with June reports and are similar in size to Winter Wheat Seedings surprises. Overall, the magnitude of surprises for the Grain Stocks report generally are larger than the other reports, which is interesting considering this is one of the least studied USDA reports in the literature.

Based on the discussion in the introduction and the apparent shift in crop prices seen in Fig. 1, it appears that significant changes in commodity markets began to take place in late 2006. Therefore, our first sub-sample includes data from pre-2007 period (1984–2006 for corn and soybeans, 1994–2006 for wheat) reflecting "traditional" commodity markets. The post-2007 sub-period (2007–2016) may be described as a "new era," characterized by extensive structural changes in agricultural commodity markets.

Table 3 compares the magnitude of market surprises across pre- and post-2007 sub-periods by using a *t*-test with Welch adjustment.[5] Our findings demonstrate that the news component of USDA reports has remained stable over time with few exceptions. There is some evidence of increasing surprises in Grain Stocks for corn and Crop Production for winter wheat. Specifically, a significant 0.87 percentage point increase is found for winter wheat surprise in June Crop Production reports, and significant increases of 1.90 and 6.83 percentage points are found for corn in June and September in Grain Stocks reports.

4. Changes in price reaction to USDA reports

Following Colling and Irwin (1990) and Garcia et al. (1997), we use price reaction tests based on the efficient market hypothesis which asserts that market prices reflect all publicly available information and instantly adjust to incorporate new information entering the market (Fama, 1970). Accordingly, prices will respond only to the unanticipated news component of the new information. The main premise of these price reaction tests is that the USDA reports have value for the market if futures prices change in response to the unanticipated information contained in the reports, whereas they have no value if futures prices do not change.

Our model specification takes into account several data characteristics. Daily futures returns have nonlinear dynamics which make traditional ordinary least squares regressions unsuitable for their analysis (e.g., Yang and Brorsen, 1993). GARCH-type models are more appropriate for modeling time-varying volatility and dynamic patterns in the

[5] Welch (1947) adjustment relaxes the assumption of equal variances across samples allowing for a comparison of the means of sub-periods with unequal variances.

Table 3
Tests of equality in average absolute surprises across pre-2007 and post-2007 sub-periods.

	Corn			Soybeans			Winter wheat			Spring wheat			All wheat		
	1984–2006 Mean	2007–2016 Mean	Mean equality test	1984–2006 Mean	2007–2016 Mean	Mean equality test	1994–2006 Mean	2007–2016 Mean	Mean equality test	1994–2006 Mean	2007–2016 Mean	Mean equality test	1994–2006 Mean	2007–2016 Mean	Mean equality test
Prospective plantings	1.58	1.26	0.68	1.86	1.91	−0.09				3.21	3.97	−0.51			
Acreage/WWS	0.98	1.58	−1.67	1.12	1.41	−0.47	3.02	4.06	−0.95	3.91	3.57	0.31			
Crop production (pooled)	1.11	1.03	0.48	1.34	1.58	−1.12	1.71	1.75	−0.16	3.00	2.54	0.69			
1	1.89	1.78	0.29	2.02	2.31	−0.55	2.16	2.38	−0.40						
2	1.05	0.94	0.35	1.20	1.26	−0.15	1.25	2.13	−2.11**						
3	0.91	0.78	0.47	1.45	1.59	−0.34	2.37	1.62	1.11	3.44	2.50	0.88			
4	0.60	0.60	0.01	0.67	1.17	−1.74	1.06	0.89	0.60	2.55	2.58	−0.04			
CPAS	0.94	1.01	−0.22	1.14	0.80	1.28									
Grain stocks (pooled)	1.99	4.30	−2.83***	3.93	5.77	−1.29							2.40	3.28	−1.66
January	2.15	1.85	0.66	1.89	2.21	−0.69							1.81	1.79	0.03
March	1.48	2.27	−1.08	2.11	2.76	−0.84							1.82	2.45	−0.91
June	1.83	3.73	−1.98*	2.38	3.58	−1.39							3.11	4.62	−1.01
September	2.51	9.34	−2.83**	9.33	14.54	−1.16							2.87	4.25	−1.53

Note: Sample period is 1984/85–2016/17 marketing years for corn and soybeans and 1994/95–2016/17 marketing years for winter and spring wheat. Crop Production reports for corn and soybeans are released in 1 = August, 2 = September, 3 = October, and 4 = November. Crop Production reports for wheat are released in 1 = May, 2 = June, 3 = July, and 4 = August. Winter Wheat Seedings reports are used instead of Acreage reports for winter wheat. The equality of means is tested by the two-tailed *t*-test with Welch adjustment allowing for unequal variances across sub-periods. The asterisks *, **, *** represent statistical significance at the 10%, 5%, and 1% level, respectively. CPAS = Crop Production Annual Summary report; WWS = Winter Wheat Seedings.

distribution of daily futures returns. Additionally, market surprises across multiple corn and soybean reports are significantly correlated. These correlations likely highlight the fact that corn and soybeans are close substitutes commonly grown in the same production areas. Significant correlations are also found across winter wheat and spring wheat Crop Production surprises. On the other hand, surprises are mostly independent between corn and wheat (except for Acreage and January Grain Stocks) as well as between soybean and wheat reports (except for September Grain Stocks). Commonality in shocks between corn and soybeans and between winter and spring wheat can be captured within a multivariate GARCH system.

To this end, we estimate the following DCC MGARCH-X system for two commodity pairs, corn-soybeans and winter wheat-spring wheat:

$$\Delta \boldsymbol{P}_t = \boldsymbol{\mu} + \boldsymbol{A}\boldsymbol{S}_t + \varepsilon_t, \tag{2}$$

$$\varepsilon_t = \boldsymbol{H}_t^{1/2}\boldsymbol{z}_t,$$

$$\boldsymbol{H}_t = \boldsymbol{V}_t^{1/2}\boldsymbol{C}_t\boldsymbol{V}_t^{1/2},$$

$$\boldsymbol{C}_t = diag(\boldsymbol{Q}_t)^{-1/2}\boldsymbol{Q}_t\, diag(\boldsymbol{Q}_t)^{-1/2},$$

$$\boldsymbol{Q}_t = (1 - \lambda_1 - \lambda_2)\boldsymbol{C} + \lambda_1\varepsilon_{t-1}\varepsilon'_{t-1} + \lambda_2\boldsymbol{Q}_{t-1},$$

where $\Delta \boldsymbol{P}_t$ is a 2×1 vector of dependent variables consisting close-to-close returns defined as $\Delta \boldsymbol{P}_t = 100 \times (\ln \boldsymbol{P}_t - \ln \boldsymbol{P}_{t-1})$ with $\boldsymbol{P}_t$ representing settlement futures prices on day t, $\boldsymbol{\mu}$ is a 2×1 vector of intercept coefficients, $\boldsymbol{A}$ is a $2 \times k$ matrix of parameters,[6] $\boldsymbol{S}_t$ is a $k \times 1$ vector of independent variables consisting of own and cross surprises in USDA reports as defined in (1).[7] ε_t is a 2×1 vector of regression error terms, $\boldsymbol{H}_t^{1/2}$ is the Cholesky factor of the time-varying conditional covariance matrix $\boldsymbol{H}_t$, and $\boldsymbol{z}_t$ is a 2×1 vector of normal, independent, and identically distributed innovations. $\boldsymbol{V}_t$ is a 2×2 diagonal matrix of conditional variances where each diagonal element $\sigma_{i,t}^2$ evolves according to a univariate GARCH(1,1) model as:

$$\sigma_{i,t}^2 = \exp(\omega_i + \psi_i D_t) + \alpha_i \varepsilon_{i,t-1}^2 + \beta_i \sigma_{i,t-1}^2, \tag{3}$$

with α_i and β_i representing ARCH and GARCH parameters, respectively, ω_i and ψ_i are parameters, and D_t is a dummy variable taking the value of one on the release days of any of the USDA reports considered and zero otherwise.[8] $\boldsymbol{C}_t$ is a 2×2 matrix of conditional quasicorrelations vector given as:

[6] For the commodity pair corn and soybeans, $k = 22$, whereas $k = 13$ for the winter and spring wheat commodity pair.

[7] Each surprise variable in $\boldsymbol{S}_t$ takes its corresponding value on the exact release day for reports released before or during trading hours, or on the following trading day for reports released after trading hours, and the value of zero on non-report days. Specifically, the release times of the considered USDA reports during our study period are 3:00pm EST (January 1984-April 1994), 8:30am EST (May 1994-December 2012), and 12:00pm EST (January 2013-January 2017). While close-to-close returns, ΔP_t, may not reflect the full price reaction to USDA news (Isengildina et al., 2006), their use is required in this study due to changes in both trading times and the report release times during our sample period. Further, the model incorporates market surprises in Crop Production and Grain Stocks in different report months separately rather than pooled as the joint equality of surprise coefficients across report months is rejected in most cases.

[8] The dummy variable is included in the conditional variance equation to allow futures price volatility to increase on report release days as shown in the literature (e.g., Sumner and Mueller, 1989; Isengildina et al., 2006; Isengildina-Massa et al., 2008; Adjemian, 2012; Karali, 2012). Alternatively, the absolute value of market surprises or separate release-day dummy variables can be incorporated to tease out each report's specific effect on volatility. However, this approach significantly increases the number of parameters to be estimated in this nonlinear, dynamic system of equations, creating convergence issues in the algorithm.

Table 4
Tests of price reaction to surprises in USDA reports for corn and soybeans, 1984/85–2016/17 marketing years.

	(I) 1984–2016		(II) 1984–2006		(III) 2007–2016	
	Corn	Soybeans	Corn	Soybeans	Corn	Soybeans
	Mean equation		*Mean equation*		*Mean equation*	
Constant	−0.03**	−0.01	−0.03**	−0.02	−0.01	0.02
	(0.01)	(0.01)	(0.01)	(0.01)	(0.03)	(0.02)
Own surprises						
Prospective plantings	−0.68***	−0.68***	−0.58***	−0.63***	−1.11***	−1.11***
	(0.10)	(0.09)	(0.11)	(0.09)	(0.34)	(0.28)
Acreage	−1.48***	−1.07***	−1.04***	−1.04***	−2.27***	−0.93***
	(0.25)	(0.170)	(0.29)	(0.20)	(0.49)	(0.30)
Crop production						
August	−0.85***	−0.25**	−0.98***	−0.18	0.37	−0.65***
	(0.14)	(0.11)	(0.14)	(0.12)	(0.46)	(0.26)
September	−0.58***	−0.32***	−0.62***	−0.22	−0.38	−0.69**
	(0.17)	(0.13)	(0.18)	(0.16)	(0.48)	(0.29)
October	−0.98***	−0.67***	−0.85***	−0.87***	−4.34***	0.48
	(0.25)	(0.14)	(0.24)	(0.14)	(1.14)	(0.48)
November	−1.04***	−0.58***	−0.75***	−0.49*	−2.73***	−0.58*
	(0.26)	(0.21)	(0.28)	(0.30)	(0.87)	(0.36)
CPAS	−0.37*	−1.26***	−0.46**	−0.92***	−0.91	−3.21***
	(0.20)	(0.21)	(0.23)	(0.22)	(0.59)	(0.62)
Grain stocks						
January	−0.60***	0.12	−0.37***	−0.03	−1.60***	0.43*
	(0.11)	(0.12)	(0.13)	(0.14)	(0.28)	(0.25)
March	−0.70***	−0.06	−0.50***	−0.05	−1.25***	−0.11
	(0.08)	(0.07)	(0.11)	(0.08)	(0.22)	(0.17)
June	−0.31***	−0.24***	−0.25**	−0.28***	−0.32	−0.30**
	(0.08)	(0.07)	(0.10)	(0.10)	(0.21)	(0.15)
September	−0.19***	−0.05***	−0.11	−0.07***	−0.24***	0.01
	(0.04)	(0.02)	(0.07)	(0.02)	(0.05)	(0.03)
Cross surprises						
Prospective plantings	−0.13	−0.18*	−0.05	−0.18*	−0.81***	−0.35
	(0.08)	(0.10)	(0.09)	(0.11)	(0.30)	(0.31)
Acreage	−0.34*	−0.39*	−0.14	−0.46	−0.65*	−0.23
	(0.194)	(0.23)	(0.22)	(0.29)	(0.37)	(0.42)
Crop production						
August	0.27**	−0.45***	0.37***	−0.52***	−0.52*	0.07
	(0.12)	(0.13)	(0.13)	(0.14)	(0.31)	(0.43)
September	0.20	0.25	0.19	0.18	0.33	0.73
	(0.13)	(0.17)	(0.15)	(0.19)	(0.35)	(0.46)
October	0.24	−0.94***	0.00	−0.99***	2.26***	−2.00**
	(0.16)	(0.22)	(0.15)	(0.22)	(0.53)	(0.88)
November	−0.22	−0.90***	−0.76***	−0.91***	0.76*	−0.93
	(0.22)	(0.26)	(0.30)	(0.28)	(0.42)	(0.76)
CPAS	−0.39**	0.03	−0.24	−0.10	−1.25	0.57
	(0.17)	(0.23)	(0.18)	(0.28)	(0.78)	(0.53)
Cross surprises						
Grain stocks						
January	−0.10	−0.38***	−0.25**	−0.24	−0.09	−0.81***
	(0.10)	(0.13)	(0.12)	(0.16)	(0.32)	(0.27)
March	0.06	−0.42***	0.11	−0.39***	0.17	−0.46***
	(0.07)	(0.07)	(0.08)	(0.10)	(0.20)	(0.18)
June	−0.25***	−0.13**	−0.18**	−0.24**	−0.40*	−0.09
	(0.08)	(0.06)	(0.09)	(0.11)	(0.22)	(0.13)
September	0.01	−0.09***	0.00	−0.03	0.04	−0.12***
	(0.01)	(0.03)	(0.01)	(0.07)	(0.03)	(0.04)
	Variance equation		*Variance equation*		*Variance equation*	
Constant	−3.68***	−3.66***	−3.33***	−3.46***	−2.94***	−3.58***
	(0.15)	(0.14)	(0.15)	(0.15)	(0.29)	(0.29)
Report dummy	2.73***	2.66***	2.22***	2.24***	2.72***	3.15***
	(0.19)	(0.19)	(0.21)	(0.23)	(0.34)	(0.33)
ARCH	0.09***	0.08***	0.09***	0.08***	0.08***	0.08***
	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)
GARCH	0.89***	0.90***	0.87***	0.90***	0.89***	0.90***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Quasicorrelation (ρ_{12})	0.69***		0.70***		0.66***	
	(0.02)		(0.02)		(0.02)	
Adjustment coeff. (λ_1)	0.03***		0.03***		0.04***	
	(0.00)		(0.00)		(0.01)	
Adjustment coeff. (λ_2)	0.96***		0.96***		0.92***	
	(0.01)		(0.01)		(0.02)	
Observations	8,319		5,799		2,520	
Log likelihood	−24575.92		−16029.51		−8406.51	

(*continued on next page*)

Table 4 (*continued*)

	(I) 1984–2016		(II) 1984–2006		(III) 2007–2016	
	Corn	Soybeans	Corn	Soybeans	Corn	Soybeans
AIC	49265.85		32173.02		16927.02	
BIC	49666.35		32552.95		17259.45	

Note: Results are obtained by the estimation of the DCC MGARCH-X(1,1) model in Eq. (2). Values in () are standard errors. The asterisks *, **, *** represent statistical significance at the 10%, 5%, and 1% level, respectively. CPAS = Crop Production Annual Summary report; AIC = Akaike Information Criterion; BIC = Bayesian Information Criterion.

$$\boldsymbol{C}_t = \begin{bmatrix} 1 & \rho_{12,t} \\ \rho_{12,t} & 1 \end{bmatrix}. \tag{4}$$

Finally, $\boldsymbol{\varepsilon}_t$ is a 2×1 vector of standardized residuals, λ_1 and λ_2 are nonnegative parameters that govern the dynamics of conditional correlations, and $\boldsymbol{C}$ is the weighted average of the unconditional covariance matrix of the standardized residuals and the unconditional mean of $\boldsymbol{Q}_t$.

Estimation results for futures price reaction regressions are presented in Table 4 for corn and soybeans and in Table 5 for winter and spring wheat. Each table shows three sets of results: regression (I) includes the entire sample period; regression (II) is estimated for the "traditional" pre-2007 sub-period; and regression (III) is estimated for the "new era" 2007–2016 sub-period. Regression (I) is also estimated after including all the independent variables interacted with the post-2007 sub-period to conduct a Chow test for the hypothesized break in the price reactions since the beginning of 2007. The null hypothesis of no change in the coefficients during 2007–2016 is rejected at the 1% level for all commodities with the Chi-squared values 109.85 for corn, 46.15 for soybeans, 30.54 for winter wheat, and 33.67 for spring wheat.

The impact of USDA reports on futures return variance seems to have intensified while the ARCH and GARCH effects remained stable over time across all commodities. The conditional quasicorrelation between the standardized residuals for winter and spring wheat returns has strengthened while that for corn and soybean returns appears to have weakened over time. For both commodity pairs, the adjustment parameter λ_2 is larger compared to λ_1, indicating that the evolution of the conditional covariances depends more on their own lagged values than on lagged residual innovations.

Full sample results show that both corn and soybean futures prices react to their own surprises in all of the reports considered in the expected direction. While the corn market reacts to soybean surprises in Acreage, August Crop Production, Crop Production Annul Summary, and June Grain Stocks reports, the soybean market appears to be more sensitive to corn information in almost all the reports except for September Crop Production and Crop Production Annual Summary. Full sample results in Table 5 depict a different picture for wheat markets. There are only a few significant price reactions to own surprises in Winter Wheat Seedings and June Crop Production for winter wheat, and in Prospective Plantings, Acreage, and August Crop Production for spring wheat. There is limited evidence of cross-commodity surprise impacts, with winter wheat futures reacting to information on spring wheat in Prospective Plantings and spring wheat futures responding to winter wheat information in June Crop Production reports. Both markets tend to react to surprises regarding all wheat in Grain Stocks reports. In the following discussion of the results, we focus on the surprise coefficients for each report across the two sub-periods (pre- and post-2007) to assess whether these price impacts varied over time.

Our results indicate that the price impact of own surprises in Prospective Plantings reports has increased almost two-fold in corn and soybeans and by about five-fold in spring wheat. These reports are based on the NASS surveys of producer planting intentions and there is limited competing information available from the private sources for these reports. This increase in price impact is indicative of greater value of reliable public information in volatile commodity markets.

Acreage reports update plantings information based on a survey of actual plantings conducted in June (similar information is available for winter wheat in Winter Wheat Seedings reports released in January). Our results indicate an increased price reaction to these reports in corn and decreased reactions in other commodities. It is important to note that planting information may be available through precision agriculture equipment making USDA a less unique source of acreage information.

Crop Production reports face the largest amount of competition from private information sources. However, our findings demonstrate that crop price reaction to new information in these reports increased in magnitude for late season (October and November) corn, early season (August, September) and November soybeans, June winter wheat, and July spring wheat. The impact of the remaining Crop Production reports remained mostly stable over time. These results suggest that competition from private information sources did not erode the value of USDA information in crop markets.

Our findings for Crop Production Annual Summary reports in Table 4 provide the most clear evidence of the benefits of report identification implemented in our study. While most previous studies (including the most recent Ying et al. (2017) and Isengildina-Massa et al. (2016) papers) find a significant market reaction to these reports, they fail to account for the fact that these reports are almost always released at the same time with the January Grain Stocks reports. Our methodology allows us to decompose the price impact of these two reports released at the same time and reveals that most of the reaction in the corn market during 2007–2016 is due to new information contained in Grain Stocks reports while the soybean market reacts mostly to Crop Production Annual Summary reports with about three-fold increase across sub-periods.

Grain Stocks reports likely face the least amount of competition from private information sources as these reports are based on survey estimates of on- and off-farm storage, which are not observable through precision agriculture or remote sensing technology. The on-farm survey is a probability survey of farm operators, the off-farm stocks survey enumerates the volume of grain in all known commercial grain storage facilities. Our results demonstrate an increased impact of January, March, and September reports for corn, June report for soybeans, and March report for winter and spring wheat. At the same time, the impact of January and September Grain Stocks reports declined in both wheat markets, and the impact of June and September reports declined for corn and soybeans, respectively. Thus, the results are largely mixed for soybeans and wheat but demonstrate a mostly stronger impact in corn. This finding may be associated with the effects of the biofuel mandate that put additional pressure on corn inventories.

Our models also measure changes in market reaction to cross-commodity surprises. Table 4 demonstrates that the soybean market appeared to react to new information on corn contained in Prospective Plantings and Crop Production more during pre-2007, and to Grain Stocks more in the post-2007 period. The opposite pattern is observed for corn: the corn market reacted to soybean surprises in Grain Stocks reports more prior to 2007 and to those in Prospective, Acreage, and Crop Production (although, in opposite direction for October and

Table 5
Tests of price reaction to surprises in USDA reports for winter and spring wheat, 1994/95–2016/17 marketing years.

	(I) 1994–2016		(II) 1994–2006		(III) 2007–2016	
	Winter wheat	Spring wheat	Winter wheat	Spring wheat	Winter wheat	Spring wheat
	Mean equation		*Mean equation*		*Mean equation*	
Constant	−0.09***	−0.04***	−0.08***	−0.04**	−0.11***	−0.06**
	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)	(0.03)
Own surprises						
Prospective plantings		−0.26***		−0.07		−0.33***
		(0.05)		(0.08)		(0.07)
Acreage/WWS	−0.15*	−0.22***	−0.28***	−0.26***	0.03	−0.16
	(0.09)	(0.065)	(0.11)	(0.08)	(0.22)	(0.14)
Crop production						
May	−0.10		−0.11		0.02	
	(0.14)		(0.17)		(0.23)	
June	−0.44**		−0.07		−0.59**	
	(0.19)		(0.29)		(0.25)	
July	0.04	−0.07	−0.10	−0.01	0.48*	−0.34**
	(0.17)	(0.10)	(0.23)	(0.13)	(0.27)	(0.17)
August	0.15	−0.25**	−0.03	−0.41***	0.43	−0.08
	(0.28)	(0.10)	(0.31)	(0.12)	(0.64)	(0.20)
Cross surprises						
Prospective plantings	−0.23***		−0.01		−0.31***	
	(0.07)		(0.10)		(0.09)	
Acreage/WWS	−0.09	−0.07	−0.17*	−0.19**	0.00	0.12
	(0.080)	(0.07)	(0.10)	(0.09)	(0.20)	(0.18)
Crop production						
May		−0.08		−0.11		0.04
		(0.11)		(0.12)		(0.17)
June		−0.31**		−0.02		−0.47***
		(0.14)		(0.23)		(0.18)
July	0.00	−0.10	0.03	−0.17	−0.35*	0.16
	(0.12)	(0.13)	(0.15)	(0.19)	(0.21)	(0.18)
August	−0.11	0.17	−0.31**	−0.13	0.17	0.68
	(0.12)	(0.23)	(0.14)	(0.28)	(0.25)	(0.52)
All wheat surprises						
Grain stocks						
January	−0.40***	−0.27**	−0.38**	−0.32**	−0.38	−0.11
	(0.15)	(0.12)	(0.17)	(0.14)	(0.31)	(0.24)
March	−0.31***	−0.13	−0.37***	−0.13	−0.55**	−0.42**
	(0.12)	(0.09)	(0.14)	(0.11)	(0.26)	(0.21)
June	−0.05	−0.02	−0.04	0.05	−0.08	−0.09
	(0.09)	(0.07)	(0.14)	(0.12)	(0.16)	(0.13)
September	−0.38***	−0.29***	−0.56***	−0.43***	−0.11	−0.10
	(0.08)	(0.07)	(0.10)	(0.09)	(0.13)	(0.11)
	Variance Equation		*Variance Equation*		*Variance Equation*	
Constant	−3.36***	−3.74***	−3.16***	−3.32***	−3.50***	−3.98***
	(0.21)	(0.20)	(0.26)	(0.24)	(0.41)	(0.39)
Report dummy	2.82***	2.52***	1.92***	1.49***	3.33***	3.21***
	(0.25)	(0.29)	(0.42)	(0.55)	(0.47)	(0.50)
ARCH	0.05***	0.06***	0.04***	0.06***	0.05***	0.06***
	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
GARCH	0.93***	0.92***	0.93***	0.91***	0.94***	0.93***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Quasicorrelation (ρ_{12})	0.88***		0.85***		0.93***	
	(0.01)		(0.01)		(0.01)	
Adjustment coeff. (λ_1)	0.06***		0.05***		0.06***	
	(0.00)		(0.01)		(0.01)	
Adjustment coeff. (λ_2)	0.92***		0.91***		0.92***	
	(0.01)		(0.01)		(0.01)	
Observations	5,792		3,272		2,520	
Log likelihood	−16794.93		−9044.03		−7637.45	
AIC	33667.86		18166.06		15354.90	
BIC	33927.77		18403.70		15588.18	

Note: Results are obtained by the estimation of the DCC MGARCH-X(1,1) model in Eq. (2). Values in () are standard errors. The asterisks *, **, *** represent statistical significance at the 10%, 5%, and 1% level, respectively. WWS = Winter Wheat Seedings report; AIC = Akaike Information Criterion; BIC = Bayesian Information Criterion.

November reports) more post 2007. Our findings in Table 5 indicate that during the post-2007 sub-period the winter wheat futures market became sensitive to information on spring wheat in Prospective Plantings and July Crop Production reports, while the spring wheat market reacted to information about winter wheat only in June Crop Production reports.

Sensitivity of our findings to sub-period selection is examined in Figs. 3–5 that show the results from the DCC MGARCH-X(1,1) model given in Eq. (2) with a 10-year rolling window by dropping the earliest calendar year and adding the newest one as we move forward in time.[9]

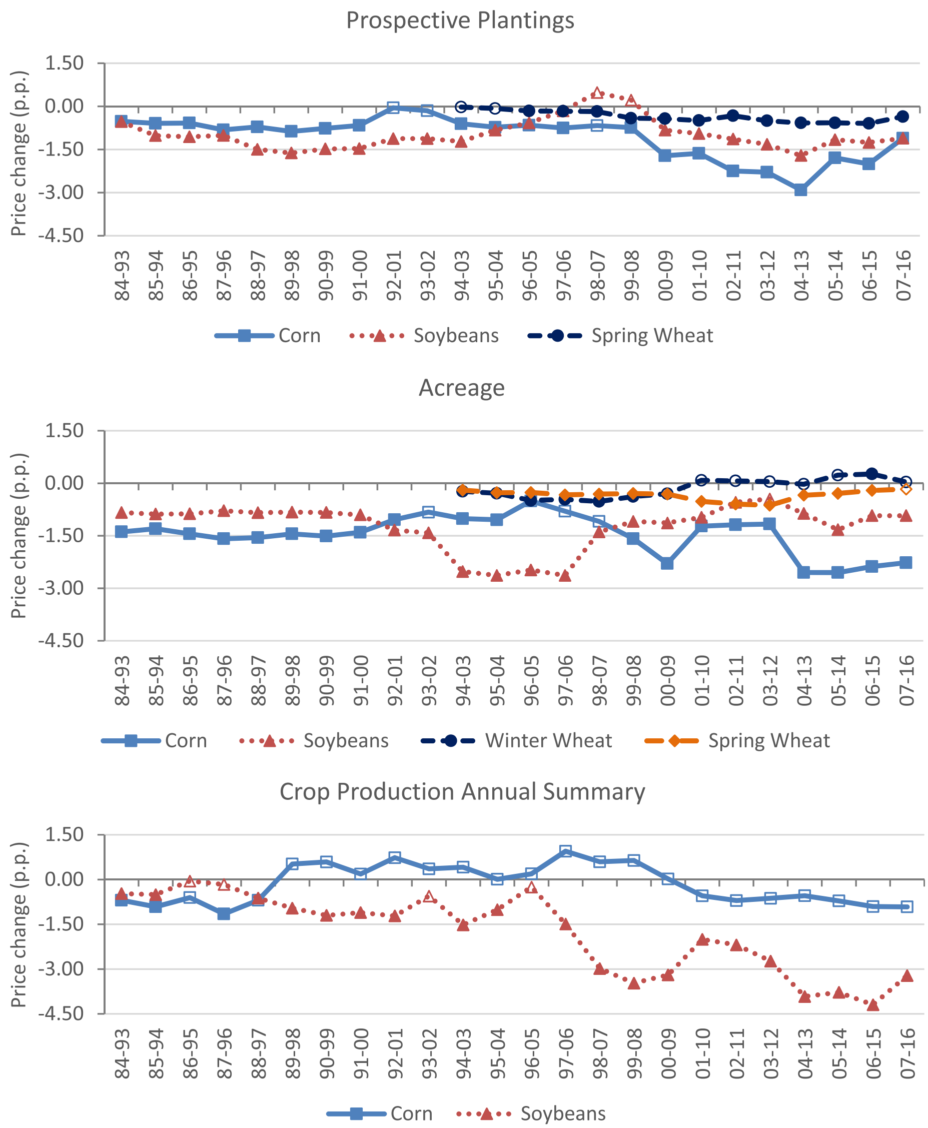

Fig. 3. Changes in crop price reaction to market surprises in Prospective Plantings, Acreage, and Crop Production Annual Summary Reports based on 10-year rolling regressions.

Note: Results are obtained by the estimation of the DCC MGARCH-X(1,1) model in Eq. (2) using a 10-year rolling sample period. Coefficient estimates that are statistically significant at the 10% level are plotted with a filled marker symbol, whereas insignificant estimates are indicated with an open marker.

In these figures, own-surprise coefficient estimates that are statistically significant at the 10% level are plotted with a filled marker symbol, whereas insignificant estimates are indicated with an open marker.[10] While our findings in Table 4 indicate a significant increase in both corn and soybean market reaction to new information contained in Prospective Plantings reports, Fig. 3 suggests that this increase was rather short lived in the soybean market. On the other hand, our results in Fig. 3 confirm a dramatic increase in the corn market reaction to surprises in Prospective Plantings reports starting in early 2000s. Our results for Acreage reports confirm our previous findings of increased price reaction to the surprises in these reports for corn, but not for other commodities. Our previous findings of increased price reaction to Crop Production Annual Summary reports in soybeans but not in corn are also confirmed in Fig. 3.

5. Summary and conclusions

USDA acreage, production, and stock reports have served as the benchmark in crop markets for almost a century. However, their role may have been affected by the numerous structural changes that took place in commodity markets. Since the early to late-2000s, crop markets observed the introduction of the biofuel mandate, the boom and bust of commodity prices, the development of various new crop varieties, the increased impacts of financialization in commodity futures, all causing increasing uncertainty in these markets. At the same time, technological innovations gave rise to a number of new firms that attempt to resolve some of this uncertainty through applications of satellite imagery, remote sensing data, and computing power commonly referred to as "big data." The growing presence of these big data firms and continuously shrinking federal budgets has spawned a major

[9] We also estimated our model using the sub-periods 1984–2003 and 2009–2016 for corn and soybeans, and using 1994–2003 and 2009–2016 sub-periods for winter and spring wheat to evaluate whether our findings are robust to excluding the years during which many structural changes occurred in crop markets as explained before and found no qualitative differences. Results are available from the authors upon request.

[10] Convergence during 1988–1997 and 1998–2007 for the corn and soybean pair, and during 1996–2005 for the winter and spring wheat pair is achieved by excluding the report-day dummy variable D_t in the conditional variance Eq. (3).

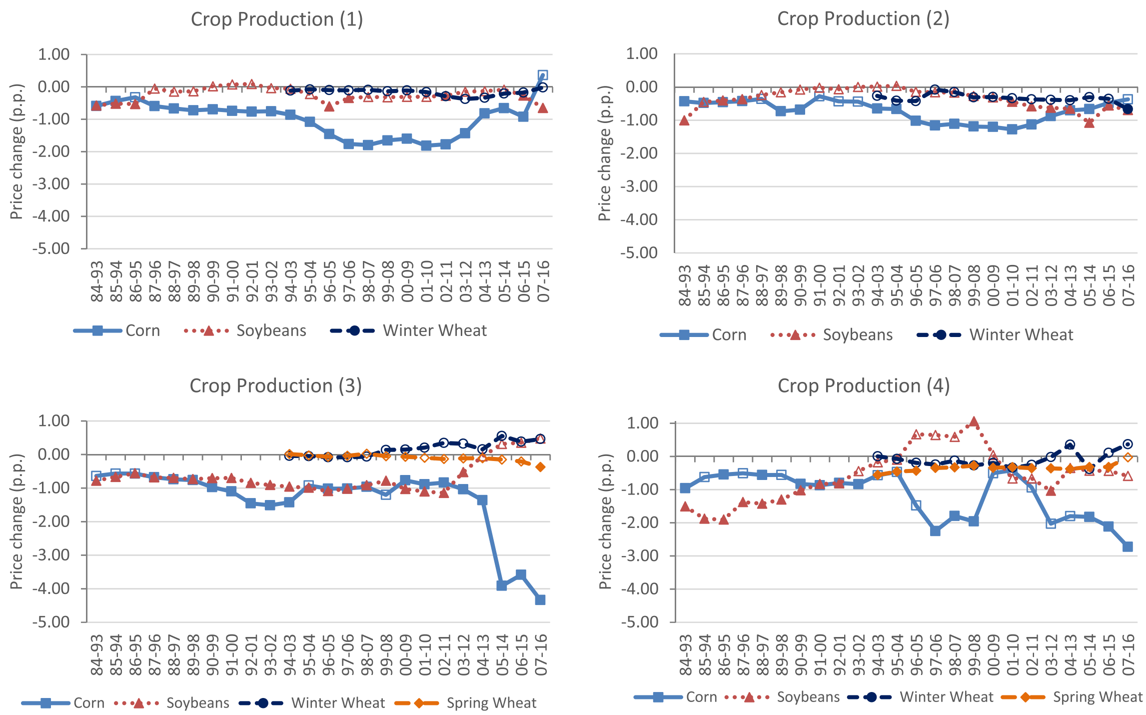

Fig. 4. Changes in crop price reaction to market surprises in Crop Production Reports based on 10-year rolling regressions.
Note: 1 = August for corn and soybeans, May for wheat; 2 = September for corn and soybeans, June for wheat; 3 = October for corn and soybeans, July for wheat; 4 = November for corn and soybeans, August for wheat. Results are obtained by the estimation of the DCC MGARCH-X(1,1) model in Eq. (2) using a 10-year rolling sample period. Coefficient estimates that are statistically significant at the 10% level are plotted with a filled marker symbol, whereas insignificant estimates are indicated with an open marker.

controversy with respect to USDA's crop forecasting program. Some argue that these public programs can be downsized or eliminated because big data sources offer faster turnaround and higher-spatial-resolution data on crop distribution, maturation status, and yield predictions than the USDA. The implication is that USDA crop reports may no longer provide important "news" to the markets.

This study investigates whether USDA reports still provide important news to changing crop markets using the most comprehensive set of market expectations in the literature to date. This allows the news impact of each report to be estimated within a properly identified system of all major reports that avoids problems related to report clustering. We measure changes in both the news component of USDA

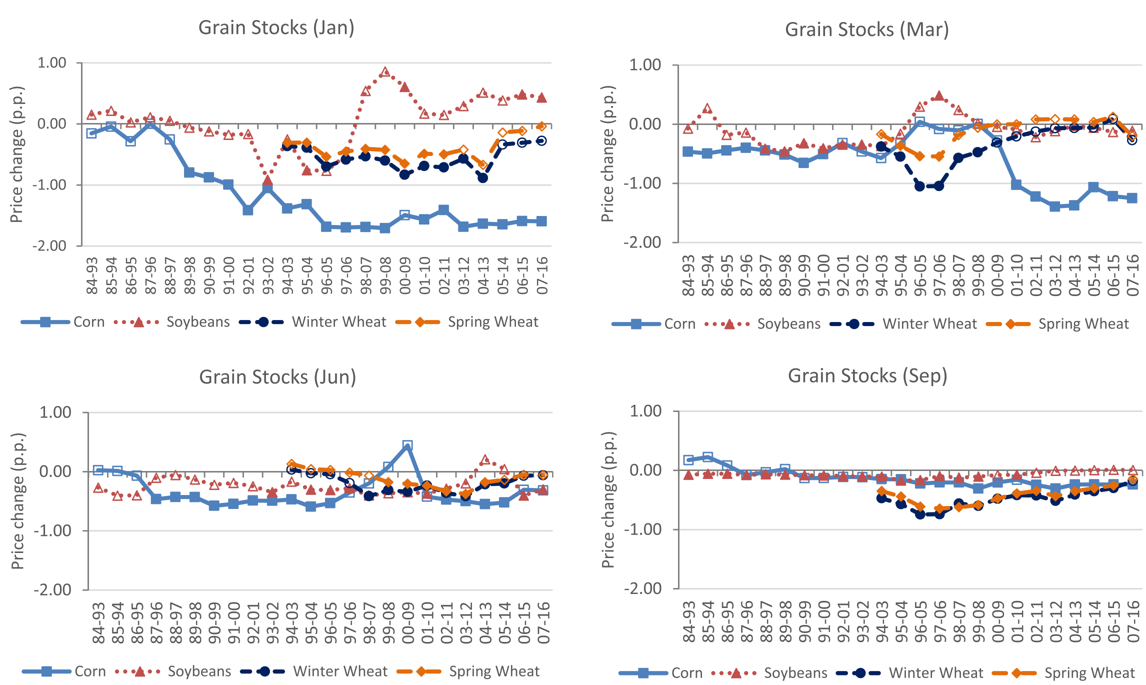

Fig. 5. Changes in crop price reaction to market surprises in Grain Stocks Reports based on 10-year rolling regressions.
Note: Results are obtained by the estimation of the DCC MGARCH-X(1,1) model in Eq. (2) using a 10-year rolling sample period. Coefficient estimates that are statistically significant at the 10% level are plotted with a filled marker symbol, whereas insignificant estimates are indicated with an open marker.

crop reports, as well as in the price reaction to these news in the reports. If the relevance of USDA information is becoming replaced by private information sources, we expect a decline in market surprises and potentially a smaller price reaction to those surprises as markets become more informed through alternative sources. On the other hand, USDA information may become more important than ever in the markets filled with greater uncertainty due to structural changes and added "noise" from new data sources without established track record. In this case, the market surprise would tend to grow.

Our tests of differences in the size of surprises across pre- and post-2007 sub-periods provide limited evidence of significant changes for all reports except for two Grain Stocks (June and September for corn) and one Crop Production (June winter wheat) reports, where the magnitude of surprises was substantially larger in the later period. The stable or increasing size of market surprises suggests the news component of USDA crop reports has not been replaced by alternative information sources.

Our findings for price reactions to the news in USDA crop reports demonstrate that the price impact of the news component of most USDA reports has tended to increase since January 2007 rather than decrease. The largest increase in the corn market is observed for October Crop Production reports, but other reports including Prospective Plantings, Acreage, November Crop Production, and Grains Stocks (except for June) also had increased impacts. Soybean markets became more sensitive to new information in Prospective Plantings reports as well as early season Crop Production and Crop Production Annual Summary reports even in the presence of private data sources providing similar information. Wheat markets demonstrated a rather limited reaction to USDA information relative to corn and soybeans. This pattern appeared to remain stable over time.

This conclusion is also supported by the finding that changes in the impact of USDA reports are most pronounced in the corn market that has been affected by structural changes relatively more than other crop markets due to the direct effects of ethanol policies. Our results demonstrate clear evidence of an increased impact of Prospective Plantings, Acreage, late season Crop Production, and Grain Stocks reports in the corn market. This evidence suggests that in the periods of increased market uncertainty, public turns to USDA for reliable information even in the presence of private firms providing data on acreage and crop production. Thus, the public good aspects of USDA information tend to become enhanced in changing crop markets.

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