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The value of USDA reports in commodity futures markets has been intensively researched, while whether such an effect is increasing or decreasing over time has rarely been answered. Given the fact that much more diverse information is available in today's futures market, understanding trends in the impact of USDA announcement effects is crucial for market participants. This study measures how USDA reports' announcement impact on market volatility has changed over time in both corn and soybean futures markets by adopting a new continuous approach with time-varying coefficients added to a model of the reports' impact. The result shows that USDA reports are still informative and influential in commodity futures markets, with a generally increasing trend in the impact of announcement effects, while there are some reports whose impact show a declining potential.

Key words: USDA reports, time-varying impact, commodity futures markets

Introduction

Beginning in the 1970s, the USDA started to publish series of reports to inform agricultural commodity market participants about the current and expected market conditions to reduce potential uncertainties. Later, this attracted lots of academicians to investigate the impact of USDA reports on commodity futures markets, and most of them found evidence in favor of the market value of public information in USDA reports. For example, Sumner and Mueller (1989) provide a variety of evidence that USDA harvest forecast announcement affects the daily price changes in corn and soybean futures market, especially in August, September, and October. Colling and Irwin (1990) show that the unanticipated component of the hogs and pigs reports evokes a significant reaction in live hog futures prices through market survey data. Mann and Dowen (1996) find increased price variability and trade volume in live hog and pork belly futures markets when Hogs and Pigs Report release. Irwin, Good, and Gomez (2001) suggest USDA outlook information has a significant impact on corn and soybean markets, and it reduces the uncertainty of market participant's expected distribution of futures prices. Schaefer, Myers, and Koontz (2004) find that USDA Cattle on Feed Report still contains new information that will move prices even when information contained in proprietary data sources has been taken into account. Isengildina, Irwin and Good (2006) investigate the impact of six major USDA reports in hog and cattle markets and reveal a statistically significant impact in majority reports. Adjemian (2012) shows that the announcement effect of World Agricultural Supply and Demand Estimates (WASDE) persists across contract positions and is rapidly incorporated into futures prices.

However, although plenty of research has investigated whether USDA reports are influential on commodity futures markets, very few of them have systematically examined how the announcement effect of USDA reports is changing over time. Information sources in today's futures markets are much more diverse with the internet booming and the rapid growth of private market advisory firms, and the accuracy of private forecasts has also been verified repeatedly (Garcia et al., 1997; Egelkraut et al., 2003; Good and Irwin, 2006). This raises the interesting

and important question of whether the impact of USDA reports has declined or not. Or more specifically, faced with so much information from the private sector, do market observers still see USDA reports as having the same importance as before, or have they shifted their attention to other information sources such that USDA reports are not as influential as they used to be?

Quite limited studies have shed light on this question. Existing research, if it has noted potential changes in USDA reports' impact that may be caused by different market condition or government policy, mainly focus on answering "whether USDA reports are still 'effective' now or in different sub-periods", instead of asking "how such an effect is changing continuously over time" directly. For example, Fortenbery and Sumner (1993) divide the whole sample from 1969 to 1985 into two sub-periods to examine the effect of Crop Production Reports and WASDE Report on corn and soybean futures and options market. They find the USDA reports bring new information in the first period (1969-1982), while not in the second period (1982-1989). Isengildina-Massa, et al. (2008) examine the impact of situation and outlook information from WASDE. They also divide the whole sample from 1985 to 2006 into three sub-periods based on government policy changes and market condition and find sub-period results are consistent with the full sample, the magnitude of USDA reports' impact increases across the three sub-periods. Similarly, Lehecka (2014) investigates the information value of USDA Crop Progress report in the four subsample periods between 1986-2012 through a futures return volatility test and concludes that information contained in Crop Progress reports is more valuable in the last two periods. However, such an approach can easily be flawed due to the bias caused by sub-period selection.

Only Karali et al. (2016) adopt a "rolling-window" method in their GARCH model to avoid the impact of sub-period selection, and provide an estimate of the USDA reports' effect in every ten-year period. Their result shows price response in the corn futures market starts to increase over time beginning in 2000, while the magnitude is decreased when 2012-2014 added. Soybean futures prices show a relatively more stable reaction pattern over time, thus the USDA reports are still as informative as before and continue to have significant impacts on the markets. However, the method of Karali et al. (2016) still cannot provide a continuous estimator of the "time-varying" effect so that the impact of a specific year (or period) could be known.

This paper explores a continuous approach to directly reveal the "time-varying" announcement effect of USDA reports without splitting the whole sample into sub-periods. By assigning time-varying coefficients to USDA announcement dummies, this paper provides specific estimators on USDA reports' impact over time. The result shows that USDA reports are still informative and influential in commodity futures markets with a generally increasing trend in the announcement effect, while there are some reports whose impacts show a declining potential.

Data Construction

USDA Reports

The USDA reports are selected based on how close the relationship is between these reports and corn and soybean production and market condition. Ten reports that have been widely investigated in previous studies are included in this paper. They are Acreage; Prospective Plantings; Crop Progress; Feed Outlook, Grain Stocks, WASDE, Cattle, Cattle on Feed, Oil Crops Outlook, and Crop Production. We combine the "Acreage" and "Prospective Plantings" into one report, considering both reports provide supply conditions for crops and are released only once a year by the National Agricultural Statistics Service (NASS).

A brief introduction of these reports is 1) "Prospective Planting" reports provide expected plantings for several crops that include corn and soybeans annually at the end of March; "Acreage" reports present planted and/or harvested acreages for those crops annually at the end of June. 2) "Crop Progress" reports are published weekly in the growing season (April to November) by NASS with planting, fruiting, harvesting progress and overall conditions of selected crops that include corn and soybeans. 3) "Feed Outlook" is published monthly by the Economic Research Service (ERS) and examines supply, use, prices and trade for feed grains that include both corn and soybean. 4) "Grain Stocks" reports are released seasonally by NASS, contain stocks of some crops (including corn and soybeans), and the number and capacity of on- and off-farm storage facilities. 5) World Agricultural Supply and Demand Estimates (WASDE) is released monthly by the World Agricultural Outlook Board. It provides current USDA forecasts of U.S. and world supply-use balances of major grains (including corn), soybeans and products, and cotton. "Cattle" and "Cattle on Feed" are selected because corn is used to feed cattle. 6) "Cattle" reports are released twice per year by NASS and contain the inventory numbers and values of all cattle and calves, number of operations and size group estimates by class, state and U.S. 7) "Cattle on Feed" reports are also released by NASS monthly with total number of cattle and calves on feed, placements, marketing and other disappearances, number of feedlots and fed cattle marketings. 8) "Oil Crops Outlook" reports are released by ERS monthly, examining supply, use, prices, and trade information for oil crops (primarily soybeans and products). 9) "Crop Production" reports are published monthly by NASS with forecasts of production for major crops.

It is important to note that the release time of a certain report could be either before futures markets open or after they close. To precisely capture the announcement effect of USDA reports, the announcement dummy variables should be constructed accordingly: if a report is released before or during the trading hours, the impact of this report is expected to be captured in that day's settlement price, and the announcement dummy of that report should equal "1" on the exact day the report released; if a report is released after the trading hours, then the impact of such a report would be expected to be seen in next day's settlement price, and the announcement dummy variable should equal "1" on the "next trade day" after the report released. Among the ten reports, Acreage, Feed Outlook, and Grain Stocks are released before futures market open; Crop Process, Oil Crops Outlook, Cattle and Cattle on Feed are released after futures market are

closed. For the three remaining reports, Prospective Plantings reports were released after market close until 1996 and started to be published before market open in 1996; the release schedule of WASDE changed since 1995 to before the market open; Crop Production reports were released at 8:30 am EST during 1995 to 2012, and 12:00 pm EST since January 2013. Thus, the announcement dummies of these three reports (Prospective Planting, WASDE and Crop Production) are added to the exact day the report release, except for the first year's observations (1995) in Prospective Planting that will be added to the next trade day. A summary of USDA reports announcement dummies is provided in table 1.

Another concern of the USDA reports is the potential overlaps among the nine announcement dummies that would be of interest in the following analysis. To investigate this, we calculate the overlap rate of every possible pair of two reports by dividing the number of overlapping announcement days over the total announcement days of the report whose announcement day is larger within the two reports. The results are shown in table 1.

From table 1, the overlap rates of the nine USDA reports are generally low and acceptable, except for the pair of report 9 (Crop Production) and report 5 (WASDE) that is highly overlapped. It is because Crop Production and WASDE are released simultaneously since 1985. Besides, there are two pairs whose overlap rate is over 10%, that is report 4 (Grain Stock) and Report 1 (A&P), report 3 (Feed Outlook) and report 8 (Oil Crops Outlook). We shall carefully consider the impact of the overlap of announcement dummies in the following analysis.

Futures Returns

Daily returns of corn and soybean futures contracts are analyzed in this paper, both are traded at the Chicago Board of Trade (CBOT). To construct a rolled-over nearby futures series, we adopt the common method (e.g., Dorfman and Karali, 2015), splicing the nearby contract price at the end of the month preceding expiration with the second nearby contract price, so that the delivery period when abnormal price observations may occur is avoided. The delivery months for corn futures contracts are March, May, July, September, and December; January, March, May, July, August, September, and November for soybean. Contracts used in empirical analysis are shown in table 2.

Daily return is generally adopted to reflect futures market price fluctuations in previous studies (Isengildina, Irwin and Good, 2006; Isengildina-Mass, et al., 2008; Dorfman and Karali, 2015, etc.). Following this, we define daily return as

$$R_{it} = 100 * (\ln F_{i,t} - \ln F_{i,t-1}) \qquad (1)$$

where $\ln F_{i,t}$ is the natural logarithm of the settlement price of commodity i's future contract on day t. The "close to close" approach performs well in capturing the non-instantaneous market reactions to USDA report as large and abnormal price reactions are often seen right after the open of futures markets. Also, the sample period is selected as from January 1995 to December 2015 to ensure all nine USDA reports are available and to include a complete crop production cycle at the end of the sample period.

Summary statistics for daily returns in corn and soybean futures markets are provided in table 3. During the sample period, we have 5293 observed trading days in all for the corn futures market, among which 1561 are announcement days, and the remaining 3732 are non-announcement days. There are 5287 observed trading days in all for the soybean futures market, with 1561 announcement days and 3726 non-announcement days. From table 3, the average daily returns R_t is negative for both corn and soybean on announcement days, while its positive for soybeans on non-announcement days. The standard deviations of both daily return and absolute daily return are higher on announcement days than non-announcement days, for both corn and soybeans futures markets. And the mean of absolute daily return is also higher on announcement days. These statistics suggest the variability of daily returns on announcement days is higher than that on non-announcement days in both futures markets.

Methodology

Absolute daily return is a good indicator to measure volatilities of commodity futures markets and has been adopted by many previous studies to evaluate the impact of USDA reports on futures markets (Williams, 2001; Isengildina-Massa et al. (2008a); Adjemian, 2012). Following the insight of these studies, the dependent variable of this paper is selected to be the absolute value of the "close-to-close" daily returns for corn and soybean nearby futures contracts.

To address the potential time-varying effect of USDA reports in the relationship between volatility and USDA report releases, a time-varying coefficient is designed for USDA report announcement dummies by replacing the traditional form $D_t \cdot \gamma$ with $D_t \cdot \gamma_t$, where $\gamma_t = B_1 + B_2 \cdot \ln(t)$. The time indicator t here is constructed at a monthly frequency, ranging from 2 to 253 during our sample period as we have 252 months in all during the 21 years from January 1995 to December 2015[1]. In this way, each trade day will be assigned with a specific time indicator "t" that denotes the month it belongs to. For example, the first month of 1995 would be assigned with t=2, the second month with t=3 and so on, so that the last month in December 2015 would be assigned with t=253. With this setting, we will see ln(t) ranges from 0.693 to 5.533 as t increases through the sample period.

Lagged returns are added to the mean equation to account for autocorrelation in futures returns (Taylor, 1986; Yang and Brorsen, 1994; Karali, 2012). Since the absolute value of daily returns

[1] The reason we set the starting value of t to be 2 instead of 1 is to avoid ln(1), which is zero.

are adopted as the dependent variable, absolute lagged daily returns is included in our model. Also, to incorporate external influence on futures returns and their volatilities, two common external factors, seasonality (Anderson, 1985; Isengildina, Irwin, and Good, 2006; Adjemian, 2012; Karali, 2012) and day-of-the-week (Junkus, 1986; Isengildina, Irwin, and Good, 2006; Adjemian, 2012; Karali, 2012) are included into the mean equation with a set of dummy variables for month and Monday.

With these settings, the mean equation of our main model becomes:

$$|R_t| = \mu + \sum_{p=1}^{5} \varphi_p |R_{t-p}| + Z_t \cdot B_0 + \sum_{i=1}^{m} D_{it} \cdot (B_{1i} + B_{2i} \cdot \ln(t)) + u_t \qquad (2)$$

where $|R_t|$ is the absolute value of daily returns that we defined in equation (1), Z_t is a matrix that includes Monday and monthly dummy variables, and m is the number of USDA reports that will be analyzed together. Choosing an appropriate number of m is crucial since, at one hand, the overall impact of USDA reports is of interest so that more reports are expected to be included, while at the other hand, potential multicollinearity should be avoided to ensure the validity of the model. From previous discussion, the overlap rates of the nine USDA reports are low and acceptable in general, except for the pair with report 9 (Crop Production) and report 5 (WASDE) whose overlap rate is over 90%, and there are two other pairs whose overlap rate is over 10%. Given this, we first set m to be 8 in the main model, dropping the Crop Production reports, and will perform a robustness analysis later to check the validity of the result and measure the time-varying impact of report 9 (Crop Production). And we will apply the analysis to both corn and soybean futures contract data.

Note that as we define $\gamma_{it} = B_{1i} + B_{2i} \cdot \ln(t)$ to be the time-varying impact of USDA reports, the significance criteria of such impact should be constructed by using its variance which is calculated by:

$$Var(B_{1i} + B_{2i} \cdot \ln(t)) = Var(B_{1i}) + Var(B_{2i}) \cdot \ln(t)^2 + 2 \cdot \ln(t) \cdot cov(B_{1i}, B_{2i})$$

As t is increasing over the sample period, both γ_t and its variance are changing so that a time-varying significance criteria is expected to be seen for USDA reports' announcement effect. Also, as B_{2i} captures the time-varying part of the USDA reports' impact, the effect of an USDA report would be declining if B_{2i} is negative and statistically significant, and vice versa.

Empirical Results

Time-varying Effect of USDA Reports on Corn Futures Market

To estimate our main model (equation 2) with the first eight reports, we use GLS to control for potential heteroskedasticity. Table 4 provides the regression results. The R-squared of the regression is 16.74%, which is relatively high in commodity futures price analysis. The impact of all lagged one to five day's absolute daily returns are highly significant at 1% level, which validates the strong necessity of accounting for autocorrelation.

For external effects, the result shows the impact of both Monday and months in the growing and harvest seasons (April to October) are highly statistically significant. This is reasonable because, first, on Mondays accumulated information from the weekends can have an impact, so more volatility is expected; Second, in the growing and harvest seasons, the market is expected to be more sensitive and volatile as crop production is highly influenced by natural conditions like weather, temperature, and rainfall, etc.

For the USDA reports, estimators from table 4 cannot be used directly to indicate the impact of any report without further calculation. As defined above, the impact for each of USDA report is $B_1 + B_2 \cdot \ln(t)$, where *t* is the time indicator that ranges from 2 to 253 and represents the month when the report is published. This means that there are 252 time-varying coefficients and 252 different estimated variances for those estimators for each of the eight reports, where $Var(B_{1i} + B_{2i} \cdot \ln(t)) = Var(B_{1i}) + Var(B_{2i}) \cdot \ln(t)^2 + 2 \cdot \ln(t) \cdot cov(B_{1i}, B_{2i})$. The result of such time-varying coefficients and their t-values are presented in table 5 and table 6, respectively.

Table 5 shows that most USDA reports' impacts on the corn futures market ranges from a negative to a positive value, except for Report 6 and 8. This is reasonable as the estimators for B_{1i} are mainly negative and estimators for B_{2i} are mainly positive. To examine the extent by which the USDA report effect has changed over the sample period, we define a *Report Impact Change Rate* as the ratio of reports impact changes over time ($\Delta\gamma_t$) divided by the mean of absolute market daily returns, that is

$$\frac{\gamma_{251} - \gamma_1}{E(|R_t|)}$$

with the results shown in the last column of table 5. Report 1 (A&P) and Report 4 (Grain Stock) have relatively high *Report Impact Change Rates*, which means these two reports changed a lot over time in magnitude. Similarly, Report 2 (Crop Progress), Report 3 (Feed Outlook), Report 5 (WASDE) and Report 7 (Cattle on Feed) also have positive report impact change rates although not as large. Only Report 6 (Cattle) and Report 8 (Oil Crop Outlook) show negative and small variation over the 21 years. This indicates the impact of USDA reports is more likely to be changing significantly during our sample period than remaining the same. To present the changing trend of USDA reports' impact more clearly, the estimated values of γ_t are shown in figure 1, where six out of the eight reports have increasing impact over time, especially Report 4

(Grain stock), Report 1 (A&P) and Report 5 (WASDE) whose impacts increased drastically over the sample period. For only two reports (Report 6 and Report 8), the impact declined.

Obviously, the validity of such a time-varying trend of USDA reports' impact hinges on whether the report's impact itself is statistically significant or not. Table 6 provides t-values for each reports' impact over the 21 years (252 months), and marks reports in bright yellow if the impact is statistically significant at the 10% level at that time. And a more visualized result is shown in Figure 2. It can be found that four out of the eight reports are statistically significant at some period during the 21 years, which is consistent with most previous studies verifying the information value of USDA reports.

More specifically, the impact of Report 1 (A&P), Report 4 (Grain Stock) and Report 5 (WASDE) become statistically significant at the 5% level from 2001, 1995 and 1996 onward, respectively, with very high t-values. Combining the facts that the estimated coefficients γ_t of the three reports are increasing over time, and the estimated time-varying factor (B_{2i}) in each report's impact ($\gamma_{it} = B_{1i} + B_{2i} \cdot \ln(t)$) are all positive and significant, we conclude that the announcement value of these three reports is increasing over time.

In contrast, the impacts of the other five reports are generally not statistically significant. A special case is Report 2 (Crop Progress), whose impact is statistically significant before 1998, and then falls to insignificant after that. This means the impact of Report 2 is decaying over time. For the remaining reports, it is hard to draw any conclusion as their impact is not statistically significant throughout of the sample period.

Time-varying Effect of USDA Reports on Soybean Futures Market

Now we apply the same approach to the soybean futures market with estimation results provided in Table 7. The result is very similar to the corn futures market, with R-squared a little bit lower (11.08%). All of the five lagged absolute daily returns are highly significant, as well as the Monday dummy and three months in the growing and harvest seasons: July, August, and October. To further test how the impacts of these eight USDA reports are changing over time, the time-varying coefficient estimates and their t-values are provided in table 8 and table 9.

Table 8 provides the time-varying impact of USDA reports on the soybean futures market. Similar to corn futures market, most reports' impacts trend from a negative to a positive value. The *Report Impact Change Rate* is the largest for Report 4 (Grain Stock), while they are smaller in general than the change rate of corn futures market, which means the changes of USDA reports' impact in the soybean market are relatively smaller than that from the corn market. Again, we present the result in a more visualized way in figure 3. It could be found that the impacts of all the eight reports on the soybean futures market are increasing during the 21 years, especially for Report 4 (Grain Stock), whose impact grew drastically.

Again, the validation of such trend depends on whether these reports are statistically significant. From table 9, we can see that four out of the eight reports are statistically significant at the 10% level in some periods of the 21 years. This is similar to the corn futures market and further validates that USDA reports are still influential in commodity futures markets.

Figure 4 provides a visual way to examine the eight reports' t-values over the 21 years. It shows that Report 4 (Grain Stock) and Report 5 (WASDE) became statistically significant at the 5% level after 1996 and 1995, respectively, and their t-values increased to a very high level after that and remain statistically significant to the end of the sample period. Combined with results that both reports' impact is increasing over time, the significance criteria further verifies the increasing trend of the two reports' impact on the soybean market.

Report 1 (A&P) and Report 2 (Crop Progress) are not significant throughout the sample period for soybeans, although their t-values trend similar to those for corn: the t-value of Report 1 (A&P) is increasing, and the t-value of report 2 (Crop Progress) is declining over time. Report 6 (Cattle) and Report 8 (Oil Crop Outlook) are significant at the end and the beginning of the sample period, respectively. This indicates the impact of Report 6 (Cattle) on the soybean futures market is increasing, while the impact of Report 8 is decreasing over time. For the remaining four reports, since their impact is not significant throughout the whole sample period, we cannot draw any conclusion.

In summary, from the main model, Report 4 (Grain Stock) and Report 5 (WASDE) are found to have significant increasing impact on both corn and soybean futures markets. In addition, the impacts of Report 1 (A&P) and Report 6 (Cattle) are also increasing in the two markets. In contrast, the impact of Report 2 (Crop Progress) and Report 8 (Oil Crop Outlook) are shown to be decaying in the two markets. For the remaining four reports in both markets, no conclusion could be drawn as their impact is not significant during the sample period.

Robustness Checks

A potential concern for our main model is the overlaps among USDA reports announcement dummies which may obscure reports' impact identification if several reports are released on the same day. To further test the validity of our result, a robustness check is conducted by applying the main model with (a) only the reports whose impacts are most significantly increasing in both markets, that is Report 4 (Grain Stock) and Report 5 (WASDE), and (b) only the reports whose impact are the weakest and insignificant in either markets, that is Report 3 (Feed Outlook) and Report 7 (Cattle on Feed). The results are provided in figures 5 and 6.

For both corn and soybean futures markets, figure 5 shows that in the additional regression with only both Report 4 and Report 5, both reports have increasing impact over the 21years at a high significance level. This is consistent with the result from the main model. And Figure 6 shows although the impact of Report 3 and Report 7 are increasing, they are insignificant in general; the

impact of Report 7 is insignificant throughout the sample period, and the impact of Report 3 is insignificant except for about six years near 2000. This is also in accordance with the result of the main model so that the first robustness check verifies the validity of our conclusion.

Next, we apply the model with only Report 9 (Crop Production) to reveal its impact changes over time, as we deleted it from the main model to avoid multicollinearity. The results are shown in figure 7: the impact of Report 9 (Crop Production) is increasing in both the corn and soybean futures markets, and the impact is also highly statistically significant. Combined with previous findings from the main model, Report Grain Stock, WASDE, Crop Production all have statistically significant and increasing impact over time in both markets, which further validate that USDA reports are still influential in commodity futures market.

Finally, to further ensure the robustness of our finding, we run the main model with each of the nine reports separately to have a comparison with the previous findings. The results for corn futures markets are shown in figure 8, where four out of the nine reports have statistically significant impact after 1996 and stay at a high level after that, and their impacts are all increasing. The four reports, Report 1 (A&P), Report 4 (Grain Stock), Report 5 (WASDE) and Report 9 (Crop Production), are the same reports we found from the main model. Report 2 (Crop Progress) falls to insignificant after 2000 so that its impact is decreasing, which is consistent with the main model conclusion. For corn the futures market, the findings of the separate regression test is exactly the same qualitatively as those from the main model.

The results of separate regressions for the soybean futures market are provided in figure 9. Similar to previous findings, all reports' impacts are increasing, but only Report 1 (A&P), Report 4 (Grain Stock), Report 5 (WASDE), and Report 9 (Crop Production) have statistically significant impacts throughout the sample. The impact of Report 6 (Cattle) reached the significant level after 2009 so its impact is also slightly increasing. For Report 8 (Oil Crop Outlook) the impact falls to insignificant after 2001 and its impact is decreasing over time. Compared with the results from the main model, the only difference is the significance of Report 1 (A&P), which is not significant in the main model but significant in the separate regression. Considering the overlap rate of Report 1 and Report 4 are also relatively high (50%), this difference is not too surprising.

In summary, the robustness checks confirm the conclusions we derived from the main model. It also shows that Report 9 (Crop Production) has a statistically significant and increasing impact on both markets, and further reveals the impact of Report 1 (Acreage and Prospective Planting) may also be significant for soybeans.

Summary and Discussion

Combining the results from the main model and the robustness check, our empirical study shows that USDA reports are still informative and influential in both the corn and soybean futures markets.

In either market, more than half of the nine USDA reports are shown to have statistically significant impacts in some period during the 21 years, which is as expected and is consistent with the conclusions of most previous studies.

Second, the empirical results suggest that four reports, Report 1 (Acreage and Prospective Planting), Report 4 (Grain Stock), Report 5 (WASDE), and Report 9 (Crop Production), have statistically significantly increasing impact over the 21 years on both the corn and soybean markets, as all four reports' impacts present an increasing trend and their significance criteria remains at very high levels during the sample period. Further, the time-varying factors in the reports' impact (B_{2i}) for these four reports are also shown to be positive and statistically significant in at least one of our two commodity markets. In addition, Report 6 (Cattle) in the soybean market approached the 10% significant level at the end of the sample period (since 2010), which means its impact in the soybean futures market is increasing but not that strong. Such an increasing trend of USDA reports' impact is also found in some previous studies (Isengildina_Massa, et al., 2008; Lehecka, 2014) although they tested the USDA reports' impacts over different sub-periods.

At the same time, there are also two reports whose impact is declining: Report 2 (Crop Progress) in the corn futures market, and Report 8 (Oil Crop Outlook) in the soybean futures market. The evidence is that both reports have decreasing t-values over time: the impact of Report 2 (Crop Progress) in the corn futures market is first significant at 1995, but falls to insignificant after 1999 and keeps declining all years after that; and it is the same for Report 8 (Oil Crop Outlook), whose impact is also statistically significant at the beginning but falls to insignificant post-1997 with its t-value decreasing after that, too. This evidence suggests the market is not sensitive to these two reports as time goes by. It should be noted that similar downward trends for some USDA reports are also found in Karali, et. al (2016) which employs a rolling regression framework and suggests the price response in the corn market increases over time after 2000, achieves a peak during 2002-2011, and then starts to decrease when the years 2012 -2014 are added. A summary of the previous discussion is provided in Table 10.

Conclusion

This paper presents new evidence for how the impact of USDA report announcements on commodity futures market volatility has changed over time by adopting a continuously time-varying approach to estimate the impacts. Different from the majority of previous studies that adopt a sub-period method, this paper avoids the potential bias caused by sub-period selection and provides a more precise evaluation of USDA reports' impact in specific time periods (months). It shows that USDA reports are not only still informative and influential in commodity futures markets, but have a generally increasing impact over time, with only a few reports showing impacts that decline over the time studied.

The empirical results find that half of nine USDA reports have statistically significant and increasing announcement effects over time in both the corn and soybean futures markets. This is

a bit surprising as our intuition suggested USDA reports' impact might be declining as more diverse information sources (more competitors) are available to today's futures market participants.

There are several possible reasons for our findings. First, the quality and accuracy of USDA reports themselves may have been improved over the 21 years. Second, compared with private sector information, the fact that USDA reports are published by the government may cause market participants to trust their information. Third, although the spread of the internet brings USDA reports a lot of competitors , it also provides USDA reports a much better platform to publish and spread their information so that a larger audience, especially those who used to have difficulties in accessing USDA reports, can reach the information faster and more conveniently.

Another important and crucial reason for USDA reports becoming more impactful on volatility may be noise caused by private sector information. Although the emergence of private sector reports provides much more diverse information so that market participants have more choices, it is quite likely that the multitude of available information causes different futures market participants to take differing positions prior to the release of USDA reports, rather than waiting to see what the report contains. By necessity, some of those positions will prove to be unfavorable once a USDA report is released. The rapid action of mispositioned participants to cover their positions could lead to increased market volatility immediately following a report release. Thus, the USDA reports are valuable because they resolve uncertainty caused by conflicting private sector information.

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Table 1. Summary Statistics of USDA Reports Announcement Dummies

USDA Reports	Release Time	Announcement Day Dummy Variables (n)
Acreage and Prospective Plantings	Acreage: Before market open; Prospective Plantings: Before Market open since 1996	42
Crop Progress	After market close	739
Feed Outlook	Before market open	242
Grain Stocks	Before market open	84
WASDE	Before market open since 1995	249
Cattle	After market close	42
Cattle on Feed	After market close	252
Oil Crops Outlook	After market close	234
Crop Production	8:30 am EST during 1995 to2012, and 12:00 pm since January 2013	253

Overlap Rate of Announcement Day Dummy Variables (%)

	Report 1	Report 2	Report 3	Report 4	Report 5	Report 6	Report 7	Report 8	Report 9
Report 1 (A&P)	1	0.68	0.00	50.00	0.00	0.00	0.00	0.00	0.00
Report 2 (Crop Progress)	0.68	1	4.86	1.08	2.70	0.00	0.00	7.43	2.43
Report 3 (Feed Outlook)	0.00	4.86	1	0.00	0.80	0.00	0.79	31.69	0.39
Report 4 (Grain Stocks)	50.00	1.08	0.00	1	8.37	0.00	0.00	0.00	5.91
Report 5 (WASDE)	0.00	2.70	0.80	8.37	1	0.00	0.00	0.40	92.91
Report 6 (Cattle)	0.00	0.00	0.00	0.00	0.00	1	7.94	0.00	0.39
Report 7 (Cattle on Feed)	0.00	0.00	0.79	0.00	0.00	7.94	1	0.40	0.00
Report 8 (Oil Crops Outlook)	0.00	7.43	31.69	0.00	0.40	0.00	0.40	1	0.39
Report 9 (Crop Production)	0.00	2.43	0.39	5.91	92.91	0.39	0.00	0.39	1

Table 2. Nearby Futures Contracts Used in Empirical Analyses

Calendar Month	Corn	Soybean
January	March	March
February	March	March
March	May	May
April	May	May
May	July	July
June	July	July
July	September	September
August	September	September
September	December	November
October	December	November
November	December	January
December	March	January

Table 3. Summary Statistics of Daily Return

		$R_t = 100*(\ln F_t - \ln F_{t-1})$				$\lvert R_t \rvert = \lvert 100*(\ln F_t - \ln F_{t-1}) \rvert$			
		Mean	Min.	Max.	Std.Dev.	Mean	Min.	Max.	Std.Dev.
Corn Futures Market									
Announcement Days	(n=1561)	-0.042	-10.409	8.662	1.843	1.350	0.000	10.409	1.254
Non-announcement Days	(n=3732)	-0.020	-7.929	7.397	1.598	1.175	0.000	7.929	1.083
Soybeans Futures Market									
Announcement Days	(n=1561)	-0.004	-7.411	6.366	1.609	1.174	0.000	7.411	1.100
Non-announcement Days	(n=3726)	0.037	-7.318	6.729	1.421	1.060	0.000	7.318	0.948

Table 4. Impacts of USDA Reports on Corn Futures Market

	Coefficient	*Standard Error (robust)*	*Prob.*
Constant	0.4431***	0.0543	<0.0001
lag 1day	0.1239***	0.0133	<0.0001
lag 2day	0.1048***	0.0134	<0.0001
lag 3day	0.0439***	0.0133	0.001
lag 4day	0.0921***	0.0133	<0.0001
lag 5day	0.0967***	0.0133	<0.0001
Monday	0.1863***	0.0419	<0.0001
Jan	0.0215	0.0704	0.7602
Feb	0.0182	0.0709	0.797
Mar	0.0634	0.0688	0.357
Apr	0.1247*	0.07	0.0748
May	0.1754**	0.0697	0.0118
Jun	0.2846***	0.0703	0.0001
Jul	0.3615***	0.0724	<0.0001
Aug	0.202***	0.0693	0.0036
Sep	0.1459**	0.0707	0.0392
Oct	0.1481**	0.0689	0.0316
Nov	0.0703	0.0701	0.3159
B11	-1.9748*	1.1161	0.0769
B12	-0.4356**	0.2102	0.0383
B13	-0.4591	0.3436	0.1816
B14	-0.4069	0.792	0.6075
B15	-0.1508	0.3642	0.6789
B16	0.1267	0.7843	0.8717
B17	-0.1589	0.3415	0.6419
B18	0.1434	0.347	0.6795
B21	0.5562**	0.2403	0.0207
B22	0.0904**	0.0448	0.0436
B23	0.0951	0.0764	0.2132
B24	0.4407***	0.1703	0.0097
B25	0.149*	0.0779	0.0558
B26	-0.0423	0.169	0.8023
B27	0.0378	0.073	0.6046
B28	-0.0529	0.0767	0.4907

R^2=0.1674

Table 5. Time-varying Impact of USDA Reports on Corn Futures Market

Month	*1*	*11*	*21*	*31*	*41*	*51*	*61*	*71*	*81*	*91*	*101*	*111*	*121*	*131*	*141*	*151*	*161*	*171*	*181*	*191*	*201*	*211*	*221*	*231*	*241*	*251*	$\frac{\gamma_{251}-\gamma_1}{E(\lvert R_t\rvert)}$
Correspond Year	*1995*	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2015*	
(1) A&P	-1.59	-0.59	-0.26	-0.05	0.10	0.22	0.32	0.40	0.48	0.54	0.60	0.65	0.70	0.74	0.78	0.82	0.86	0.89	0.92	0.95	0.98	1.00	1.03	1.05	1.08	1.10	2.19
(2) Crop Progress	-0.37	-0.21	-0.16	-0.12	-0.10	-0.08	-0.06	-0.05	-0.04	-0.03	-0.02	-0.01	0.00	0.01	0.01	0.02	0.02	0.03	0.03	0.04	0.04	0.05	0.05	0.06	0.06	0.06	0.36
(3) Feed Outlook	-0.39	-0.22	-0.17	-0.13	-0.10	-0.08	-0.07	-0.05	-0.04	-0.03	-0.02	-0.01	0.00	0.01	0.01	0.02	0.02	0.03	0.04	0.04	0.05	0.05	0.05	0.06	0.06	0.07	0.37
(4) Grain Stock	-0.10	0.69	0.96	1.12	1.24	1.33	1.41	1.48	1.54	1.59	1.63	1.67	1.71	1.74	1.78	1.81	1.84	1.86	1.89	1.91	1.93	1.95	1.97	1.99	2.01	2.03	1.74
(5) WASDE	-0.05	0.22	0.31	0.37	0.41	0.44	0.46	0.49	0.51	0.52	0.54	0.55	0.57	0.58	0.59	0.60	0.61	0.62	0.62	0.63	0.64	0.65	0.65	0.66	0.67	0.67	0.59
(6) Cattle	0.10	0.02	0.00	-0.02	-0.03	-0.04	-0.05	-0.05	-0.06	-0.06	-0.07	-0.07	-0.08	-0.08	-0.08	-0.09	-0.09	-0.09	-0.09	-0.10	-0.10	-0.10	-0.10	-0.10	-0.11	-0.11	-0.17
(7) Cattle on Feed	-0.13	-0.06	-0.04	-0.03	-0.02	-0.01	0.00	0.00	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.15
(8) Oil Crop Outlook	0.11	0.01	-0.02	-0.04	-0.05	-0.07	-0.07	-0.08	-0.09	-0.10	-0.10	-0.11	-0.11	-0.11	-0.12	-0.12	-0.13	-0.13	-0.13	-0.13	-0.14	-0.14	-0.14	-0.14	-0.15	-0.15	-0.21

Table 6. Statistically Significance Criteria (t-value) of the Time-varying Impact of USDA Reports on Corn Futures Market

Month	*1*	*11*	*21*	*31*	*41*	*51*	*61*	*71*	*81*	*91*	*101*	*111*	*121*	*131*	*141*	*151*	*161*	*171*	*181*	*191*	*201*	*211*	*221*	*231*	*241*	*251*
Correspond Year	*1995*	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2015*
(1) A&P	-1.66	-1.08	-0.61	-0.13	0.34	0.81	1.25	1.65	1.99	2.28	2.51	2.70	2.84	2.95	3.04	3.10	3.15	3.19	3.22	3.24	3.25	3.26	3.27	3.27	3.28	3.28
(2) Crop Progress	-2.07	-2.03	-1.94	-1.82	-1.67	-1.49	-1.28	-1.05	-0.83	-0.60	-0.40	-0.20	-0.03	0.12	0.26	0.38	0.49	0.58	0.67	0.74	0.81	0.87	0.92	0.97	1.01	1.05
(3) Feed Outlook	-1.35	-1.34	-1.28	-1.18	-1.05	-0.91	-0.76	-0.60	-0.46	-0.33	-0.22	-0.11	-0.02	0.06	0.13	0.19	0.24	0.29	0.33	0.37	0.41	0.44	0.47	0.49	0.52	0.54
(4) Grain Stock	-0.15	1.77	3.19	4.49	5.70	6.78	7.71	8.45	9.00	9.39	9.62	9.75	9.79	9.77	9.71	9.62	9.52	9.41	9.29	9.17	9.05	8.94	8.83	8.72	8.62	8.52
(5) WASDE	-0.15	1.23	2.28	3.27	4.23	5.13	5.93	6.61	7.13	7.50	7.74	7.86	7.90	7.88	7.82	7.73	7.62	7.51	7.40	7.28	7.17	7.06	6.95	6.85	6.75	6.66
(6) Cattle	0.15	0.06	-0.01	-0.08	-0.15	-0.21	-0.26	-0.31	-0.35	-0.38	-0.41	-0.43	-0.44	-0.45	-0.45	-0.46	-0.46	-0.46	-0.46	-0.46	-0.46	-0.46	-0.46	-0.45	-0.45	-0.45
(7) Cattle on Feed	-0.45	-0.38	-0.32	-0.25	-0.18	-0.11	-0.03	0.04	0.10	0.16	0.21	0.26	0.29	0.33	0.35	0.38	0.40	0.41	0.43	0.44	0.45	0.46	0.47	0.47	0.48	0.49
(8) Oil Crop Outlook	0.36	0.07	-0.15	-0.36	-0.54	-0.70	-0.83	-0.94	-1.02	-1.08	-1.13	-1.16	-1.18	-1.20	-1.21	-1.21	-1.22	-1.22	-1.22	-1.22	-1.21	-1.21	-1.21	-1.20	-1.20	-1.20

*$Critical\ value$: $t_{0.1} = 1.645;\quad t_{0.05} = 1.96$

Table 7. Impacts of USDA Reports on Soybean Futures Market

	Coefficient	*Standard Error (robust)*	*Prob.*
Constant	0.4894***	0.0505	<0.0001
lag 1day	0.0794***	0.0135	<0.0001
lag 2day	0.1073***	0.0135	<0.0001
lag 3day	0.0461***	0.0135	0.0007
lag 4day	0.0936***	0.0135	<0.0001
lag 5day	0.1035***	0.0135	<0.0001
Monday	0.1353***	0.0378	0.0004
Jan	-0.0076	0.0641	0.9054
Feb	0.017	0.0646	0.7925
Mar	0.0425	0.0627	0.4977
Apr	0.0389	0.0636	0.5404
May	0.0584	0.0632	0.3552
Jun	0.0915	0.0636	0.1499
Jul	0.2629***	0.0647	<0.0001
Aug	0.1912***	0.0632	0.0025
Sep	0.0819	0.0644	0.2035
Oct	0.1064**	0.0626	0.0896
Nov	0.0543	0.064	0.3957
B11	-0.6483	1.0081	0.5202
B12	-0.2085	0.1892	0.2703
B13	-0.475	0.3096	0.125
B14	-0.4682	0.7153	0.5128
B15	0.2236	0.3286	0.4962
B16	-0.527	0.7081	0.4568
B17	-0.0429	0.3079	0.8893
B18	0.1064**	0.3128	0.0983
B21	0.172	0.2171	0.4281
B22	0.0332	0.0403	0.4104
B23	0.0937	0.0688	0.1731
B24	0.341**	0.1538	0.0267
B25	0.0391	0.0703	0.5778
B26	0.1595	0.1526	0.296
B27	0.0235	0.0658	0.7212
B28	0.1024	0.0691	0.1385

R^2=0.1108

Table 8. Time-varying Impact of USDA Reports on Soybean Futures Market

Month	*1*	*11*	*21*	*31*	*41*	*51*	*61*	*71*	*81*	*91*	*101*	*111*	*121*	*131*	*141*	*151*	*161*	*171*	*181*	*191*	*201*	*211*	*221*	*231*	*241*	*251*	$\frac{\gamma_{251}-\gamma_1}{E(\lvert R_t\rvert)}$
Correspond Year	*1995*	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2015*	
(1) A&P	-0.53	-0.22	-0.12	-0.05	-0.01	0.03	0.06	0.09	0.11	0.13	0.15	0.16	0.18	0.19	0.20	0.22	0.23	0.24	0.25	0.26	0.26	0.27	0.28	0.29	0.30	0.30	0.68
(2) Crop Progress	-0.19	-0.13	-0.11	-0.09	-0.08	-0.08	-0.07	-0.07	-0.06	-0.06	-0.06	-0.05	-0.05	-0.05	-0.04	-0.04	-0.04	-0.04	-0.04	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	0.13
(3) Feed Outlook	-0.41	-0.24	-0.19	-0.15	-0.12	-0.10	-0.09	-0.07	-0.06	-0.05	-0.04	-0.03	-0.02	-0.02	-0.01	0.00	0.00	0.01	0.01	0.02	0.02	0.03	0.03	0.04	0.04	0.04	0.37
(4) Grain Stock	-0.23	0.38	0.59	0.71	0.81	0.88	0.94	0.99	1.03	1.07	1.11	1.14	1.17	1.20	1.22	1.25	1.27	1.29	1.31	1.32	1.34	1.36	1.37	1.39	1.40	1.42	1.34
(5) WASDE	0.25	0.32	0.34	0.36	0.37	0.38	0.39	0.39	0.40	0.40	0.40	0.41	0.41	0.41	0.42	0.42	0.42	0.43	0.43	0.43	0.43	0.43	0.44	0.44	0.44	0.44	0.15
(6) Cattle	-0.42	-0.13	-0.03	0.03	0.07	0.10	0.13	0.16	0.18	0.19	0.21	0.23	0.24	0.25	0.26	0.27	0.28	0.29	0.30	0.31	0.32	0.33	0.33	0.34	0.35	0.36	0.63
(7) Cattle on Feed	-0.03	0.02	0.03	0.04	0.05	0.05	0.05	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09
(8) Oil Crop Outlook	-0.45	-0.26	-0.20	-0.16	-0.13	-0.11	-0.09	-0.08	-0.07	-0.05	-0.04	-0.03	-0.03	-0.02	-0.01	0.00	0.00	0.01	0.02	0.02	0.03	0.03	0.04	0.04	0.05	0.05	0.40

Table 9. Statistically Significance Criteria (t-value) of the Time-varying Impact of USDA Reports on Soybean Futures Market

Month	*1*	*11*	*21*	*31*	*41*	*51*	*61*	*71*	*81*	*91*	*101*	*111*	*121*	*131*	*141*	*151*	*161*	*171*	*181*	*191*	*201*	*211*	*221*	*231*	*241*	*251*
Correspond Year	*1995*	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2015*
(1) A&P	-0.61	-0.45	-0.31	-0.16	-0.02	0.13	0.27	0.40	0.51	0.61	0.69	0.75	0.80	0.85	0.88	0.91	0.93	0.94	0.96	0.97	0.98	0.98	0.99	0.99	1.00	1.00
(2) Crop Progress	-1.15	-1.35	-1.46	-1.55	-1.60	-1.63	-1.62	-1.59	-1.53	-1.46	-1.38	-1.29	-1.20	-1.12	-1.03	-0.96	-0.89	-0.82	-0.76	-0.71	-0.66	-0.61	-0.57	-0.53	-0.49	-0.46
(3) Feed Outlook	-1.56	-1.61	-1.59	-1.51	-1.40	-1.26	-1.11	-0.95	-0.79	-0.65	-0.52	-0.40	-0.29	-0.20	-0.12	-0.05	0.02	0.08	0.13	0.18	0.22	0.26	0.30	0.33	0.36	0.39
(4) Grain Stock	-0.38	1.08	2.17	3.17	4.11	4.95	5.68	6.27	6.72	7.04	7.25	7.37	7.42	7.42	7.40	7.35	7.28	7.21	7.13	7.05	6.96	6.88	6.81	6.73	6.66	6.59
(5) WASDE	0.89	2.00	2.81	3.56	4.27	4.91	5.45	5.88	6.19	6.37	6.44	6.44	6.38	6.28	6.15	6.02	5.88	5.74	5.60	5.47	5.35	5.23	5.12	5.02	4.92	4.82
(6) Cattle	-0.69	-0.38	-0.13	0.12	0.36	0.59	0.80	0.99	1.15	1.28	1.38	1.46	1.52	1.56	1.59	1.62	1.63	1.64	1.65	1.66	1.66	1.66	1.66	1.66	1.65	1.65
(7) Cattle on Feed	-0.10	0.10	0.25	0.39	0.52	0.63	0.73	0.82	0.88	0.93	0.97	0.99	1.00	1.01	1.01	1.01	1.01	1.00	0.99	0.98	0.98	0.97	0.96	0.95	0.94	0.93
(8) Oil Crop Outlook	-1.67	-1.72	-1.68	-1.60	-1.48	-1.33	-1.16	-0.99	-0.83	-0.68	-0.54	-0.41	-0.30	-0.20	-0.11	-0.03	0.04	0.11	0.16	0.21	0.26	0.30	0.34	0.38	0.41	0.44

*$Critical\ value$: $t_{0.1} = 1.645$; $t_{0.05} = 1.96$

Table 10. Summary of USDA Reports Impact Trend in Corn and Soybean Futures Markets				
	Corn Futures Market		***Soybean Futures Market***	
	Statistically Significant at Some Period (10% level)	Report's Impact Trend Over Time	Statistically Significant at Some Period (10% level)	Report's Impact Trend Over Time
A&P	√	↑	√	↑
Crop Progress	√	↓	×	unclear
Feed Outlook	×	unclear	×	unclear
Grain Stock	√	↑	√	↑
WASDE	√	↑	√	↑
Cattle	×	unclear	√	↑ (slightly)
Cattle on Feed	×	unclear	×	unclear
Oil Crop Outlook	×	unclear	√	↓
Crop Production	√	↑	√	↑

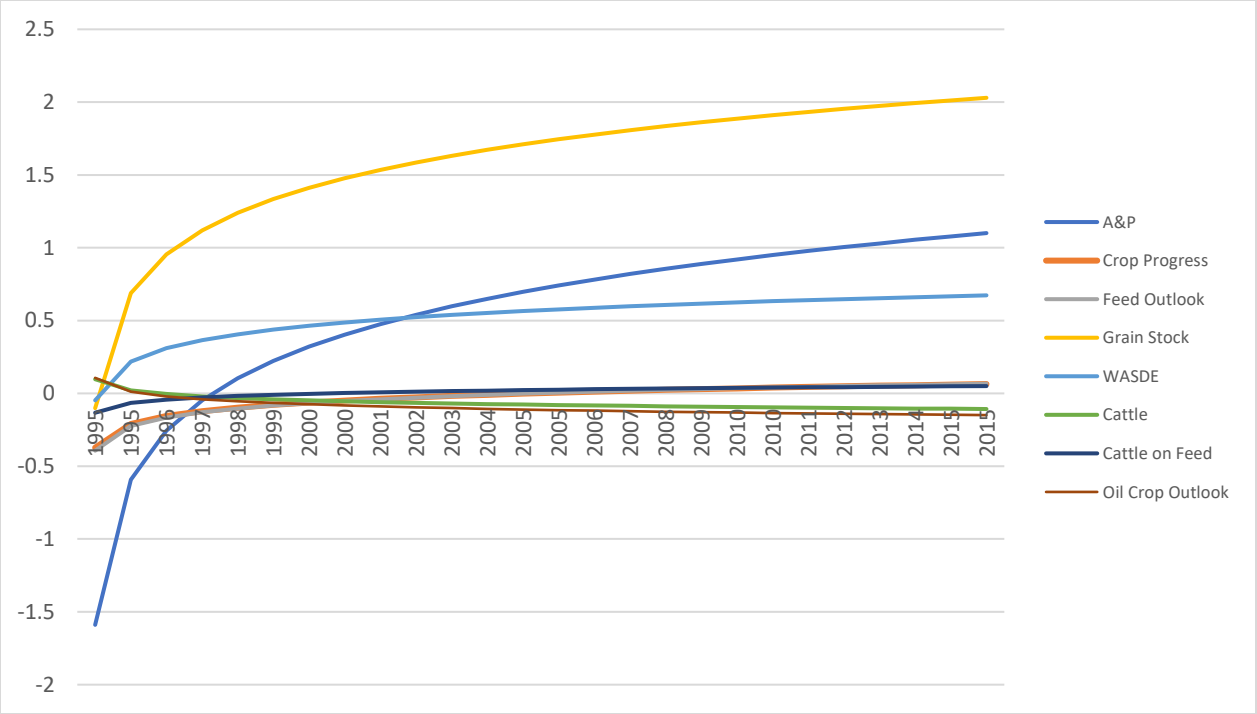

Figure 1. Time-Varying Impact of USDA Reports on Corn Futures Market

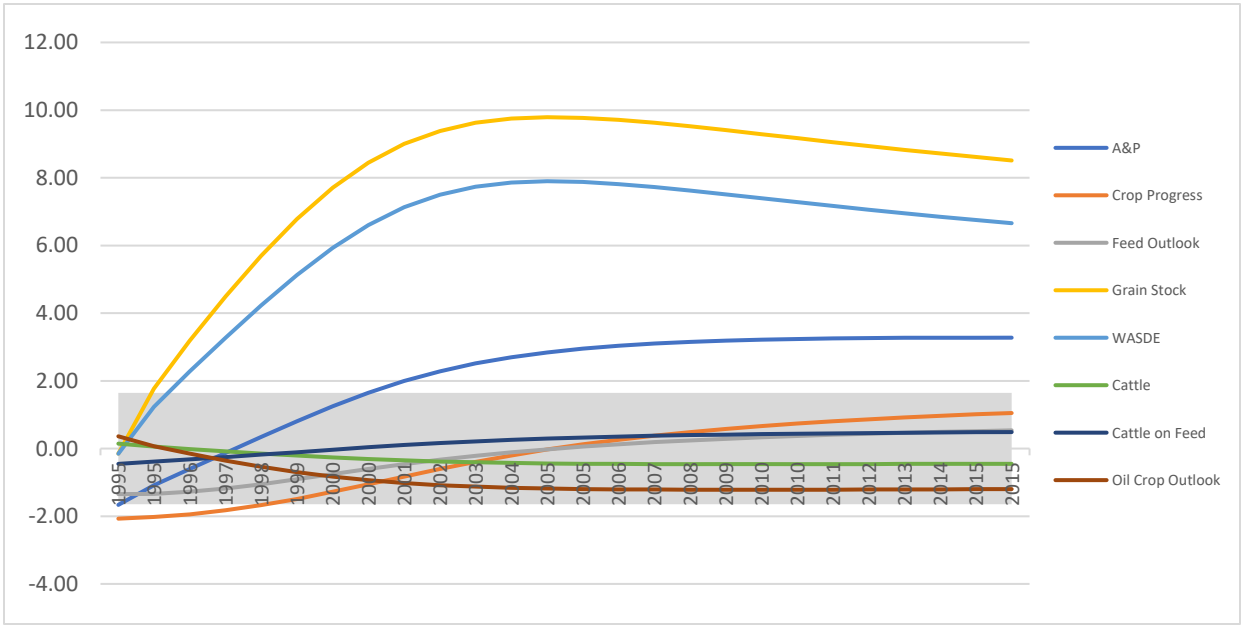

Figure 2. t-value of the Time-varying Impact of USDA Reports on Corn Futures Market

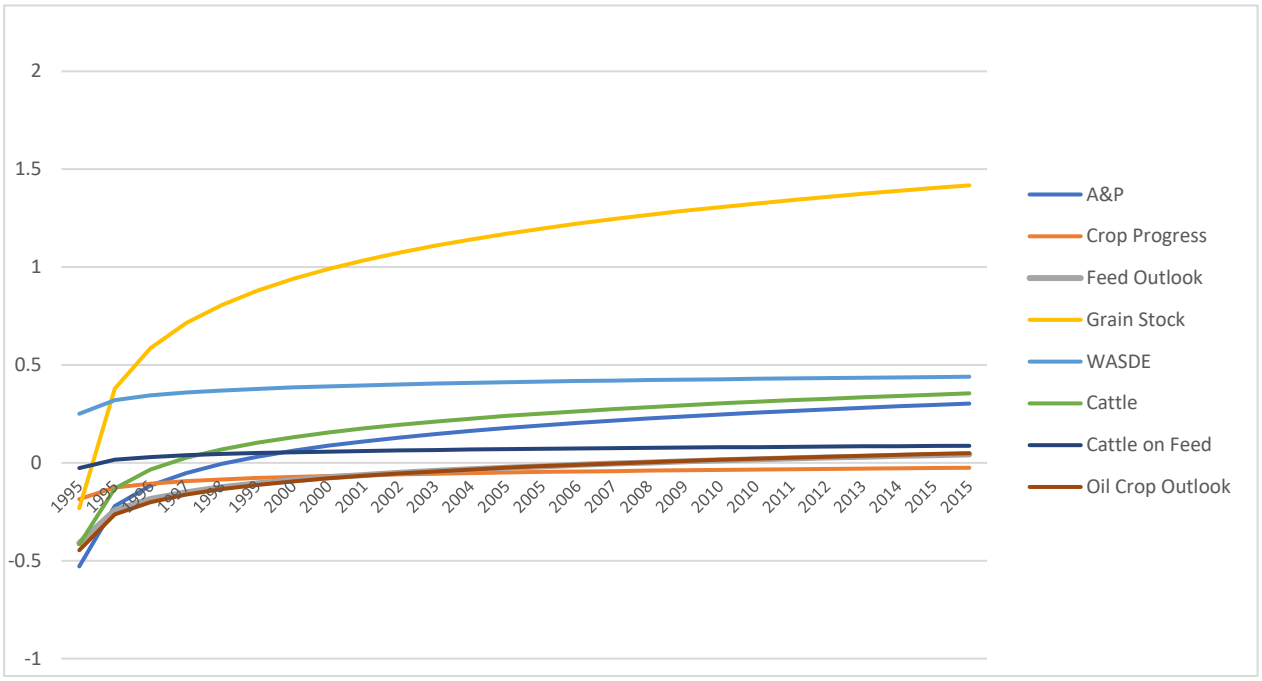

Figure 3. Time-Varying Impact of USDA Reports on Soybean Futures Market

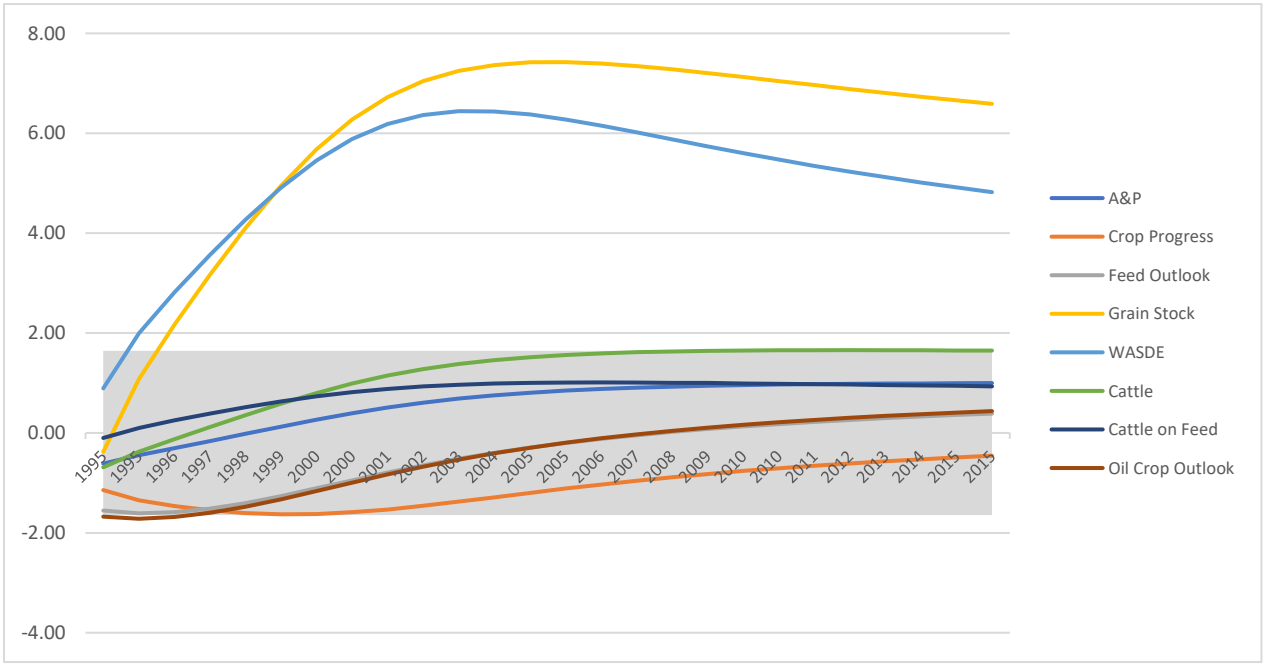

Figure 4. t-value of the Time-varying Impact of USDA Reports on Soybean Futures Market

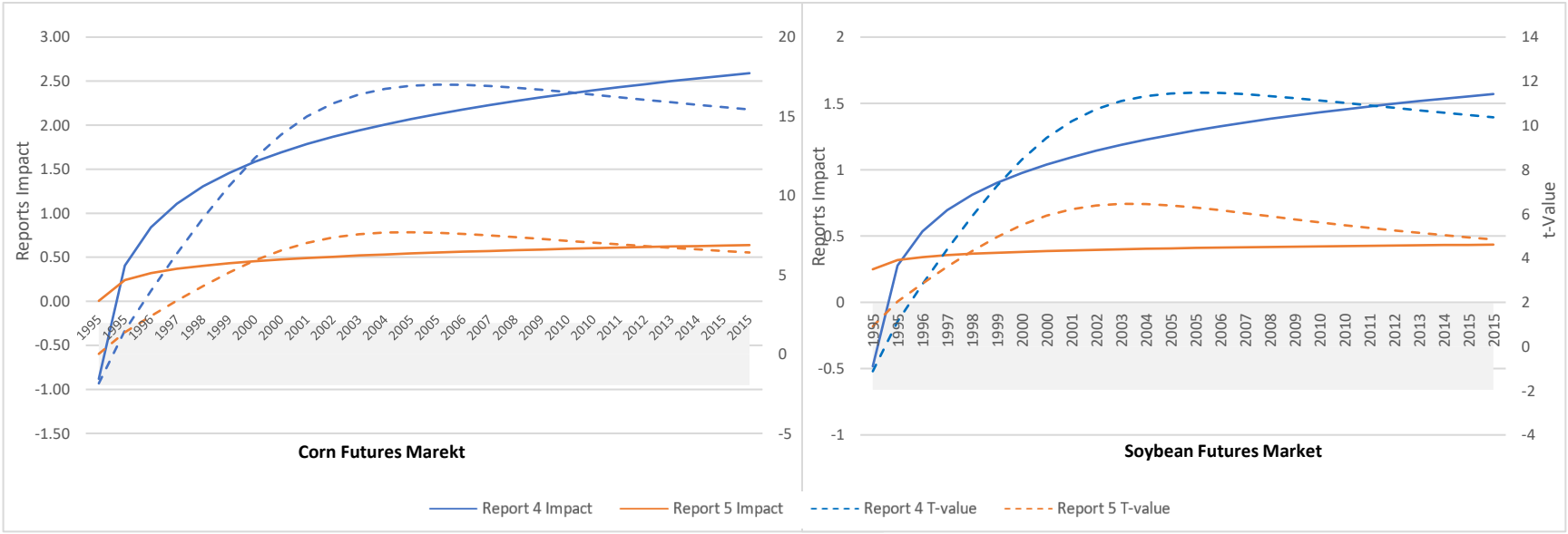

Figure 5. Robustness Check for the Most Significant Two Reports (Report 4 and Report 5)

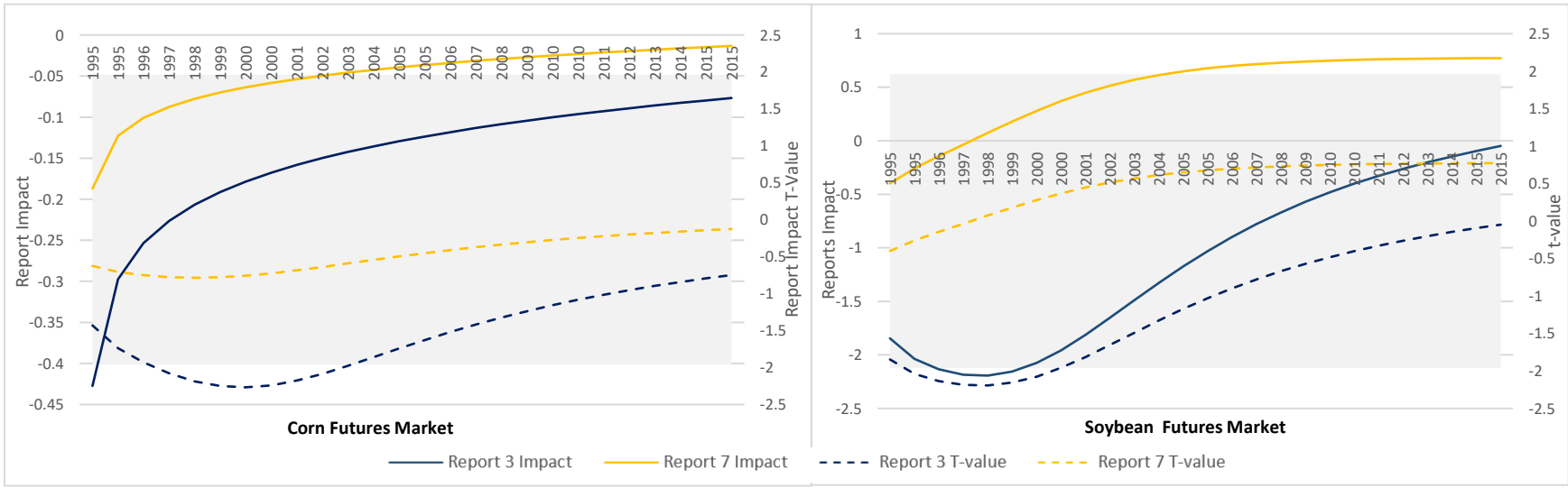

Figure 6. Robustness Check for the Most Insignificant Two Reports (Report 3 and Report 7)

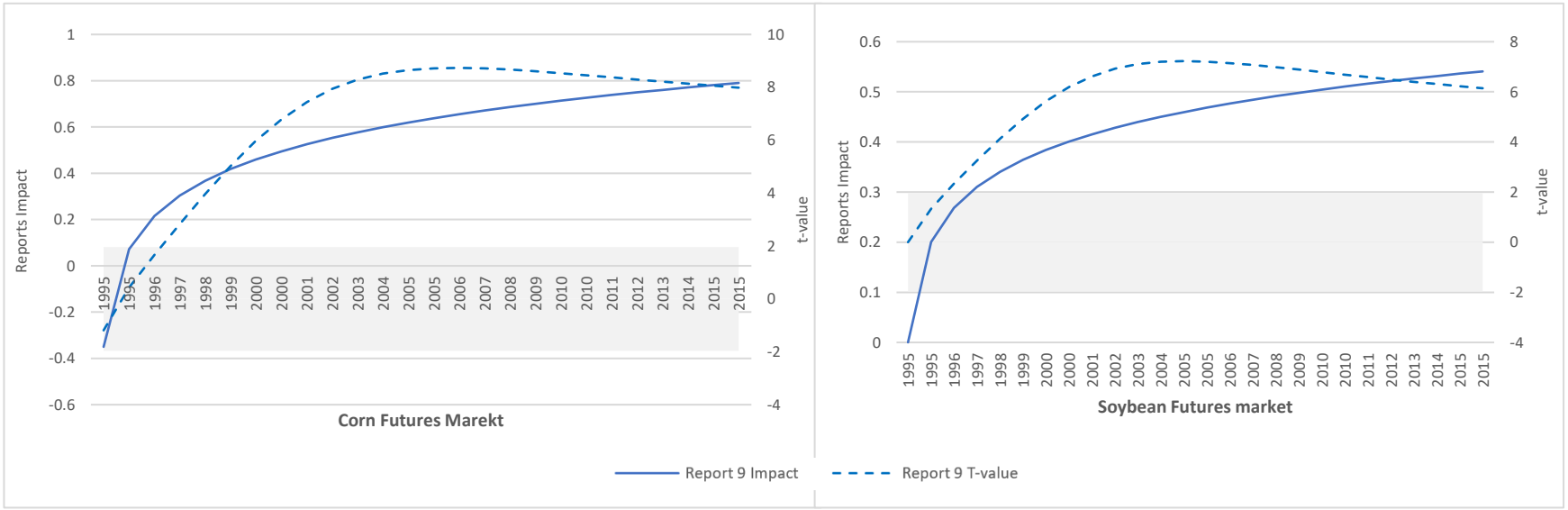

Figure 7. Time-varying Impact of Reports 9 (Crop Production)

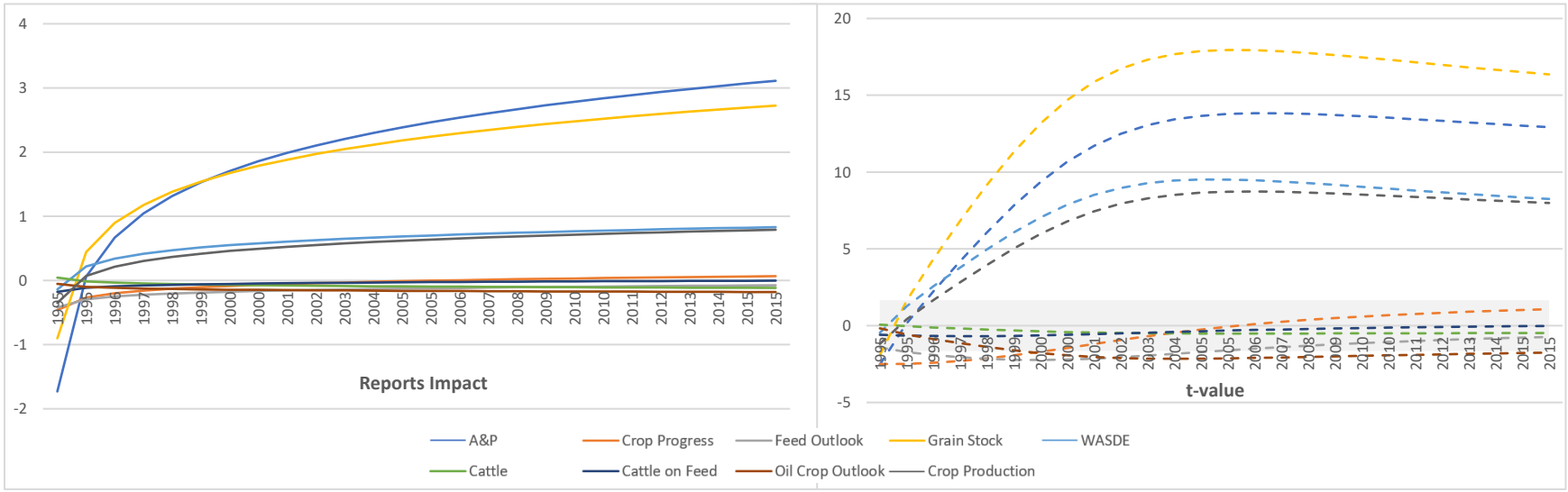

Figure 8. Robustness Check for all the Nine Reports Impact on corn Futures Market (from Separate Regression)

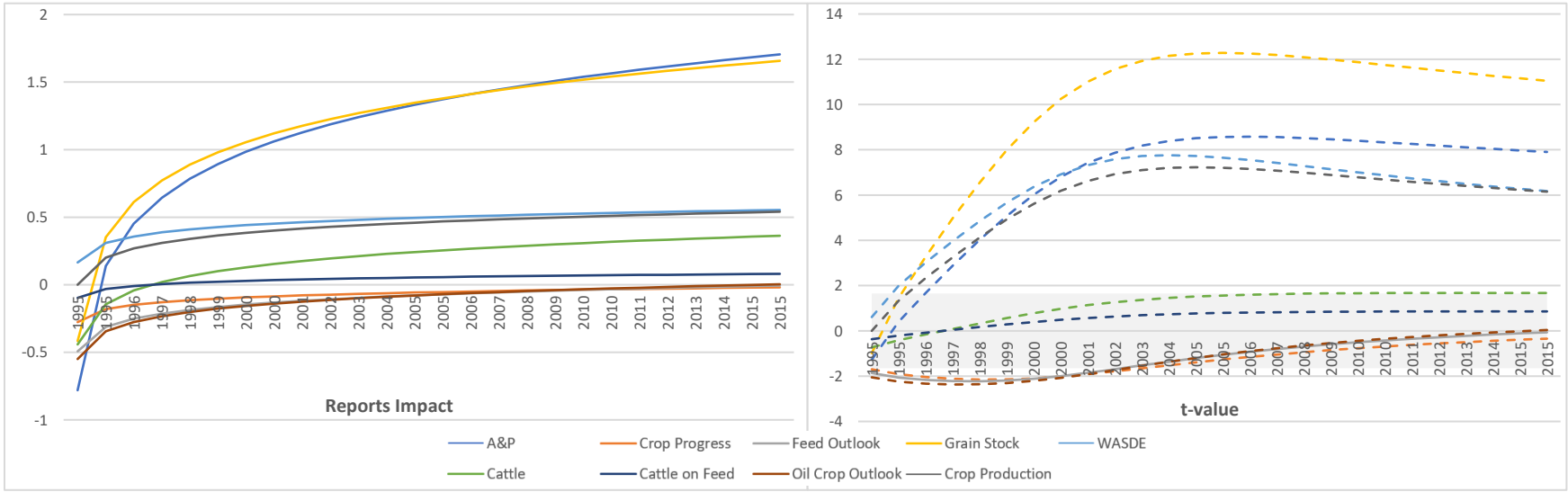

Figure 9. Robustness Check for all the Nine Reports Impact on Soybean Futures Market (from Separate Regression)