Title: What do we know about the value and market impact of USDA reports?

Authors: Olga Isengildina Massa, Berna Karali, Scott H. Irwin[1]

Correspondence to be sent to:

Olga Isengildina Massa
Department of Agricultural and Applied Economics,
Virginia Polytechnic Institute and State University
250 Drillfield Drive
Hutcheson Hall, 321-A
Blacksburg, Virginia 24061
P: (540) 231-0891
F: (540) 231-7417
oimassa@vt.edu

[1]Olga Isengildina Massa is the John and Kristi Rowsell Professor in the Department of Agricultural and Applied Economics at Virginia Polytechnic Institute and State University. Berna Karali is a Professor in the Department of Agricultural and Applied Economics at the University of Georgia. Scott H. Irwin is the Laurence J. Norton Chair of Agricultural Marketing in the Department of Agricultural and Consumer Economics at the University of Illinois at Urbana Champaign.

WHAT DO WE KNOW ABOUT THE VALUE AND MARKET IMPACT OF USDA REPORTS?

Abstract. The purpose of this paper is to comprehensively review the literature on the value and impact of USDA reports and discuss theoretical issues and empirical evidence. Only a handful of studies provide direct estimates of the welfare benefits of USDA information using rational expectations framework in storable commodity markets. Most studies examine indirect evidence of welfare benefits associated with market response to USDA information. These studies are classified as unconditional market impact, conditional market impact, impact on market uncertainty, impact of unanticipated information, intraday impact and informational value, returns and survey-based studies. We discuss methodological and empirical contributions of these studies as well as their shortcomings and potential opportunities for future work.

Keywords. Commodity futures, informational value, market impact, options, value of public information, unanticipated information, welfare benefits,

JEL codes: D40, Q11, Q13, Q19.

1. Introduction

The United States Department of Agriculture (USDA) has been the primary source of public information in agriculture since the 1920s. Kunze (1990) and Allen (1994) provide excellent reviews of the history of public situation and outlook programs in the U.S. USDA collects and disseminates a diverse and sizable amount of data on agricultural markets as a part of the federal government's broader statistical programs. The rationale for USDA's situation and outlook information 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, these situation and outlook products also incur considerable costs. The Office of Management and Budget reported that out of "6.6 billion in total direct 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 were allocated to National Agricultural Statistical Service (NASS), an agency primarily responsible for data collection and dissemination. Thus, the relevance and economic value of public situation and outlook information has long been a subject of debate.

This debate has become more intense for several reasons, including the changing structure of agriculture, the growth of private firms that provide relatively low-cost information and market analysis of the type traditionally provided by public programs and evolving priorities within the USDA. For example, Just (1983) argued that public situation and outlook programs should be downsized or eliminated because private firms perform the functions historically provided by public programs. Salin et al. (1998) provided the following strong challenge to public programs: "If public information simply replicates what is known and disseminated in the private sector, then the public sources are superfluous and might be eliminated. As proprietary data play an increasingly central role in agricultural decision making, the public sector niche in the market for agricultural information must be reconsidered." (p.122)

In light of these challenges, the value and market impact of USDA information has generated considerable attention in the academic literature with dozens of studies published on this subject over the years. This scrutiny has increased dramatically in recent years due to the release of intraday data by futures exchanges that allows researchers to zoom into market reaction and market operation around report releases. Despite the explosion in the literature on the impact of USDA reports, no study has surveyed this literature systematically. The purpose of this paper is to comprehensively review the literature on the value and impact of USDA reports and discuss theoretical issues, empirical evidence as well as shortcomings and potential extensions in future work.

The need for such an extensive study has also been repeatedly expressed in the popular press and by producer groups across the country (e.g., National Corn Growers Association, American Farm Bureau Foundation). Agricultural producers are the foundation of the USDA information system, as most of it is survey-based and relies on voluntary participation. However, producer concerns regarding the increasing complexity of the USDA survey processes has lead to declining participation rates documented by Johansson, Effland, and Coble (2017). Therefore, better understanding of USDA reports and the value they provide to agricultural markets would help maintain the quality of USDA information through increased survey participation rates.

Myers, Sexton, and Tomek (2010, p.391), argued that, "It is widely believed that more and better information about agricultural market outcomes has benefits and that there is a role for public provision of such information due to the public-good nature of information. But little rigorous research exists on the returns to investment in agricultural market information." The extant literature focused primarily on the value or benefits of information, without any reference to the cost of collection and dissemination. Nevertheless, there are a variety of approaches that have been used to (partially) assess the value of USDA situation and outlook information, including direct measures based on welfare models, indirect measures based on market response to information, and indirect measures based on informational value, trading returns and surveys. We group the published studies based on the approaches they applied in order to highlight the gaps in the literature and opportunities for further research.

2. Direct Measures Based on Welfare Models

Several studies attempted to directly estimate the welfare benefits of public situation and outlook information using the rational expectations framework in storable commodity markets. Hayami and Peterson (1972) and Bradford and Kelejian (1978) developed analytical frameworks based on intra-annual storage models to assess the welfare costs of measurement errors in public information. Hayami and Peterson (1972) is one of the only studies that compared the costs of data collection to an estimate of the benefits. They used two approaches to value improvements in the accuracy of USDA price and production information. The first relies on an "inventory adjustment model," which assumes that supply is perfectly inelastic (i.e., crop production is essentially predetermined after planting). Improved information, however, can lead to more accurate decisions about the value of returns to storage. Inaccurate information might result in over- or under-storage relative to what the true competitive equilibrium would indicate as socially optimal. The second is a "production adjustment model," which argues that better information leads producers to more accurately choose a quantity of production that corresponds to the competitive equilibrium.

Hayami and Peterson (1972) estimated substantial benefits that exceed the costs of improving the accuracy of USDA statistics. They found that, given the costs of data collection at the time of their study: "each extra dollar invested in increasing the accuracy of statistics from the 2.5 to the 2.0 level of error returns more than $600 worth of benefit to society. And increasing the level of accuracy from 2.0 to 1.5 percent error produces $90 to $100 of benefit for each extra dollar invested." These estimates correspond to the value of improved information but do not relate to the total value of data. As Hayami and Peterson (1972) discuss (p. 124), the answer to that question will depend on the relative sizes of the elasticities of supply and demand, and whether the "stability" conditions hold in their cobweb-type model.

Bradford and Kelejian (1978) analyzed the social value of improving the accuracy of USDA wheat crop forecasts. They specified a model where market participants have rational expectations, but the only source of information on potential crop size is an information agency (e.g., the USDA). Market participants are assumed to apply a Bayesian updating procedure to the crop forecasts. Bradford and Kelejian (1978) reported a point estimate of the net social loss of less than perfect wheat crop forecasts of $64 million (1975 dollars).

Antonovitz and Roe (1986) studied the value of improved price forecasts to fed cattle producers using an expected utility framework. They estimated the value of adopting a rational expectations price forecast (presumably provided by the USDA). They found that (p. 722), "The mean expected bimonthly value of information for the 1970-80 period was $0.21 per hundredweight (cwt) of production or, in total value terms, a mean of approximately $13.3 million per bimonth."

Abbot, Boussios, and Lowenberg-DeBoer (2016) used dynamic multi-period Monte Carlo simulation of the inventory adjustment models for the U.S. corn market to estimate the value of the WASDE report and its components. 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).

Gouel (2020) developed a rational expectations storage model of the global soybean market accounting for both inter-annual and intra-annual market dynamics. He estimated that the efficiency gains related to the availability of advanced information (from USDA and private firms) were equivalent to 2% of storage costs, with a reduction of stock levels being the main source of welfare gains. "This corresponds to welfare benefits of news of $43 million for news about the U.S. and Latin America harvest, $20 million being related to the U.S. harvest. Because for the U.S. harvest seasonal crop forecasts by private firms predict two-thirds of the total shocks variance, they also account in the model for most of the welfare benefits of news shocks, the increased precision brought by USDA reports accounting only for $7 of the $20 million." (Gouel, 2020, p. 863) However, the authors recognized that their study dealt with only a small part of the potential benefits of public information in these markets and likely led to underestimation of its value.

As a group, these empirical studies suggest the social welfare value of public situation and outlook information substantially exceeds the cost. C-FARE (2013, p. 14) argued that the advantage of these studies is that "they provide a direct estimate of the value of information that can (in principle) be compared to costs. Moreover, they are based on structural models of supply and demand, firmly grounding the estimated value of information as a welfare measure derived from economic theory. Downsides of this approach can include: 1) it may not be accurate to assume that market participants (and the analysts) know the structural parameters of the model (which is highly dubious in the absence of public data); 2) benefit estimates are often associated with improved accuracy of information rather than the total value of a data product; 3) such approaches often fail to consider the effects of private data sources or futures market prices on the accuracy of producers' expectations; 4) the approaches may under-estimate the full value of information because they do not consider the benefits from improved research, education, and public policy advice." For example, Adjemian and Smith (2012) demonstrated how USDA forecasts can be used to estimate price flexibility of demand for agricultural commodities. Therefore, extensions of these models that relax some of these assumptions and include additional benefits that more accurately reflect the total value of the data products represent potential avenues for future research.

3. Indirect Measures based on Market Response to Information

Given the technical challenges associated with direct welfare estimation, it is probably not surprising that most studies examine indirect evidence of welfare benefits. The evidence is indirect because only measures indirectly related to welfare are examined, such as price impact or forecast accuracy. For example, Sumner and Muller (1989) argued that "For information services provided by the government (or any other source) to have more than consumption value, the announcement must affect economic agents' decisions and the resulting allocations of goods and services. Four factors are required for information services to be effective. First, they must cover a topic of interest to economic agents. Second, they must reach agents while relevant decisions are pending. Third, they must be considered relatively accurate – or at least useful for forecasting. Fourth, the announcements must be new in the sense that some interested economic agents do not already possess the information." (p.1)

The price impact of information on commodity markets is traditionally measured using an event study approach. The basic notion of the event study is simple: if prices react to the announcement of information ("the event") in an efficient market, then the information is valuable to market participants (Campbell, Lo, and MacKinlay, 1997). Specifically, variability of futures prices around important scheduled news announcements should be characterized by a "spike" in variability on the announcement date and "normal" variability on non-announcement dates (Sumner and Mueller, 1989). For example, figure 1 shows corn market reaction to WASDE report release (Isengildina-Massa et al., 2008a). Since, under market efficiency, futures prices represent the conditional expectation of spot prices at contract maturity, the spike in futures return variance reflects the change in market participants' expectation of spot prices due to the new announcement. Note that the change in futures prices can be either positive or negative depending on the implications of the news for the level of prices, therefore the analysis focuses on changes in volatility as a measure of market reaction, typically measured as absolute value of price changes (futures returns). The purpose of the statistical tests is to determine whether futures return variability on event (report release) sessions is significantly different from the normal variability on non-event days.

3.1 Unconditional Market Impact Studies

Table 1 provides a summary of the first set of event studies where the event is measured by the date and time of USDA report releases and the unconditional (where other factors were not considered) market impact is assessed using various parametric and non-parametric tests. While earlier studies (Hoffman, 1980; Conklin, 1983; Fackler, 1985; Milonas, 1987; Sumner and Mueller, 1989; Fortenbery and Sumner, 1983; Isengildina-Massa et al., 2008a; Lehecka, 2014) typically focused on a single report, later studies (Dorfman and Karali, 2015; McKenzie and Darby, 2017; Ying, Chen and Dorfman, 2019; and Isengildina-Massa et al., 2021) included multiple reports. There is extensive evidence of significant market reactions to WASDE and Crop Production reports in corn, soybean, wheat, and rice markets. Prospective Plantings and Acreage reports also lead to significant market reactions and not just in directly affected markets (corn, soybeans, wheat, cotton, rice), but in related markets such soybean meal and oil (Dorfman and Karali, 2015). Dorfman and Karali (2015) explored cross-commodity effects of USDA reports and demonstrated multiple cases of indirect impacts of these reports on related markets. Grain Stocks reports also caused significant market reactions in corn, soybean, wheat, cotton as well as soybean meal and oil markets.

It is important to note that many of USDA reports were typically released at the same time. This issue of report clustering was examined by Isengildina-Massa et al. (2021). Figure 2 shows corn market reaction to USDA reports over 1985-2018 (Isengildina-Massa et al, 2021) and suggests that markets move the most when several reports are released at the same time, such as WASDE, Grain Stocks, and Crop Production Annual Summary in January, Prospective Plantings and Grain Stocks reports in March, Acreage and Grain Stocks in June, and WASDE and Crop Production in August. On the other hand, most WASDE reports released by themselves did not cause significant market reaction (significance threshold indicated by the horizontal black line) with the exception of May WASDE that contain first estimates for the next marketing year. Thus, report clustering may have led to overestimation of WASDE market impact in some of the earlier studies that did not take it into account.

While Crop Progress and Export sales reports have been examined in only a few studies (Lehecka, 2014; Ying, Chen and Dorfman, 2019; Conklin, 1983), they were shown to affect the markets as well. On the other hand, there is limited evidence of the impact of Cattle, Cattle on Feed and Hogs and Pigs reports on livestock markets based on this type of study (Dorfman and Karali, 2015; Isengildina Massa et al, 2021). Several outlook reports, including Oil Crops Outlook, Feed Outlook and Livestock, Dairy and Poultry Outlook have been shown to have little to no impact on the markets (Dorfman and Karali, 2015; Ying, Chen and Dorfman, 2019).

Several of these studies (e.g., Fortenbery and Sumner, 1993; Isengildina-Massa et al, 2008a; Lehecka, 2014; Ying, Chen, and Dorfman, 2019; and Isengildina-Massa, et al, 2021) also examined changes in the impact of USDA reports over time. For example, Ying, Chen, and Dorfman (2019) found that the impact of Prospective Plantings, Acreage, Grain Stocks, WASDE and Crop Production reports increased over time, while the impact of Crop Progress reports decreased. Lehecka (2014) showed that the impact of Crop Progress reports increased over time. On the other hand, Isengildina-Massa, et al (2021) found a slight decrease in the impact of August and November Crop Production reports over time, while the impact of other reports has remained strong, as shown in figure 3. Thus, there is some evidence that the impact of the reports focused on estimating production may have declined in recent years, likely due to increased competition from private data sources and expansion of remote sensing technology for crop production estimation.

3.2 Conditional Market Impact Studies

Another group of studies, summarized in table 2, measured the release of USDA reports using dummy variables, along with modeling the underlying market dynamics to control for effects like daily, monthly and seasonal patterns, some also including inventory conditions and delivery horizon to better isolate the report impact (e.g., Adjemian, 2012). Controlling for underlying market dynamics improved the ability of these studies to isolate the impact of each report at the cost of moving away from non-parametric tests, as these models relied on various assumptions regarding underlying distributions. Some of these studies added evidence regarding the lack of impact of Cold Storage reports on the livestock markets and Cotton this Month reports on the cotton market.

These studies largely extended and confirmed the findings of the previous set of studies with some notable exceptions. There is evidence of significant market reaction of livestock markets to Cattle, Cattle on Feed, and Hogs and Pigs reports (Isengildina, Irwin and Good, 2006; Schroeder, Blair and Mintert, 1990) and corn markets to Oil Crops Outlook, Feed Outlook and Livestock, Dairy and Poultry Outlook reports (Karali, 2012). On the other hand, there is lack of evidence of market impact of Export Sales reports (Patterson and Brorsen, 1993; Xie et al., 2016) and Prospective Plantings and Acreage reports (Karali, 2012). Thus, in a number of cases, the findings of the studies regarding the market impact of USDA reports were contradictory. These differences were likely due to the different sample periods and methods applied. Table 2 demonstrates the variety of methods applied in these studies, ranging from GLS to VAR, with GARCH-type models being the most common approach due to persistence in futures return series.

Some of these studies examined the impact of USDA reports not only on volatility but the co-movement (covariances) across various commodities (Karali, 2012) and demonstrated both direct and indirect impacts. Others compared market reaction to both USDA and international market information. For example, Mattos and Silveira (2016) found that the Brazilian corn market reaction to USDA reports was much stronger than that to Brazilian market reports. On the other hand, coffee markets reacted to CONAB (a public agency under Brazilian Ministry of Agriculture) and International Coffee Organization (ICO) market reports, but not WASDE (Silveira, Mattos and Silveira, 2017). Overall, while these studies made significant improvements in measuring market reaction to USDA reports and controlled for market dynamics, they still assumed that futures price movements on report release sessions were solely due to USDA report impact and have not been able to disentangle it from other information.

3.3 Impact on Market Uncertainty Studies

The studies we examined so far have focused on changes in the mean of futures returns as evidence of market reaction to USDA information. McNew and Espinoza (1994, p. 490) argued that such approach "may neglect the benefit that information has on the uncertainty level in the market" and proposed using implied volatility estimates from the options markets to assess this impact. Implied volatility is a forward-looking measure of volatility that reflects changes in expectations of market participants about future uncertainty. Around scheduled news events, resolution of uncertainty is characterized by a rise in implied volatility before the announcement date, a peak on the day before the announcement, and a fall to a new lower level on the report day, as shown in figure 4.

Several studies that followed this approach are listed in table 3. For example, McNew and Espinosa (1994) found reduction in implied volatility in corn and soybean options after the release of USDA Crop Production reports. They concluded that if market participants make their decisions on the basis of both risk and return, then USDA information which would help reduce risk is economically valuable. The authors assessed this value at 0.03 \$/bu for soybeans and 0.05 \$/bu for corn. On the other hand, Fortenbery and Sumner's (1993) study that examined an earlier sample did not find significant evidence of such impact.

Isengildina-Massa et al. (2008b) demonstrated that WASDE report releases reduced uncertainty in corn and soybean markets about 70% of the time over 1985-2002. Implied volatility in these markets dropped substantially more following the sessions that contained both WASDE and NASS Crop Production reports (by 1.1 and 1.5 percentage points in corn and soybeans, respectively) compared to sessions that contained only WASDE reports (0.3 percentage points in both corn and soybean markets). Furthermore, it appeared that the impact of these reports increased during the later sub-period associated with greater market uncertainty. Cao and Robe (2022) extended these findings to demonstrate that market uncertainty in corn and soybean markets decreased not only immediately following the report release but remained low for up to five days after the release of WASDE, Grain Stocks, Prospective Plantings, and Acreage reports. These authors also accounted for other market factors. Thus, following WASDE reports, this decrease in market uncertainty was more pronounced when there had been greater disagreement among industry expectations prior to the reports. There was little evidence that tightness of stocks affected market reaction to these reports. Furthermore, it appeared that market reaction (drop in implied volatility) was stronger during the periods of greater market uncertainty modeled using changes in the Chicago Board of Trade (CBOT) Volatility Index (VIX) index.

On the other hand, Adjemian et al. (2018) examined patterns in implied volatility to assess whether October 2013 WASDE report, which was not issued due to government shut down, was "missed" by the markets. Using daily and intraday data, the authors found that "corn and soybean markets did not display characteristic patterns in terms of uncertainty resolution and price changes that are normally observed around scheduled USDA release times, meaning that options prices (and therefore the price of hedging) were higher than they likely would have been had a WASDE report come out," (p. 669) thus confirming the uncertainty-reducing features of USDA reports. Using a similar approach Goyal and Adjemian (2021) demonstrated that corn and soybean markets in January 2019, during a government shutdown, did not experience reductions in uncertainty normally observed around the release of USDA reports. The authors estimated that additional commodity market uncertainty caused by the government shutdown increased the cost of managing risk with options by over $117,000 for corn and almost $37,000 for soybeans on the report release session alone.

While these studies as a group offer some interesting insights, a relative paucity of such studies is striking. We found only six studies that examined option implied volatility reaction to USDA reports and all of these studies focused on corn and soybean markets. It appears that additional studies examining other markets would generate valuable information.

3.4 Impact of Unanticipated Information Studies

The next set of studies attempt to relax the assumption that futures price movements on report release sessions are fully attributable to USDA report impact and isolate market reaction to unanticipated information in these reports. The rationale behind this approach is that in an efficient market prices should react only to *unanticipated information* (Fama, 1970). The main challenge for these studies is how to measure the unanticipated component in USDA reports.

The concept of "market surprise" focuses on the "new" information in the USDA reports by calculating the difference from the previously released information in either earlier reports or private industry expectations. Private industry expectations are typically obtained from either Bloomberg or Thompson Reuters surveys in more recent studies, or Conrad Leslie and Sparks in the past. This group of studies, shown in table 4, also follow an event study framework, but measure market reaction not to the fact of report release (measured by the date and time), but to the "market surprise" with the goal of measuring "the event" more precisely.

In general, this approach reveals an even stronger market reaction to USDA reports by removing the "noise" of other information that may hit the market on the same day and focusing on the "news" component of the reports as well as specifics of this information. For example, Colling and Irwin (1990) found that nearby live hog futures were most responsive to unanticipated changes in market hog inventories in Hogs and Pigs reports (HPR), while the contracts expiring at a time horizon approximating one hog production cycle are most responsive to unanticipated breeding hog inventory changes. Most of this market reaction took place on the first day following the release of HPR. Grunewald, McNulty and Biere (1993) conducted a similar study of cattle market reactions to Cattle on Feed (COF) reports and found that nearby contracts significantly reacted to unanticipated changes in marketings while deferred contracts reacted to changes in marketings as well as placements (although not as strongly), while on-feed information had no significant market impact probably because changes in on-feed numbers were captured through placements and marketings. Most of these studies also tested whether industry expectation used to derive unanticipated information or "surprise" were rational and efficient forecasts of USDA announcements.

Baur and Orazem (1994) found that unanticipated supply changes of Valencia orange varieties, especially the ones contained in October reports, significantly affect frozen concentrated orange juice (FCOJ) futures prices, while anticipated changes did not. On the other hand, anticipated or unanticipated information on Early and Navel oranges did not move the markets. Very little additional information was contained in reports released after October. Colling, Irwin, and Zulauf (1996) examined the impact of Export Inspections reports on nearby wheat, corn, and soybean futures prices and found that only soybean prices responded significantly to unanticipated information in these reports. However, if price reaction was conditioned on time of the marketing year, corn futures responded during the December to February quarter and soybean futures responded during the June to August quarter. Soybean futures also responded significantly to unanticipated information in Export inspections reports during low and high stocks-to-use market conditions. Colling, Irwin, and Zulauf (1997) found that nearby pork belly and live hog futures prices significantly reacted to unanticipated information in the Cold Storage report. Mann and Dowen (1997) found that live hog futures markets significantly reacted (in both volatility and trading volume) to information contained in HPR releases but not to the private expectations contained in Knight-Rider surveys released a few days earlier and concluded that market participants likely believed HPR reports to be more credible.

Garcia et al. (1997) conducted several tests to infer the informational value of USDA corn and soybean crop production reports. The price reaction tests conducted in this study revealed that both corn and soybean markets reacted significantly to unanticipated changes in supply (primarily own supply with little evidence of cross-commodity effects). However, the magnitude of price reaction after the mid-1980s appears to decline in corn while increasing in soybeans. The adjusted R-squared values of price reaction regressions from these studies can be used to as an indicator of the economic value of these reports. These studies revealed that unanticipated information in HPR reports explained about 48-55% of post-release price change (Colling and Irwin, 1990), Crop Production about 31-45% (Garcia et al, 1997), orange Crop Production about 1-37% (Baur and Orazem, 1994), Cold Storage about 11-34% (Colling, Irwin and Zulauf, 1997), and Export Inspections about 0-3% (Colling, Irwin and Zulauf, 1996). Based on this information, HPR reports had the highest economic value from this list and Export Inspections the lowest, but this information still cannot be used to calculate the direct benefits and returns on investment from these reports.

Several other recent studies that evaluated market reaction to unanticipated information in the USDA reports also explored other aspects of this reaction and/or information. For example, Schaefer, Myers and Koontz (2004) found that USDA's Cattle on Feed reports significantly moved the markets even after accounting for information in the proprietary data and attempted to predict these price movements. Good and Irwin (2006) described the methodology behind USDA corn and soybean production forecasts, assessed their performance and market impact. They found that both corn and soybean production forecasts had the largest impact on futures prices in August and more recent price reactions have been somewhat larger than those in the past. Frank, Garcia and Irwin (2008) reassessed the effect of new information in the HPR reports and found that even though HPR announcements were irrational estimates of final estimates, and market expectations were irrational estimates of HPR announcements, markets reacted to HPR releases regardless of the surprise measure applied, strongly supporting the argument that these reports contain valuable new information. Consistent with previous studies, marketing (breeding) information had a larger impact on short-term (long-term) price changes.

Karali et al. (2019) examined the average size of market surprises across different reports (figure 5) and demonstrated that Grain Stocks reports had the largest surprises, followed by August Crop Production reports. Furthermore, the authors demonstrated that in the most recent years, market reaction to October and November Crop Production reports was the strongest. For Grain Stocks reports, corn market reaction was the strongest for January and March releases in recent years. Karali, Isengildina-Massa, and Irwin (2019) examined the changing role of USDA inventory reports in livestock markets and, using traditional unconditional price volatility tests, found that market reaction to the Cattle on Feed and Hogs and Pigs reports largely disappeared after 2000. In contrast, market surprise tests provided evidence of continued market reaction to Cattle on Feed information and mixed evidence of market reaction to Hogs and Pigs reports, with market inventory information increasing in value and breeding inventory decreasing. The authors argue that these contrasting results can be explained by increased market concentration in cattle and hog markets leading to smaller market surprises but proportional futures price reactions.

Other studies in this group focused on additional elements of market reaction that are possible to isolate using this approach. For example, McKenzie (2008) used the Hamilton-type approach to derive statistically optimal weights to be placed on a number of different sources of information, including the "news" element of USDA Crop Production reports. He found that "the August reports along with *ex post* prices do contain valuable information, and this helps to explain the puzzle of why futures prices continue to react to the release of USDA reports." (p.365). Adjemian and Arnade (2017) demonstrated that USDA crop production reports affect not only the US, but international corn markets as well, as shown in figure 6. Plante and Dhaliwal (2017) examine the effects of oil and grain inventory shocks (measured as surprises for ending stocks estimates in WASDE reports) on oil, ethanol, corn, and soybean futures prices. This study demonstrated that while corn and soybean prices react only to grain inventory shocks and energy futures prices react only to oil inventory shocks, ethanol futures prices react to both oil and grain inventory shocks, thus serving as a link between two sectors.

While this group of studies tend to measure informational content of USDA reports more precisely, several studies question whether traditional measure of market surprise truly reflects unanticipated information. For example, Frank, Garcia and Irwin (2008), McKenzie (2008), and Isengildina-Massa, Karali, and Irwin (2017), argued that when forecasts are not efficient, market surprise can be decomposed into predictable and unpredictable components and demonstrated that market responds only to the unpredictable component of surprise. Furthermore, a recent study by Karali, Irwin, and Isengildina Massa (2020) argued that the traditional measure of "surprise" may be riddled with measurement error and demonstrated that correcting for measurement error increased the explanatory power of market reaction models by about threefold. Thus, studies that do not correct for this measurement error likely underestimate market reaction to USDA reports.

3.5 Studies of Intraday Impact

While traditional studies typically assessed market reaction to USDA using daily price changes, more recent studies have been able to zoom in using intraday data. These studies were also triggered by the changes in USDA report release scheduled and exchange trading hours. Historically, USDA reports were released at 2pm central, after the close of trading hours to allow market participants to digest new information before the next trading session. In May 1994, the report release was changed to 7:30am central, right before markets opened to allow US exchanges to be the first to react to the new information in the reports. As the exchanges gradually expanded their trading hours in 2012 to include the time of report release, the USDA has moved its report release time to 11am central in January 2013. The studies of intraday impact shown in Table 5 focus not just on the market reaction, but also on overall market dynamics around USDA report releases.

Lehecka, Wang, and Garcia (2014), examined corn market reaction to USDA reports over 2009-2012, when the reports were released prior to market trading hours, and showed that the strongest price reaction to report releases was found immediately after markets opened and persisted for about ten minutes. They did not find evidence of systematic under- or over-reaction in prices. On the other hand, they found some subtle reactions in the last trading session before the release, suggesting that traders adjusted their market exposure in anticipation of the release.

In 2012, ICE and CME commodity exchanges expanded their trading hours, allowing trades during the release of key government reports. Kauffman (2013) showed that market volatility around WASDE report releases in 2012 has been substantially higher than those in prior years and lasted longer, as shown in figure 7. Kauffman (2013) concluded that extending trading hours resulted in brief shocks in corn futures price volatility around the release of WASDE reports that may pose a challenge for producers whose risk management strategies are affected by intraday price swings. Typically, however, the heightened volatility has not lasted more than 30 to 60 minutes, thus it should not affect long-term risk management positions. On the other hand, Wang, Garcia, and Irwin (2014) argued that introduction of electronic trading has significantly reduced bid-ask-spreads thus reducing order execution costs. However, these bid-ask-spreads were substantially larger during the index trader roll periods and on USDA report release days. The authors argue that the evidence of larger spreads during the roll periods point to a sunshine trading effect, with added liquidity entering the market in anticipation of predictable roll behavior, while the USDA announcement effects identify the importance of unexpected information and adverse selection on order execution costs.

In January 2013, the USDA moved its report publication time to 11am central to allow markets the best change to absorb news during trading hours. Using intraday data over 2009-2014, Adjemian and Irwin (2018) compared market reaction to USDA reports across two regimes. The authors found that "when agricultural futures markets are permitted to discover prices freely in response to USDA reports the adjustment process is not instantaneous, as continuously-traded futures markets experience heightened volatility and trading volume in response to news relative to what was observed during the era of trading halts. Moreover, markets appear to now have a more difficult time distinguishing between the newsworthiness of USDA reports, at least in the very short-run, but these differences persist only for a handful of trading minutes. After that, announcement shocks at major agricultural markets resemble those that were observed when (trading) timeouts were in effect." (p. 1169)

Another change to the USDA report release rules was implemented in July 2018 when USDA decided to stop sharing reports with media members inside the lockup area ahead of the official publication time to prevent an unfair advantage their customers may have relative to the general public within the two seconds following the report release due to the proximity of their servers to USDA. Adjemian and Irwin (2020) examined the impact of this change on the market reaction and did not find evidence that removing media members from lockup has increased announcement time price volatility using either daily or intraday data.

Several studies explored market dynamics around report releases using high frequency intraday data. For example, Shang, Mallory, and Garcia (2018) estimate that from 2008 to 2011 government news tended to increase the market bid-ask spread (BAS) for about an hour (through the channel of compensation for adverse selection), although average liquidity costs did not generally rise notably on USDA announcements days. Focusing on 2013–2016 data, after continuous trading of crop news began, Fernandez-Perez et al. (2019) documented that the BAS rises just preceding USDA announcement time and declines gradually over roughly the next twenty trading minutes. These studies decomposed the BAS to draw inferences about the path of information asymmetry and liquidity provision during announcement days. Couleau, Serra, and

Garcia (2020) found that announcement days in these markets are characterized by price jumps clustered around the report release—consistent with the arrival of new information and that eliminating the timeout led to more price jumps around the announcement, and wider bid-ask spreads.

Overall, these studies confirm the findings of the previous studies using daily data and provide a more detailed look at the market reaction and dynamics around report releases by zooming in at a high frequency level. The evidence of the increased market volatility, price jumps, and higher bid-ask-spreads (BAS) following the release of USDA reports, indicates that these reports contain valuable information that helps markets find a new equilibrium price.

4. Indirect Measures based on Informational Value, Trading Returns, and Surveys

Another group of studies, shown in table 6, applied informational value tests developed by Baur and Orazem (1994) to assess whether information released in the reports gets us closer to knowing the final estimate, thereby reducing uncertainty in the markets. For example, Garcia et al. (1997) found that the largest reduction in corn supply forecast variance was associated with August Crop Production reports with subsequent reports having only marginal value. Even though the relative accuracy of USDA and private forecasts in this study was similar, a significant price reaction to USDA reports implied that USDA forecasts were perceived as less risky and more objective by market participants. Isengildina-Massa, Karali, and Irwin (2020) confirmed the importance of August Crop Production reports in reducing corn market's supply forecast variance, but also showed an increasing value of October reports in post-2002 period. In addition, these authors argued that Prospective Plantings and Acreage reports played a much larger role in reducing supply uncertainty than Crop Production reports since 1983. Furthermore, the authors found that the information value of USDA forecasts has increased over time and was the strongest in the most recent 2002-2019 period.

Another approach to demonstrating informational value is by assessing whether advanced knowledge of the information in these reports would allow traders to correctly position themselves in the market. Using a willingness-to-pay test, Carter and Calopin (1993) found that a trader with advance knowledge of the report could not make statistically significant risk-adjusted profits. Colling and Irwin (1995) used a different risk adjustment approach and found that a trader could make statistically significant profits over the same period. Garcia et al. (1997) used the test developed by Henriksson and Merton (1981) to demonstrate that traders can correctly determine market direction based on the information contained in corn and soybean production reports over 1971-1992, thus indicating that these reports have market timing value. McKenzie, Thompson, and Phelan (2007) showed strong evidence of systematic returns to option straddle positions around HPR releases. McKenzie (2008) used a Hamilton-type (1992) approach to demonstrate that "there were periods when having advanced knowledge of the August report would have significantly adjusted rational agent expectations, augmenting information already embodied in futures prices. (p. 365)" Milacek and Brorsen (2017) developed trading models based on knowing the WASDE report in advance to estimate potential trading returns from using WASDE report predictions in the days before the report. Their findings reveal that the perfect foresight trading signal generated an average daily return of 1.11 cents per bushel for corn with July, September, and October reports generating the highest returns. It is important to recognize that the conclusions of these studies regarding trading profitability are heavily dependent on the assumptions about transaction costs.

C-FARE (2013) proposed a different approach to valuing USDA information and prioritizing data products. Recognizing that none of the approaches used in the previous studies are able to capture the full value of USDA reports that can be used for cost-benefit analysis, they propose a framework of eight questions that can be used to rank relative merits of competing data products. These questions include:

1. Is the data product unique with few substitutes? Would substitutes become available if the data product were eliminated?
2. Would eliminating a public data product create inequities or asymmetric information?
3. Is there a large number of users of the data product? Does the data product relate to a commodity representing a significant value of production?
4. Is the data product critical to the missions of other federal or state agencies?
5. Is the data product necessary for policy advice and evaluation?
6. Is the data used by industry for functions critical for well-functioning markets to facilitate trade?
7. Do market participants respond significantly to the release of the data product?
8. Is the data product inexpensive to produce?

These questions could be used by decision makers to assess which USDA reports could be eliminated and which should be maintained, especially under budgetary pressures.

To the best of our knowledge, only one study attempted to elicit user preferences for USDA reports through a survey. Pruitt et al. (2013) surveyed extension agents and agribusiness professionals about their preferences for USDA reports deemed relevant to livestock markets. Extension agents ranked Crop Progress, Grain Stocks and Cattle on Feed as most important. Agribusiness professionals ranked Cattle on Feed, Grain Stocks, and Hogs and Pigs reports as most important. However, the authors caution that if reports were not preferred by respondents, it does not mean they are unimportant.

Summary and Conclusions.

This paper reviewed and analyzed 70 studies of the value and impact of USDA reports published over the last 50 years. Figure 8 shows the dynamics in the literature on this topic over time, and demonstrates variation in the number of publications that roughly matches increased attention to federal budget concerns. There has been a rapid expansion in the number of studies in recent years. Much of the recent expansion is attributed to the explosion of studies of intraday effects of USDA reports in recent years. Even though it is a fairly new approach with the first study of this kind published in 2013, figure 9 shows that it quickly became one of the most common types of studies in the literature. Access to intraday data allowed researchers to zoom into market dynamics around report release and explore factors that were unattainable before, such as the magnitude and persistence of market reaction, implications of changes in release schedule, impacts on bid-ask spreads, etc. Given the expanded capabilities of these types of studies, we expect them to continue to grow. Table 5 shows that so far these studies have focused exclusively on the feed grain markets. Expansion of these studies into the livestock markets should be a beneficial avenue for future research.

Figure 9 also shows that welfare studies and market uncertainty studies using options prices were the least common. Even though welfare studies provide some of the most comprehensive measures of the value of public information, they may be difficult to estimate and deserve more attention from researchers. Similarly, options studies may be data intensive by combining premiums across different moneyness levels, but allow unique perspective not attainable from other approaches and should be further explored. On the other hand, futures market impact studies, including unconditional and conditional market reactions, represent the most straight forward and commonly used approach applied in about 30 percent of the studies.

Figures 10 and 11 show the number of studies across commodities and reports. Corn and soybean markets received most attention in the literature being included in 46 and 35 studies, respectively. Among reports, WASDE and Crop Production reports received most attention in the literature with 31 and 29 studies including them, respectively. If the research goal is to determine which reports could be eliminated during the periods of budget shortfalls, it should focus on understudied reports affecting relatively low-valued and understudied commodities. However, C-FARE (2013) warns that such approach could create an information vacuum in the markets where alternative sources are not available.

Market impact studies tend to focus on situation or inventory related reports, with very few studies including outlook reports such as Livestock, Dairy, and Poultry Outlook (LDPO), Feed Outlook or Oil Crops Outlook. While outlook reports do not tend to move the markets, they are likely valuable in helping to level the playing field and decrease information asymmetries among market participants. These effects would be captured by the market impact studies that include market surprise and those that compare the accuracy of these reports to alternative forecasts (not included in this study). To facilitate these research efforts, a full database of the studies related to the value, impact and accuracy of USDA information is available at XXX (suppressed to ensure blind review).

Continued strength of the impact of situation information illustrates the efficiencies of information collection and dissemination by the public agency. Most of USDA situation and inventory information is survey based. Continued impact of these reports on the markets indicates the value of these surveys relative to alternative tools available to private information sources even with the technological advances in precision agriculture and remote sensing that emerged in the recent decade.

The findings of this study demonstrate that most of the previous literature focused on the function of USDA information associated with facilitation of the efficient functioning of the market. Much less is known about its other functions, especially those associated with informing the policy and program formation, operation and evaluation processes. C-FARE (2013) illustrates that market impact is only a fraction of the value of public information. Finding ways of measuring other aspects of its value represent beneficial avenues for further research.

Overall, it is important to recognize the role of USDA information in market price discovery and reduction of information asymmetry. Without USDA information, agents with better resources and access to information would have an advantage over the rest of market participants through having a better insight of what the true market conditions are and what the equilibrium price should be. USDA helps uncover these market conditions for all market participants thereby providing a level playing field for all, even though the process is sometimes bumpy. In order to maintain this role and ensure the quality of this information, it is important to keep communication lines open. USDA cannot produce reliable estimates without participation of producers. Producers need to trust USDA and their approaches in order to be willing to participate in the information gathering process. Greater transparency and communication between these two critical sides of public information system is needed to maintain its integrity. While some efforts to facilitate this communication, such as USDA data users' meetings, are already in place, greater efforts can be made to increase transparency of USDA outlook and data products. One of the most effective ways of doing this would be to have an experienced statistician who is directly involved in USDA forecasting process tasked with communicating forecasting practices, challenges, procedures and limitations with the public on the regular basis in order to “open up the black box.”

References

Abbott, P., D. Boussios, and J. Lowenberg-DeBoer. 2016. "Valuing Public Information in Agricultural Commodity Markets: WASDE Corn Reports." Proceedings of the NCCC-134 Conference on Applied Commodity Price Analysis, Forecasting, and Market Risk Management. St. Louis, MO. [http://www.farmdoc.illinois.edu/nccc134].

Adjemian, M.K. 2012. "Quantifying the WASDE Announcement Effect." *American Journal of Agricultural Economics* 94(1): 238-257.

Adjemian, M.K, and S.H. Irwin. 2018. "USDA Announcement Effects in Real-Time." *American Journal of Agricultural Economics* 100(4):1151-1171.

Adjemian, M.K., and A. Smith. 2012. "Using USDA Forecasts to Estimate the Price Flexibility of Demand for Agricultural Commodities." *American Journal of Agricultural Economics* 94(4):978-995.

Adjemian, M.K., and C.A. Arnade. 2017. "Not Lost in Translation: The Impact of USDA Reports on International Corn Markets." Agricultural and Applied Economics Association Annual Meeting, Chicago, IL, July 30-August 1, 2017.

Adjemian, M.K., and S.H. Irwin. 2020. "The Market Response to Government Crop News under Different Release Regimes." *Journal of Commodity Markets* 19:100110.

Adjemian, M.K., R. Johansson, A. McKenzie, and M. Thomsen. 2018. "Was the Missing 2013 WASDE Missed?" *Applied Economic Perspectives and Policy* 40(4):653-671.

Allen, P.G. 1994. "Economic Forecasting in Agriculture." *International Journal of Forecasting* 10:81-135.

Antonovitz, F., and T. Roe. 1984. "The Value of Rational Expectations Forecast in a Risky Market: A Theoretical and Empirical Approach." *American Journal of Agricultural Economics* 66:717-723.

Arnade, C., L. Hoffman, and A. Effland. 2021. "The Impact of Public Information on Commodity Market Performance: The Response of Corn Futures to USDA Corn Production Forecasts." ERR-293, U.S. Department of Agriculture, Economic Research Service.

Baur, R. F., and P.F. Orazem. 1994. "The Rationality and Price Effects of U.S. Department of Agriculture Forecasts of Oranges." *Journal of Finance*, 49(2): 681-696.

Bian, S., T. Serra, P. Garcia, and S.H. Irwin. 2021. "New Evidence on Market Response to Public Announcements in the Presence of Microstructure Noise." *European Journal of Operational Research* 298(2):785-800.

Bradford, D.F., and H.H. Kelejian. 1978. "The Value of Information for Crop Forecasting with Bayesian Speculators: Theory and Empirical Results." *Bell Journal of Economics* 9:123-144.

Campbell, J.Y., A.W. Lo, and A.C. MacKinlay. 1997. *The Econometrics of Financial Markets*. Princeton University Press, Princeton, N.J.

Carter, C.A, and C.A. Galopin. 1993. "Informational Content of Government Hogs and Pigs Reports." *American Journal of Agricultural Economics* 75(3): 711-719.

Cao, A.N.Q., and M.A. Robe. 2022. "Market Uncertainty and Sentiment around USDA Announcements." *Journal of Futures Markets* 42(2):250-275.

C-FARE. 2013. "Value of USDA Data Products." The Council on Food, Agricultural & Resource Economics, Washington, DC.

Colling, P.L., and S.H. Irwin. 1990. "The Reaction of Live Hog Futures Prices to USDA Hogs and Pigs Reports." *American Journal of Agricultural Economics* 72(1): 84-95.

Colling, P.L., and S.H. Irwin. 1995. "Informational Content of Government Hogs and Pigs Reports: Comment." *American Journal of Agricultural Economics* 77(1):698-702.

Colling, P L., S.H. Irwin, and C.R. Zulauf. 1996. "Reaction of Wheat, Corn, and Soybean Futures Prices to USDA "Export Inspections" Reports." *Review of Agricultural Econ*omics 18(1): 127-138.

Colling, P L., S.H. Irwin, and C.R. Zulauf. 1997. "Futures Price Responses to USDA's Cold Storage Report." *Agribusiness* 13(4): 393-401.

Conklin, N.C. 1983. "Grain Exports, Futures Markets, and Pricing Efficiency." *Review of Research in Futures Markets* 2(1):I983.

Couleau, A., T. Serra, and P. Garcia. 2020. "Are Corn Futures Prices Getting 'Jumpy'?" *American Journal of Agricultural Economics* 102(2):569-588.

Dorfman, J.H., and B. Karali. 2015. "A Nonparametric Search for Information Effects from USDA Reports." *Journal of Agricultural and Resource Economics* 40(1):124-143.

Fackler, P.L. 1985. "On the Relation Between Futures Price Movements and USDA Reports." Proceedings of the NCR-134 Conference on Applied Commodity Price Analysis, Forecasting, and Market Risk Management. Chicago, IL. [http://www.farmdoc.uiuc.edu/nccc134].

Fama, E.F. 1970. Efficient Capital Markets: A Review of Theory and Empirical Work. *Journal of Finance* 25 (2): 383–417.

Fernandez-Perez, A., B. Frijns, I. Indriawan, and A. Tourani-Rad. 2019. "Surprise and Dispersion: Informational Impact of USDA Announcements." *Agricultural Economics* 50(1):113-126.

Fortenbery, T.R., and D.A. Sumner. 1993. "The Effects of USDA Reports in Futures and Options Markets." *Journal of Futures Markets* 13(2):157-173.

Frank, J., P. Garcia and S.H. Irwin. 2008. "To What Surprises Do Hog Futures Respond?" *Journal of Agricultural and Applied Economics* 40(1): 73-88.

Garcia, P., S.H. Irwin, R.M. Leuthold, and L. Yang. 1997. "The Value of Public Information in Commodity Futures Markets." *Journal of Economic Behavior & Organization* 32(4):559-570.

Good, D.L., and S.H. Irwin. 2006. "Understanding USDA Corn and Soybean Production Forecasts: Methods, Performance and Market Impacts over 1970-2005." AgMAS Project Research Report No. 2006-01, available at http://dx.doi.org/10.2139/ssrn.897279.

Gouel, C. 2020. "The Value of Public Information in Storable Commodity Markets: Application to the Soybean Market." *American Journal of Agricultural Economics* 102(3): 846-865.

Goyal, R., and M.K. Adjemian. 2021. "The 2019 Government Shutdown Increased Uncertainty in Major Agricultural Commodity Markets." *Food Policy* 102:102064.

Grunewald, O., M.S. McNulty, and A.W. Biere. 1993. "Live Cattle Futures Response to Cattle on Feed Reports." *American Journal of Agricultural Economics* 71: 84-94.

Hamilton, J.D. 1992. "Was the Deflation During the Great Depression Anticipated? Evidence from the Commodity Futures Market." *American Economic Review* 82:157–78.

Hayami, Y. and W. Peterson. 1972. "Social Returns to Public Information Services: Statistical Reporting of U.S. Farm Commodities." *American Economic Review* 62:119-130.

Henriksson, R.D., and R.C. Merton. 1981. "On Market Timing and Investment Performance II. Statistical Procedures for Evaluating Forecasting Skills." *Journal of Business*, 54: 513-533.

Hoffman, G. 1980. "The Effect of Quarterly Livestock Reports on Cattle and Hog Prices." *North Central Journal of Agricultural Economics* 2(2): 145-151.

Huang, J., T. Serra, and P. Garcia. 2021. "The Value of USDA Announcements in the Electronically Traded Corn Futures Market: A Modified Sufficient Test with Risk Adjustments." *Journal of Agricultural Economics* 72(3):712-734.

Huang, J., T. Serra, P. Garcia, and S.H. Irwin. 2022. "To Batch or not to Batch? The Release of USDA Crop Reports." *Agricultural Economics* 53(1):143-154.

Indriawan, I., V. Martinez, and Y. Tse. 2021. "The Impact of the Change in USDA Announcement Release Procedures on Agricultural Commodity Futures." *Journal of Commodity Markets* 23:100149.

Isengildina-Massa, O., X. Cao, B. Karali, S.H. Irwin, M.K. Adjemian, and R.C. Johansson. 2021. "When Does USDA Information Have the Most Impact on Crop and Livestock Markets?" *Journal of Commodity Markets* 22:100137.

Isengildina, O., S.H. Irwin, D.L. Good, and J. Gomez. 2008a. "The Impact of Situation and Outlook Information in Corn and Soybean Futures Markets: Evidence from WASDE Reports." *Journal of Agricultural and Applied Economics* 40(1):89-103.

Isengildina-Massa, O., S.H. Irwin, D.L. Good, and J.K. Gomez. 2008b. "Impact of WASDE Reports on Implied Volatility in Corn and Soybean Markets." *Agribusiness* 24(4):473-490.

Isengildina, O., S. Irwin, and D. Good. 2006. "The Value of USDA Situation and Outlook Information in Hog and Cattle Markets." *Journal of Agricultural and Resource Economics* 31(2):262-283.

Isengildina-Massa, O., B. Karali, and S.H. Irwin. 2017. "Do Markets Correct for Smoothing in USDA Crop Production Forecasts? Evidence from Private Analysts and Futures Prices." *Applied Economic Perspectives and Policy* 39(4):559-583.

Isengildina-Massa, O., B. Karali, and S.H. Irwin. 2020. "Can Private Forecasters Beat the USDA? Analysis of Relative Accuracy of Crop Acreage and Production Forecasts." *Journal of Agricultural and Applied Economics* 52(4):545-561.

Johansson, R., A. Effland and K. Coble. 2017. "Falling Response Rates to USDA Crop Surveys: Why It Matters." *farmdoc daily* (7):9, Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign, January 19, 2017.

Just, R.E. 1983. "The Impact of Less Data on the Agricultural Economy and Society." *American Journal of Agricultural Economics* 65:872-881.

Karali, B. 2012. "Do USDA Announcements Affect Comovements Across Commodity Futures Returns?" *Journal of Agricultural and Resource Economics* 37(1):77-97.

Karali, B., S.H. Irwin, and O. Isengildina-Massa. 2020. "Supply Fundamentals and Grain Futures Price Movements." *American Journal of Agricultural Economics* 102(2):548-568.

Karali, B., O. Isengildina-Massa, and S.H. Irwin. 2019. "The Changing Role of USDA Inventory Reports in Livestock Markets." *Journal of Agricultural and Resource Economics* 44(3): 591-605.

Karali, B., O. Isengildina-Massa, S.H. Irwin, M.K. Adjemian, and R. Johansson. 2019. "Are USDA Reports Still News to Changing Crop Markets?" *Food Policy* 84:66-76.

Kauffman, N. 2013. "Have Extended Trading Hours Made Agricultural Commodity Markets Riskier?" *Economic Review-Federal Reserve Bank of Kansas City* Q III:5-32.

Kishore, J., and P. Garcia. 2018. "Intraday Market Effects in Electronic Soybean Futures Market During Non-Trading and Trading Hour Announcements." *Applied Economics* 50(11) 1188-1203.

Kunze, J. 1990. "The Bureau of Agricultural Economics' Outlook Program in the 1920s as Pedagogical Device." *Agricultural History* 64:252-261.

Lehecka, G.V. 2014. "The Value of USDA Crop Progress and Condition Information: Reactions of Corn and Soybean Futures Markets." *Journal of Agricultural and Resource Economics* 39(1):88-105.

Lehecka, G.V., X. Wang, and P. Garcia. 2014. "Gone in Ten Minutes: Intraday Evidence of Announcement Effects in the Electronic Corn Futures Market." *Applied Economic Perspectives and Policy* 36(3):504-526.

Mann, T.L., and R.J. Dowen. 1997. "The Impact of Proprietary-Public Information on Pork Futures." *Journal of Futures Markets* 17: 417-433.

Mattos, F.L., and R.L.F. Silveira. 2016. "Futures Price Response to Crop Reports in Grain Markets." *Journal of Futures Markets* 36(10):923-942.

McKenzie, A.M. 2008. "Pre-Harvest Price Expectations for Corn: The Information Content of USDA Reports and New Crop Futures." *American Journal of Agricultural Economics* 90(2):351-366.

McKenzie, A.M., J.L. Darby. 2017. "Information Content of USDA Rice Reports and Price Reactions of Rice Futures." *Agribusiness* 33(4): 552-568.

McKenzie, A. M., M. Thomsen, and J. Phelan. 2007. "How Do You Straddle Hogs and Pigs? Ask the Greeks!" *Applied Financial Economics* 17: 511-520.

McNew, K.P., and J.A. Espinosa. 1994. "The Informational Content of USDA Crop Reports: Impacts on Uncertainty and Expectations in Grain Futures Markets." *Journal of Futures Markets* 14(4):475-492.

Milacek, T.T., and B.W. Brorsen. 2017. "Trading Based on Knowing the WASDE Report in Advance." *Journal of Agricultural and Applied Economics* 49(3):400-415.

Milonas, N.T. 1987. "The Effects of USDA Crop Announcements on Commodity Prices." *The Journal of Futures Markets* 7(5):571-589.

Myers, R.J., R.J. Sexton, and W.G. Tomek. 2010. "A Century of Research on Agricultural Markets." *American Journal of Agricultural Economics* 92:376–402.

Patterson, P.M., and B.W. Brorsen. 1993. "USDA Export Sales Report: Is It News?" *Review of Agricultural Economics* 15(2):367-378.

Plante, M., and N. Dhaliwal. 2017. "Inventory Shocks and the Oil-Ethanol-Grain Price Nexus." *Economics Letters* 156:58-60.

Priuitt, J.R. G.T. Tonsor, K.R. Brooks, and R.J. Johnson. 2013. "End User Preferences for USDA Market Information." SAEA Annual Meeting Selected Paper.

Salin, V., A.P. Thurow, K.R. Smith and N. Elmer. 1998. "Exploring the Market for Agricultural Economics Information: Views of Private Sector Analysts." *Review of Agricultural Economics* 20:114-124.

Schaefer, M.P., R.J. Myers and S.R. Koontz. 2004. "Rational Expectations and Market Efficiency in the U.S. Live Cattle Futures Market: The Role of Proprietary Information." *Journal of Futures Markets* 24(5): 429-452.

Schroeder, T., J. Blair, and J. Mintert. 1990. "Abnormal Returns in Livestock Futures Prices around USDA Inventory Report Releases." *North Central Journal of Agricultural Economics* 12(2): 293-305.

Silveira, R., F. Mattos, and M. Silveira. 2017. "The Reaction of Coffee Futures Price Volatility to Crop Reports." *Emerging Markets Finance and Trade*. :1-17.

Shang, Q., M. Mallory, and P. Garcia. 2018. "The Components of the Bid-Ask Spread: Evidence from the Corn Futures Market." *Agricultural Economics* 49(3):381-393.

Sumner, D.A., and R.A.E. Mueller. 1989. "Are Harvest Forecasts News? USDA Announcements and Futures Market Reactions." *American Journal of Agricultural Economics* 71(1):1-8.

Wang, X., P. Garcia, and S.H. Irwin. 2014. "The Behavior of Bid-Ask Spreads in the Electronically-Traded Corn Futures Market." *American Journal of Agricultural Economics* 96(2):557-577.

Xie, R., O. Isengildina-Massa, and J.L. Sharp. 2016. "Can Rationality of USDA's Fixed-Event Crop Forecasts be Improved?" *Advances in Business and Management Forecasting* 11:117-146.

Ying, J., Y. Chen, and J.H. Dorfman. 2019. "Flexible Tests for USDA Report Announcement Effects in Futures Markets." *American Journal of Agricultural Economics* 101(4):1228-1246.

Table 1. Studies of Unconditional Market Reaction to USDA Report Releases

Authors	Year	Sample Period	Method	USDA Reports	Live Cattle	Lean Hogs	Corn	Soybeans	Wheat	Cotton	Soybean meal, Soybean oil	Feeder Cattle	Rice
Hoffman	1980	1970-1979	OLS regression of post-report prices on pre-report prices and an announcemnt dummy variable	quarterly livestock reports	1 (cash), 0 (futures)	1 (cash), 0 (futures)							
Conklin	1983	1975-1980	Cross-spectral analysis of futures returns reactions	Export Sales			1	1	1				
Fackler	1985	1974-1982	F-tests of futures return volatility reaction, regression of log returns on release days vs non-release days	CP			1	1					
Milonas	1987	1966-1984	tests of the residuals of cash returns on report vs non-report days	CP			1	1	1		1		
Sumner and Mueller	1989	1961-1982	t-and F-tests of futures return volatility reaction	CP			1	1					
Fortenbery and Sumner	1993	1969-1989	Parametric and non-parametric tests of futures and options volatility reaction	CP			1 (futures), 0 (options), ↓	1 (futures), 0 (options), ↓					
Isengildina-Massa et al	2008a	1985-2006	Parametric and Non-parametric tests of futures return variance	WASDE (all), WASDE, WASDE+CP			1/1/1, ↑	1/1/1, ↑					
Lehecka	2014	1986-2012	Parametric and Non-parametric tests of futures return variance	Crop Progress			1 (July and August), ↑	1 (July and August), ↑					
Dorfman and Karali	2015	1995-2009	Non-parametric Kolmigorov-Smirnov and Henriksson-Merton tests of differences between announcement vs non-announcement day return distributions	PP, ACR	0	0	1	1			1	0/1	
				Crop Progress	0/1	1/0	0	0			0	0	
				Feed Outlook	0/1	0	0	0			0	0	
				Grain Stocks	0	0	1	1			1	0/1	
				Oil Crops Outlook	0	0/1	0	0			0	0	
				WASDE	0	0	1	1			1	1/0	
				Cattle	0	0/1	0	0/1			0	0	
				COF	0	0	1/0	0			0	0/1	
				HPR	0	0/1	1	1			1/0	0	
				LDPO	0	1/0	0	0			0/1	0	
McKenzie and Darby	2017	1990-2015	Parametric tests of futures return variance and regressions of price reactions on changes in usage and production	WASDE									1/0
				CP									1/0
				PP, ACR									1
Ying, Chen, and Dorfman	2019	1995-2015	Theil-Goldberger mixed estimation of time-varying effects	PP, ACR			1,↑	0					
				Crop Progress			1,↓	0					
				Feed Outlook			0	0					
				Grain Stocks			1,↑	1,↑					
				WASDE			1,↑	1,↑					
				Cattle			0	1,↑					
				COF			0	0					
				Oil Crops Outlook			0	1,↑					
				CP			1,↑	1,↑					

Notes: WASDE=World Agricutural Supply and Demand Estimates, WWS=Winter Wheat Seedings, PP=Prospective Plantings, ACR=Acreage, CP=Crop Production, CPAS=Crop Production Annual Summary, SGAS=Small Grain Annual Summary, COF=Cattle on Feed, HPR= Hogs and Pigs repots. "1" indicates a significant market reaction. "0" indicates an insignificant market reaction. "0/1" refers to results that are mostly insignificant and significant in only a few cases. "1/0" refers to results that are mostly significant and insignificant in only a few cases. "↑"Increased/"↓"decreased describes changes in market reaction over time.

Table 1. (Continued) Studies of Unconditional Market Reaction to USDA Report Releases

Authors	Year	Sample Period	Method	USDA Reports	Live Cattle	Lean Hogs	Corn	Soybeans	Wheat	Cotton	Soybean meal, Soybean oil	Feeder Cattle	Rice
Arnade, Hoffman and Effland	2021	1992-2017	Regressions of daily futures on release dummies and output projections	WASDE			1						
Isengildina-Massa et al	2021	1985-2018	Parametric and Non-parametric tests of futures return variance	WASDE			0/1	0/1	0/1	0/1			
				WASDE+CP			1,↓	1,↓	0,↓	1/0			
				PP+GS, ACR+GS			1,↑	1,↑	1,↑	1,↓			
				SGAS+GS					1,↑				
				CPAS+GS+WASDE+ WWS			1,↑	1,↑	1,↑	no			
				COF	1/0	0							
				HPR	0	0/1, ↓							

Notes: WASDE=World Agricutural Supply and Demand Estimates, WWS=Winter Wheat Seedings, PP=Prospective Plantings, ACR=Acreage, CP=Crop Production, CPAS=Crop Production Annual Summary, SGAS=Small Grain Annual Summary, COF=Cattle on Feed, HPR= Hogs and Pigs repots. "1" indicates a significant market reaction. "0" indicates an insignificant market reaction. "0/1" refers to results that are mostly insignificant and significant in only a few cases. "1/0" refers to results that are mostly significant and insignificant in only a few cases. "↑"Increased/"↓"decreased describes changes in market reaction over time.

Table 2. Studies of Conditional Market Reaction to USDA Report Releases

Authors	Year	Sample Period	Method	USDA Reports	Live Cattle	Lean Hogs	Corn	Soybeans	Wheat	Cotton	Soybean meal	Soybean oil	Coffee
Schroeder, Blair and Mintert	1990	1972-1987	VAR model of abnormal returns and volatility in cash and futures markets	COF	1								
Patterson and Brorsen	1993	1980-1990	GARCH(1,1) model of close to close futures return reaction to reports	Export Sales			1	0	0	0			
Isengildina, Irwin, and Good	2006	1985-2004	TARCH-in-mean model of overnight futures returns controlling for weekly effects and seasonality	Cattle	1	1							
				COF	1	1							
				Cold Storage	0	0							
				HPR	1	1							
				LDPO	0	0							
				WASDE	1	1							
Adjemian	2012	1980-2010	GLS model of absolute overnight returns controlling for daily, monthly and position effects, inventory conditions, and delivery horizon	WASDE			1	1	1	1			
Karali	2012	1995-2009	GARCH model of variances and covariances of futures returns	WASDE, WASDE+CP		0/1	1/1	0/1			0/0	0/0	
				PP, ACR		0	0	0			0	0	
				Crop Progress		0	1	0			1/0	1/0	
				Feed Outlook		0	1	0			0	0	
				Grain Stocks		0	1	1			1/0	1/0	
				Oil Crops Outlook		0	1	0			0	0	
				Cattle		0	1	0			0	0	
				LDPO		1	1	0			0	0	
				HPR		0	1	0			1	1	
				COF		0	0	0			0	0	
Xie et al.	2016	1995-2012	I-GARCH(1,1)-t model of overnight futures returns accounting for weekly and seasonal effects and stock levels	Export Sales						0			
				Crop Progresss						0			
				WASDE						1			
				PP						1			
				Cotton this Month						0			
Mattos and Silveira	2016	2003-2014	GARCH model of overnight futures returns controlling for weekly effects	WASDE			1	1					
				CONAB			0	0/1					
Silveira, Mattos and Silveira	2017	2004-2014	TARCH-in-mean model of overnight futures returns controlling for weekly effects and seasonality	WASDE									0
				CONAB									1/0
				ICO									1

Notes: WASDE=World Agricutural Supply and Demand Estimates, WWS=Winter Wheat Seedings, PP=Prospective Plantings, ACR=Acreage, CP=Crop Production, CPAS=Crop Production Annual Summary, SGAS=Small Grain Annual Summary, COF=Cattle on Feed, HPR= Hogs and Pigs repots. "1" indicates a significant market reaction. "0" indicates an insignificant market reaction. "0/1" refers to results that are mostly insignificant and significant in only a few cases. "1/0" refers to results that are mostly significant and insignificant in only a few cases.

Table 3. Studies of Options Market Reaction to USDA Reports.

Author	Year	Sample Period	Method	USDA Reports	Corn	Soybeans
Fortenbery and Sumner	1993	1969-1989	Parametric and non-parametric tests of futures and options volatility reaction	Crop Production	0	0
McNew and Espinosa	1994	1985-1991	Non-parametric tests of options volatility reaction	Crop Production	1	1
Isengildina-Massa, et al	2008b	1985-2002	Parametric and non-parametric tests of options volatility reaction	WASDE	1	1
Adjemian, et al	2018	1995-2015	Daily and monthly models of implied volatility changes controlling for market factors	WASDE	1	1
Goyal and Adjemian	2021	1995-2019	Daily models of implied volatility changes controlling for market factors	WASDE	1	1
Cao and Robe	2022	2009-2019	Daily models of implied volatility changes controlling for market factors	WASDE	1	1
				Grain Stocks	1	1
				PP, ACR	1	1

Notes: WASDE=World Agricutural Supply and Demand Estimates, PP=Prospective Plantings, ACR=Acreage. "1" indicates a significant market reaction. "0" indicates an insignificant market reaction.

Table 4. Studies of Market reaction to unanticipated information in USDA reports

Author	Year	Sample Period	Method	USDA Reports	Live Cattle	Lean Hogs	Corn	Soybeans	Wheat	Orange Juice
Colling and Irwin	1990	1981-1988	futures market reaction to unticipated changes in market hog and breedign hog inventories	Hogs and Pigs		1(nearby), 1(deferred)				
Grunewald, McNulty, and Biere	1993		futures price reaction to unticipated changes in marketings, placements and on-feed inventories	Cattle on Feed	1(nearby), 1(deferred), 0					
Baur and Orazem	1994	1973-1992	futures price reaction to unanticipated supply changes of Valencia, Early and Navel oranges	Crop Production						1, 0, 0
Colling, Irwin, and Zulauf	1996	1988-1991	futures price reaction to market surprise	Export Inspections			0/1	1	0	
Garcia, et al	1997	1971-1992	futures price reaction to market surprise	Crop Production			1,↓	1,↑		
Mann and Dowen	1997	1988-1994	futures market reaction to HPR vs private expectations	Hogs and Pigs		1				
Schaefer, Myers, and Koontz	2004	1986-1994	futures market reaction after accounting for private data	Cattle on Feed	1					
Good and Irwin	2006	1970-2005	futures price reaction to market surprise	Crop Production			1,↑	1,↑		
McKenzie	2008		Hamilton-type appproach to derive optimal weitghts on USDA info	Crop Production			1			
Frank, Garcia and Irwin	2008	1982-2002	futures market reaction to unticipated changes in market hog and breedign hog inventories	Hogs and Pigs		1(nearby), 1(deferred)				
Plante and Dhaliwal	2017	2009-2017	futures price reaction to oil and grain inventory shocks	WASDE			0, 1	0 ,1		
Adjemian and Arnade	2017	2009-2016	US, Brazil, Japan, China futures market reaction to market surprise	Crop Production			1, 1, 1, 0			
Karali et al	2019	1984-2016	changes in futures price reaction to market surprise	Crop Production			1,↓	1	1/0, ↓	
				PP, ACR			1,↑	1,↑	0/1	
		1994-2016		Grain Stocks			1,↑	0/1	1/0, ↓	
Karali, Isengildina-Massa and Irwin	2019	1977-2016	changes in futures price reaction to inventory market surprise	Cattle on Feed	1	1				
		1982-2016		Hogs and Pigs	0/1	0/1				
Karali, Irwin, and Isengildina-Massa	2020	1970-2016	instrumental variable correction for measurement errors in market surprise	Crop Production			1	1	0	

Notes: WASDE=World Agricutural Supply and Demand Estimates, PP=Prospective Plantings, ACR=Acreage. "1" indicates a significant market reaction. "0" indicates an insignificant market reaction. "0/1" refers to results that are mostly insignificant and significant in only a few cases. "1/0" refers to results that are mostly significant and insignificant in only a few cases. "↑"Increased/"↓"decreased describes changes in market reaction over time.

Table 5. Studies of Intraday dynamics of market response to USDA reports

Author	Year	Sample Period	Title	USDA Reports	Corn	Soybeans	Wheat
Bian, Serra, Garcia, and Irwin	2021	2009-2017	New evidence on market response to public announcements in the presence of microstructure noise.	ACR, Crop Production, Grain Stocks, PP, WASDE	1	1	
Huang, Serra, and Garcia	2021	2010-2020	The Value of USDA Announcements in the Electronically Traded Corn Futures Market: A Modified Sufficient Test with Risk Adjustments.	Crop Production, WASDE	1		
Huang, Serra, Garcia, and Irwin	2022	2008-2019	To batch or not to batch? The release of USDA crop reports	PP, ACR, Grain Stocks, Crop Production, WASDE	1		
Indriawan, Martinez, and Tse	2021	2017-2019	The impact of the change in USDA announcement release procedures on agricultural commodity futures	WASDE, Grain Stocks, PP, ACR	1	1	1
Couleau, Serra, and Garcia	2020	2008-2015	Are Corn Futures Prices Getting "Jumpy"?	WASDE, Grain Stocks	1		
Adjemian, and Irwin	2020	2009-2019	The Market Response to Government Crop News under Different Release Regimes	PP, ACR, Grain Stocks, Crop Production, CPAS	1		
Fernandez-Perez, Frijns, Indriawan, and Tourani-Rad	2019	2013-2016	Surprise and dispersion: informational impact of USDA announcements.	WASDE, Grain Stocks, PP, ACR	1	1	1
Adjemian, and Irwin	2018	2009-2014	USDA Announcement Effects in Real-Time.	PP, ACR, Crop Production, CPAS, Grain Stocks	1	1	1
Shang, Mallory, and Garcia	2018	2008-2011	The components of the bid-ask spread: Evidence from the corn futures market.	WASDE, Crop Progress, Grain Stocks, PP, ACR	1		
Lehecka, Wang, and Garcia	2014	2009-2012	Gone in Ten Minutes: Intraday Evidence of Announcement Effects in the Electronic Corn Futures Market.	Crop Production, Grain Stocks, PP, ACR, WASDE	1		
Wang, Garcia, and Irwin	2014	2008-2010	The Behavior of Bid-Ask Spreads in the Electronically-Traded Corn Futures Market.	Crop Production, WASDE, Crop Progress,Grain Stocks	1		
Kauffman	2013	2008-2012	Have Extended Trading Hours Made Agricultural Commodity Markets Riskier?	WASDE	1		
Kishore and Garcia	2018	2010-2014	Intraday market effects in electronic soybean futures market during non-trading and trading hour announcements.	WASDE, Crop Production, Grain Stocks, PP, ACR		1	

Notes: WASDE=World Agricultural Supply and Demand Estimates, PP=Prospective Plantings, ACR=Acreage, CPAS=Crop Production Annual Summary. "1" indicates a significant market reaction. "0" indicates an insignificant market reaction.

Table 6. Studies of Informational Value and Trading Profitability for USDA Forecasts.

Author	Year	Sample Period	Method	USDA Reports	Lean Hogs	Corn	Soybeans	Wheat
Carter and Galopin	1993	1981-1991	Profitability of trading around report release	Hogs and Pigs	0			
Colling and Irwin	1990	1981-1988	Profitability of trading around report release	Hogs and Pigs	1			
Garcia, et al.	1997	1971-1992	informational value test and Henrickson and Merton test of market timing value	Crop Production		1	1	
McKenzie, Thomsen and Phelan	2007	1985-2000	profitability of long straddle positions established around the release of HPRs	Hogs and Pigs	1			
McKenzie, A.M.	2008	1970-2005	Hamilton-type approach of informational value	Crop Production		1		
Milacek and Brorsen	2017	1975-2012	Profitability of trading around report release	WASDE		1		
Isengildina-Massa, Karali and Irwin	2020	1970-2019	Informational value tests	Crop Production		1	0/1	1/0
				PP, ACR		1	1	1

Notes: WASDE=World Agricutural Supply and Demand Estimates, PP=Prospective Plantings, ACR=Acreage. "1" indicates a significant market reaction. "0" indicates an insignificant market reaction. "0/1" refers to results that are mostly insignificant and significant in only a few cases. "1/0" refers to results that are mostly significant and insignificant in only a few cases.

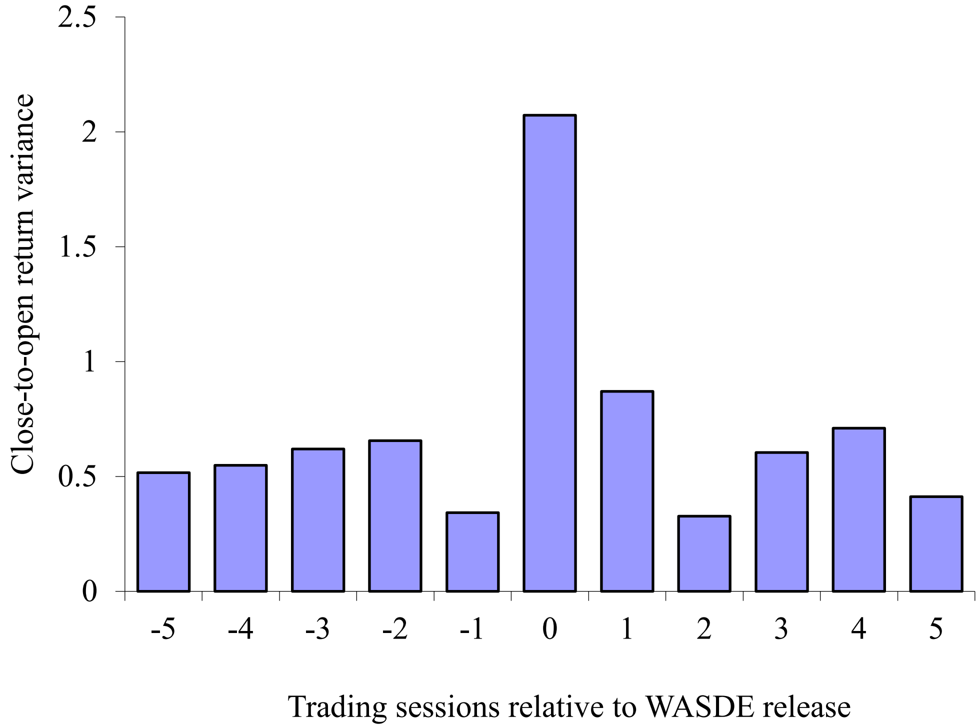

Figure 1. Corn close-to-open return variance around all WASDE report release months, January 1985-December 2006
Source: (Isengildina-Massa et al., 2008a)

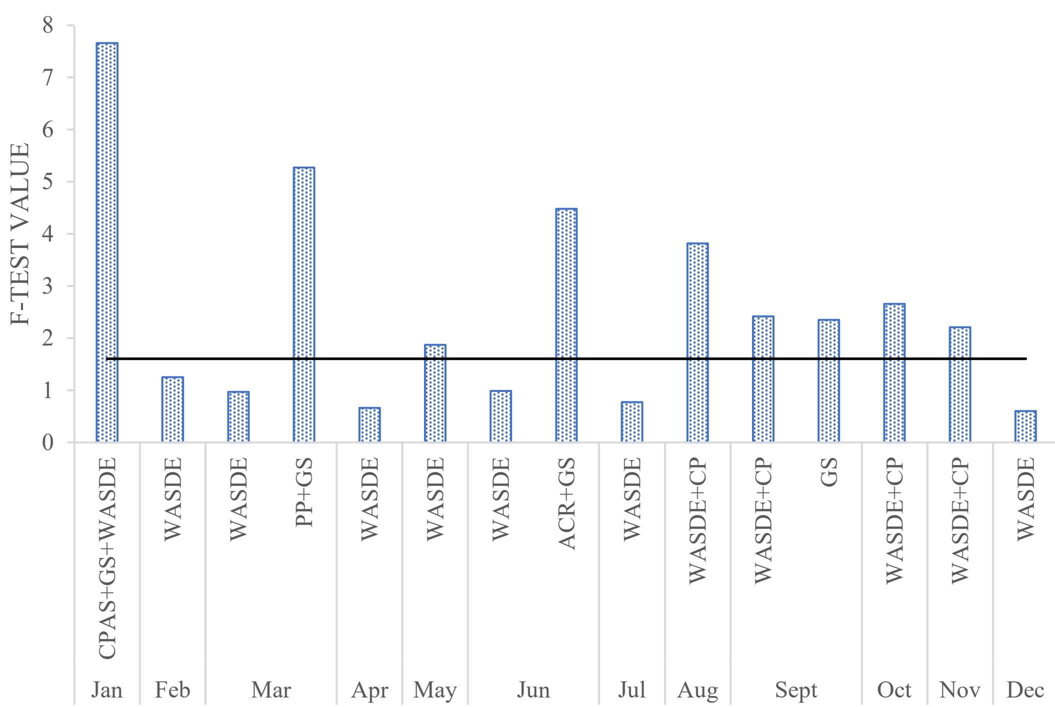

Figure 2. Corn Market Reaction to USDA Reports, 1985-2018

Notes: The bars represent the ratios of report day variance to non-report day variance. WASDE=World Agricultural Supply and Demand Estimates, PP=Prospective Plantings, ACR=Acreage, CP=Crop Production, CPAS=Crop Production Annual Summary, GS=Grain Stocks, WWS=Winter Wheat Seedings. Solid black line shows the critical value for the F-test at 90 percent level.

Source (Isengildina-Massa et al, 2021)

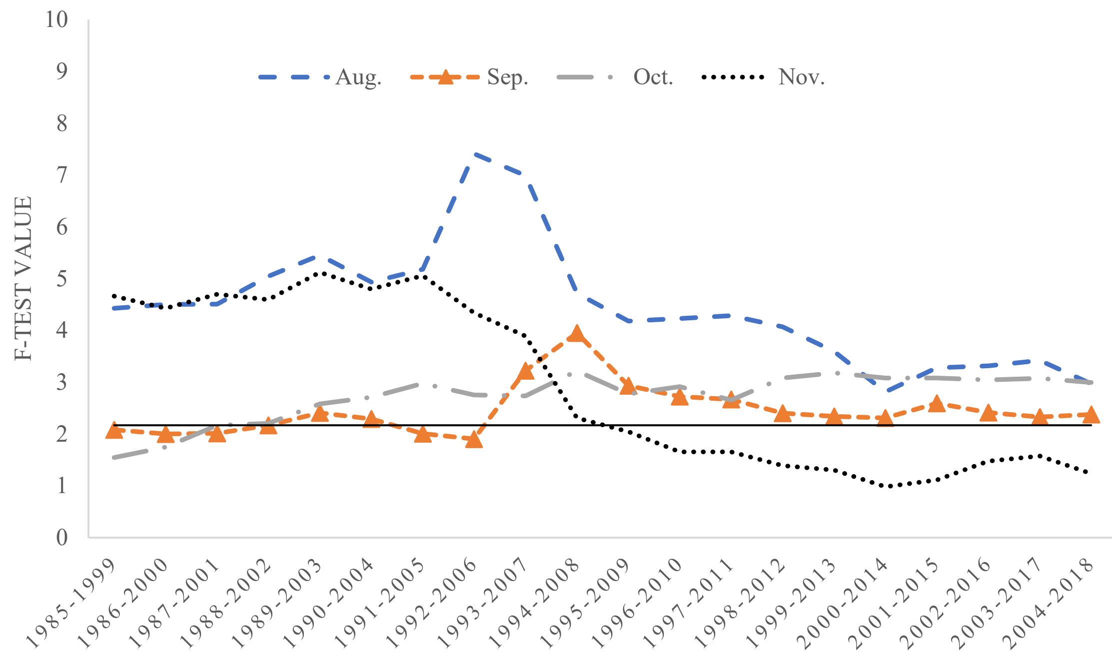

Figure 3. 15-year rolling analysis of changes in corn market reaction to Crop Production reports released in different months.
Solid black line shows the critical values for the F-test at 90 percent confidence level.
Source (Isengildina-Massa et al, 2021)

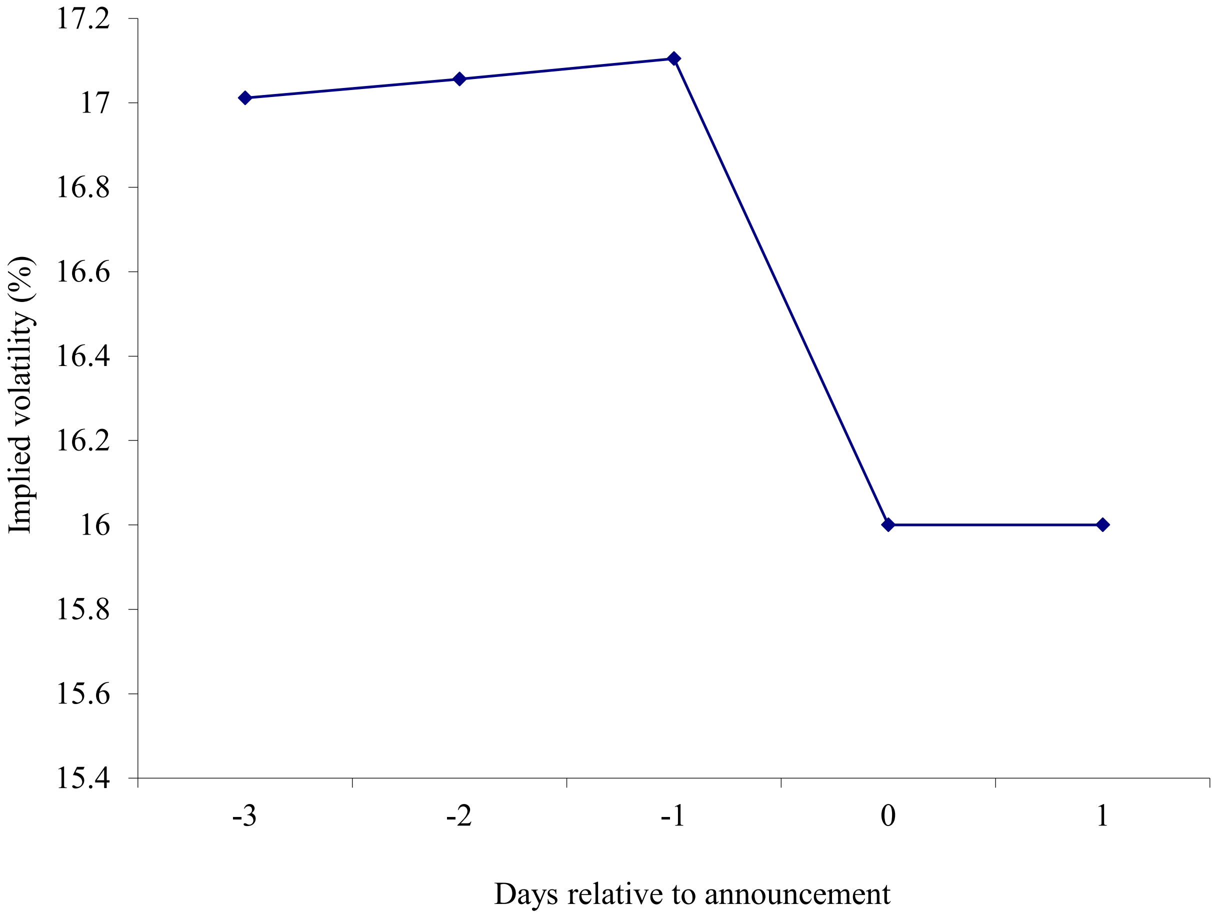

Figure 4. Evolution of Implied Volatility around News Announcements.
Source: (Isengildina-Massa et al. 2008b)

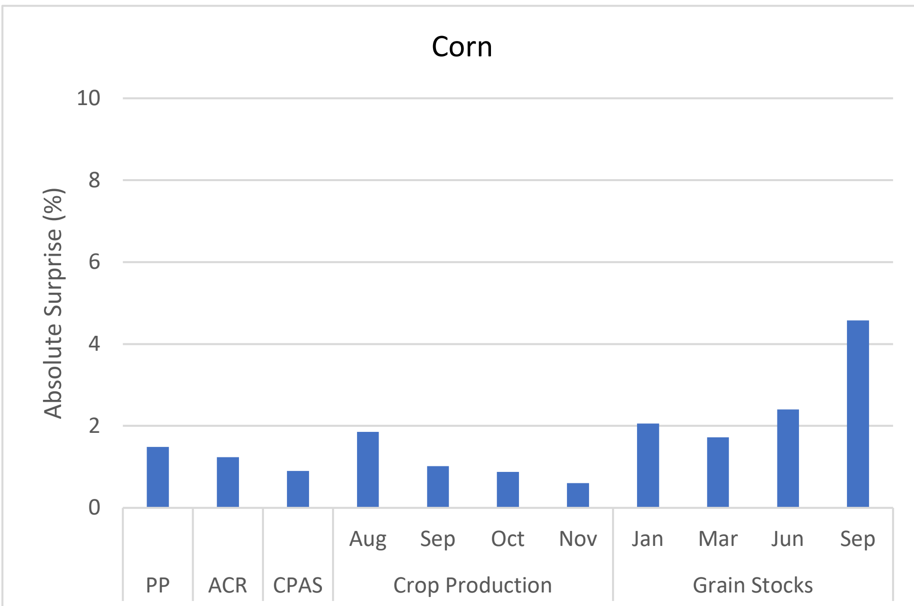

Figure 5. Average absolute market surprises

Note: Sample period is 1984/85-2016/17 marketing years. PP=Prospective Plantings, ACR=Acreage, CPAS=Crop Production Annual Summary, and WWS=Winter Wheat Seedings report.
Source: Karali et al, 2019

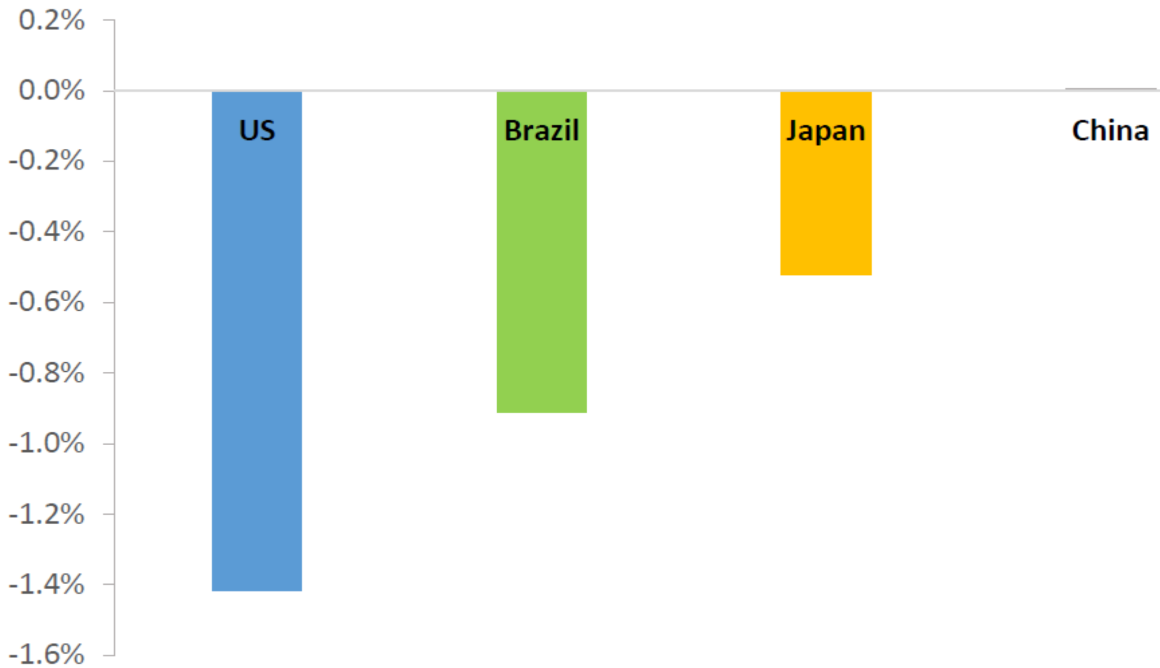

Figure 6. Direct effect of a +1-percent USDA corn crop surprise
Source: Adjemian and Arnade, 2017.

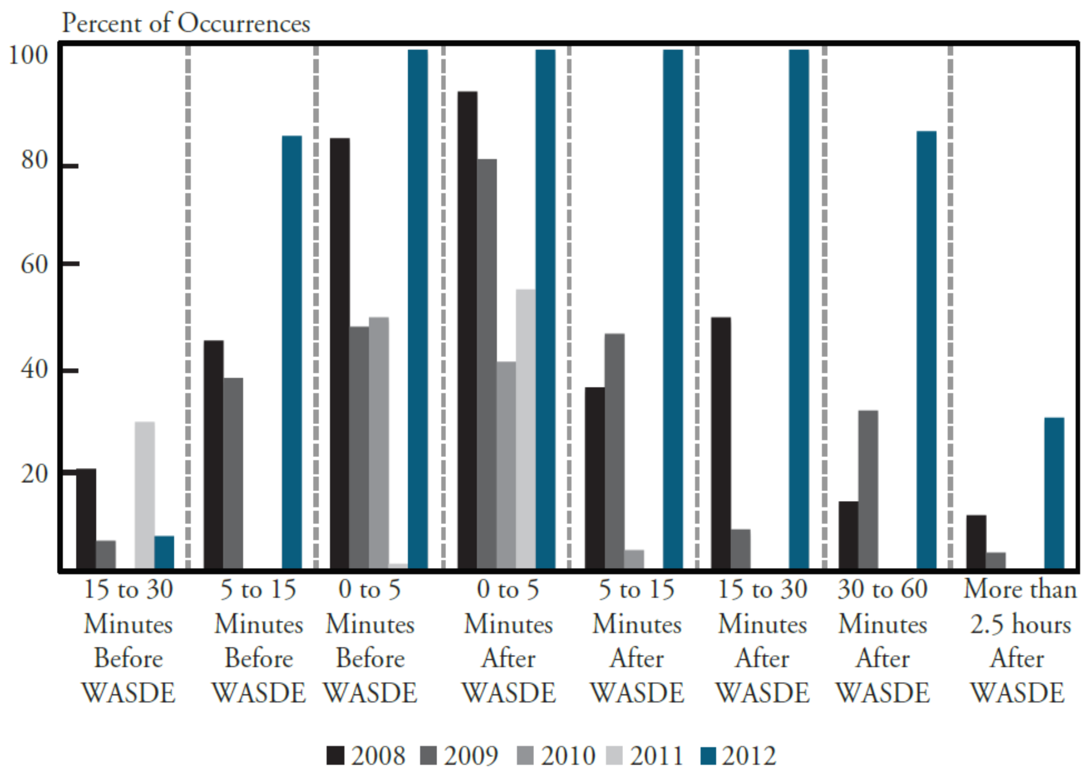

Figure 7. Elevated Volatility on WASDE Release Days Relative to Non-WASDE Baseline.
Source: Kaufmann, 2012

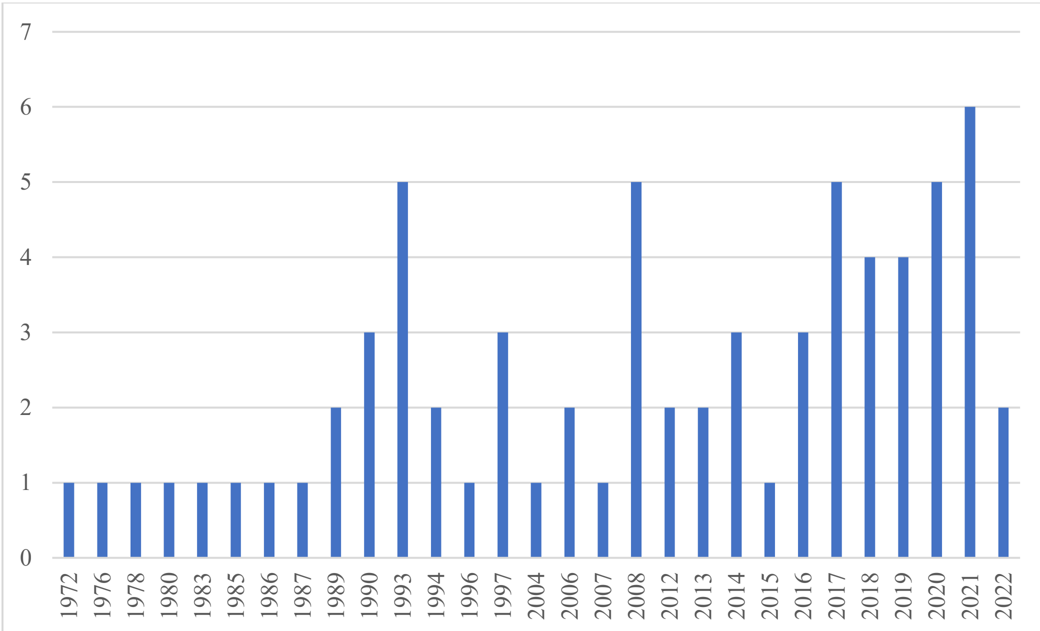

Figure 8. Number of Studies Published Over Time.

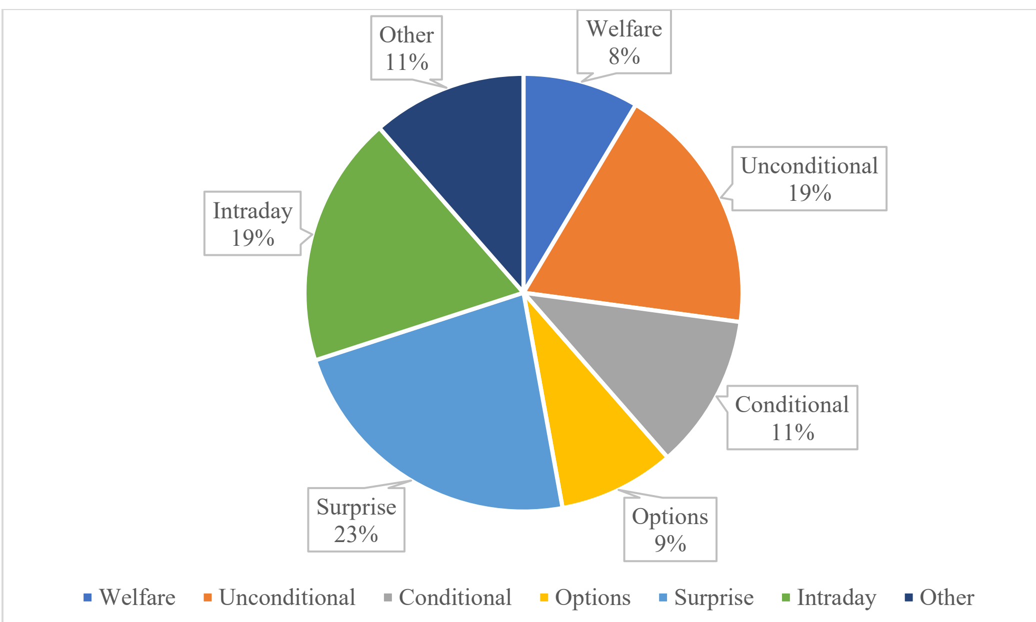

Figure 9. Distribution of Published Studies by Method.

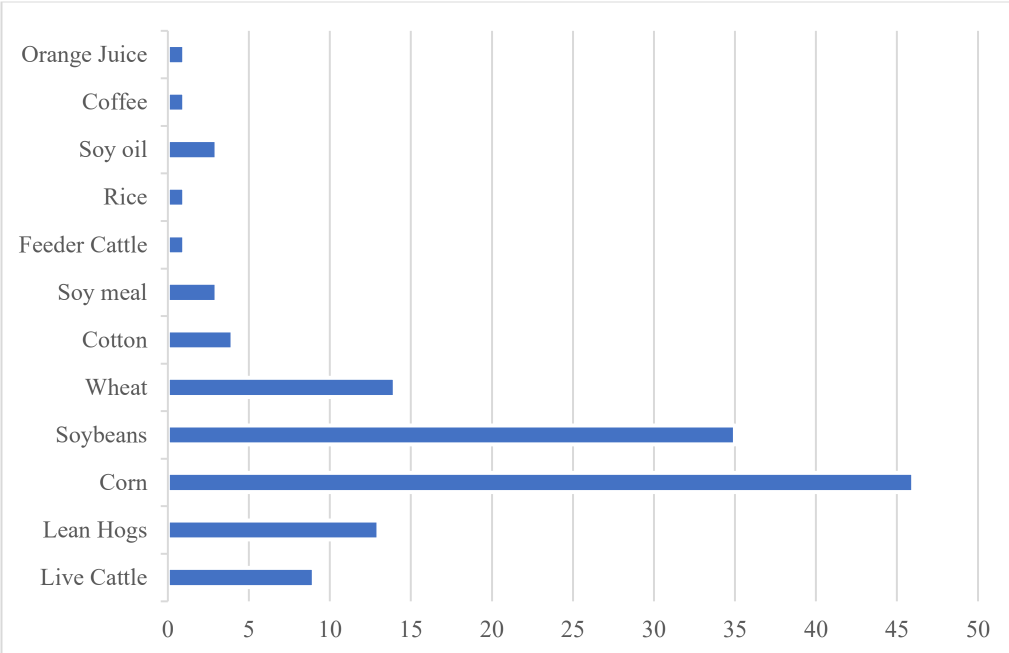

Figure 10. Number of Published Studies by Commodity.

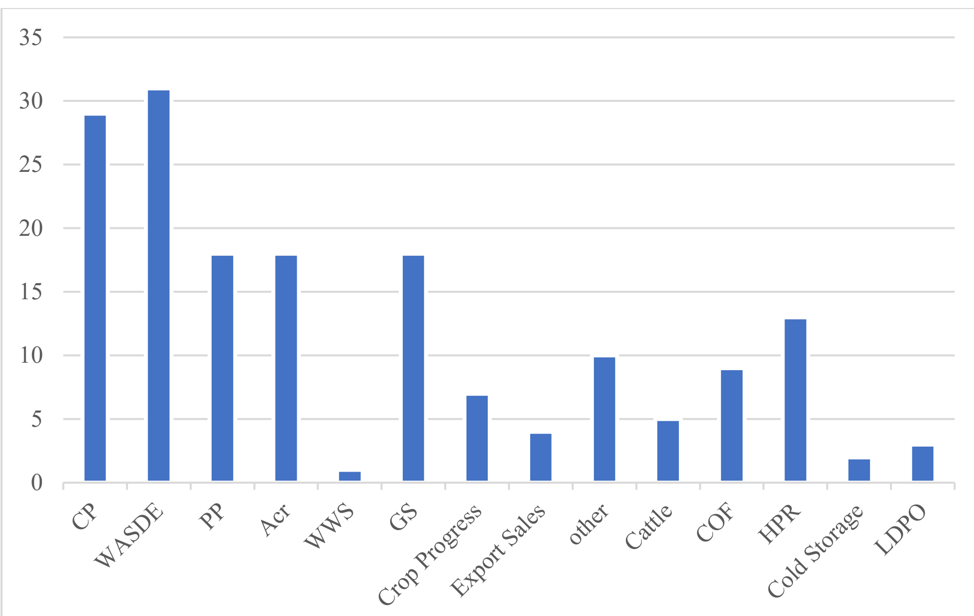

Figure 11. Number of Published Studies by Report.