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United States Department of Agriculture Forecasts: A Meta-Analysis Study

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Abstract

The primary goal of this study is doing a meta-analysis research on two groups of published studies. First, the ones that focus on the evaluation of the United States Department of Agriculture (USDA) forecasts and second, the ones that evaluate the market reactions to the USDA forecasts. We investigate four questions. 1) How the previously published studies evaluate the accuracy of the USDA forecasts? 2) How they evaluate the market reactions to the USDA forecasts? 3) Is there any heterogeneity in the results of the mentioned studies? 4) Is there any publication bias? About the first question, while some researchers argue that the forecasts are unbiased, most of them maintain that they are biased, inefficient, not optimal, or not rational. About the second question, while a few studies claim that the forecasts are not newsworthy, most of them maintain that they are newsworthy, provide useful information, and cause market reactions. About the third and the fourth questions, based on our findings, there are some clues that the results of the studies are heterogeneous, but we could not find enough evidences of publication bias.

Keywords: *USDA forecasts, meta-analysis, publication bias*

JEL Classification: *D49, Q10*

ABD Tarım Bakanlığı Tahminleri: Bir Meta-Analiz Araştırması

Özet

Bu çalışmanın temel amacı, yayınlanmış iki grup çalışma üzerinde bir meta-analiz araştırması yapmaktır. Bunlardan birincisi, ABD Tarım Bakanlığı (USDA) tahminlerinin değerlendirilmesine odaklanan, ikincisi ise bu tahminlere piyasanın gösterdiği tepkileri değerlendiren çalışmalardır. Çalışmada bu dört soru araştırılmıştır: 1) Daha önce yayınlanan çalışmalar USDA tahminlerinin doğruluğunu nasıl değerlendiriyor? 2) Bu çalışmalar USDA tahminlerine piyasanın gösterdiği tepkileri nasıl değerlendiriyor? 3) Söz konusu çalışmalar sonuçları bakımından heterojenlik gösteriyor mu? 4) Bu yayınlarda yayın yanlılığı var mı? İlk soruya ilişkin olarak, bazı araştırmacılar tahminlerin tarafsız olduğunu savunurken, araştırmacıların çoğunluğu bu tahminlerin yanlı, etkinsiz, optimal olmadığını veya rasyonel olmadığını iddia etmiştir. İkinci soru hakkında, tahminlerin haber değeri taşımadığını az sayıda çalışma ileri sürse de, çalışmaların çoğunluğu tahminlerin haber değeri taşıdığını, faydalı bilgiler sağladığını ve piyasa tepkilerine neden olduğunu savunmuştur. Üçüncü ve dördüncü sorulara ilişkin elde edilen bulgular ise, çalışmaların sonuçlarının heterojen olduğuna yönelik bazı ipuçları sunmakla birlikte yayın yanlılığına dair yeterli kanıtın olmadığını göstermiştir.

Anahtar Kelimeler: *USDA tahminleri, meta-analiz, yayın yanlılığı*

JEL Sınıflandırması: *D49, Q10*

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1. Introduction

Meta-analysis is a systematic approach to analyze literature review by statistical methods where the goal is to compile and contrast the findings of several related studies. For the first time, this method proposed by Glass (1976: 3-8). Also, other researchers such as Jarrell and Stanley (1990: 54-67) are among the first ones that applied meta-analysis. The studies that aim to aggregate and synthesize the literature on a certain topic progressively apply meta-analysis (Olkin,1995: 457–472). Currently researchers apply this method in many different areas including psychology, education, science, marketing, and social sciences. Meta-analysis is popular among the economists as well.

In this paper we exclusively focus on two types of studies. First, the studies that evaluate the United States Department of Agriculture (USDA) forecasts. Second, the ones that evaluate the market reactions to these forecasts. Note that almost all the studies that focus on the USDA forecasts can be categorized in one or both of mentioned categories above. The number of published papers in mentioned areas are high and they report mixed often contradict findings.

USDA provides the monthly report "World Agricultural Supply and Demand Estimates" (WASDE) which is a comprehensive forecast of supply and demand for major crops (produced in U.S. and the rest of the world) and livestock (U.S. only). WASDE report applies the statistical reports compiled by the USDA agencies and other government agencies (Xiao et al., 2014: 17-18).

We are interested in finding answers for four questions. First, how the academic published studies evaluate accuracy of USDA forecasts? In other words, do their findings show that the USDA forecasts are accurate? Second, how the academic published studies evaluate market reactions to the USDA forecasts? Third, are results of the academic papers heterogeneous? Fourth, are there any clues of publication bias?

In the rest of this paper, we focus on answering the mentioned questions above. In the next section, we briefly talk about the USDA forecasts. 'Methodology of data-analyzing' is the topic thing that we discuss. Then, we represent 'Analysis', 'Accuracy of the USDA Forecasts', 'Market Reactions to the USDA Forecasts', 'Meta-analysis', and 'Discussion' respectively.

The rest of this paper is organized, as follows. Section 2 discusses the literature. Section 3 outlines the research methodology of paper. Section 4 provides the results and discussion and section 5 presents the conclusion of the study.

2. Literature Review

In a comprehensive search in the literature we found 54 relevant studies. We mainly applied the key words "USDA forecast", "USDA", "forecast", "Evaluation", "Accuracy", "market reaction", "market participants", etc. The searching process

has been done mainly through Google Scholar[2] and ScienceDirect[3]websites. Figure 1 represents the scatter plot that shows the number of published papers each year.

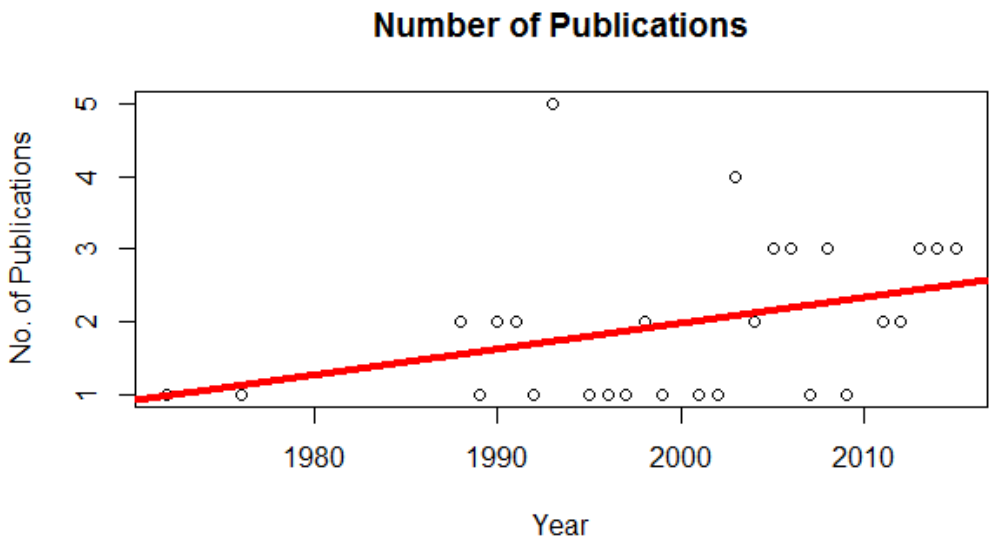

Figure 1: Scatter Plot of Number of Relevant Publications.
Note: Each dot shows the number of publications in one specific year. The positive slope of the red line shows that the number of publications per year has been increasing.

2.1. Summary of the Literature

In this section, first, we provide the summary of findings of the studies that evaluate the USDA forecasts, then we summarize the findings of the ones that evaluate market reactions to the USDA forecasts.

Researcher & Topic (Accuracy of the USDA Forecasts)	**Summary of study**
Egelkraut et al. (2003: 92-94). An evaluation of crop forecast accuracy for corn and soybeans: USDA and private information agencies.	Even though, all agencies' forecast accuracy is improved, and relative accuracy is varied by crop and time, the USDA predictions are more accurate than other agencies. However, when it comes to soybeans the forecast errors are very similar for all agencies.
Good & Irwin (2005: 10-15). Understanding USDA corn and soybean production forecasts: Methods,	The USDA production forecast errors are largest in August. For August, the private market forecasts for soybeans are more accurate than the USDA forecasts, but the USDA corn production forecasts

[2] https://scholar-google-com.eres.library.manoa.hawaii.edu/
[3] http://www.sciencedirect.com.eres.library.manoa.hawaii.edu/

performance and market impacts over 1970-2005.	are more accurate than the private market. In addition, as the growing season goes on the accuracy of the USDA forecast for soybeans improves.
Gunnelson et al. (1972: 640). Analysis of the accuracy of USDA crop forecasts.	The USDA forecasts are improved moderately over 1929 to 1970, but it still underestimates the crop size, year to year production changes, and its own errors in earlier forecasts when it revises the new forecasts.
Irwin et al. (2014: 52-59). Evaluation of Selected USDA WAOB and NASS Forecasts and Estimates in Corn and Soybeans.	Neither for corn nor for soybeans the accuracy of the WAOB forecasts have not changed significantly over time. Also, there is no evidence of bias in NASS forecasts for corn. In addition, there is some evidences of improvement in the accuracy of NASS corn forecasts over time. However, soybean forecasts usually underestimate the yield.
Isengildina-Massa et al. (2013a: 105-106). Do Big Crops Get Bigger and Small Crops Get Smaller? Further Evidence on Smoothing in US Department of Agriculture Forecasts.	The USDA forecasts for both soybeans and corn increase in big crop years and decrease in small crop years and the magnitude of smoothing is significantly large.
Isengildina-Massa et al. (2006: 1101-1102). Are Revisions to USDA Crop Production Forecasts Smoothed?	The USDA forecasts are smoothed, but due to smoothing, loss in forecast accuracy happens which is statistically and economically significant in several cases.
Isengildina-Massa et al. (2011: 3801-3802). Empirical confidence intervals for USDA commodity price forecasts.	This study suggests that empirical approaches such as kernel density, quantile distribution, and best fitting parametric distribution methods might be used to construct more accurate confidence intervals for USDA wheat, soybean, and corn forecasts.
Isengildina-Massa et al. (2013b: 5101-5102). When do the USDA forecasters make mistakes?	The errors in ending stocks forecasts are usually driven by errors in production forecasts across all commodities. In addition, for all commodities, errors in price forecasts are caused by errors in U.S. ending stocks forecasts.
Isengildina-Massa et al. (2012: 111). A comprehensive evaluation of USDA cotton forecasts.	The USDA forecast overestimates China's exports, but underestimates China's domestic use and rest of the world imports. In addition, USDA repeats errors in ROW (i.e. rest of the world except China) production forecasts and overcorrects errors in ROW exports forecasts.
Isengildina-Massa et al. (2011: 11-12). What Can We Learn from our	Correction for correlation in forecast revisions does not improve the USDA cotton forecasts. Correction for correlation of errors with previous year's errors

Mistakes? Evaluating the Benefits of Correcting Inefficiencies in USDA Cotton Forecasts.	and correlation of errors with forecast levels, result in improvement of USDA cotton forecasts.
Kastens et al. (1998: 259). Evaluation of extension and USDA price and production forecasts.	For livestock series, Extension forecasts are more accurate than the USDA forecasts, but for the crops USDA forecasts are more accurate. However, in most of the cases Composite forecasts are more accurate than both of Extension and the USDA forecasts.
Manfredo & Sanders (2004: 128-130). The value of public price forecasts: Additional evidence in the live Hogs market.	The lean Hogs futures-based forecast is more accurate than Extension and the USDA forecasts.
Meyer & Lawrence (1988: 28-29). Comparing USDA Hogs and Pigs Reports to Subsequent Slaughter: Does Systematic Error Exist?	Seasonal nature of Hogs production must be scrutinized. Pigs and Hogs forecasts over emphasize this seasonality.
No & Salassi (2009: 480-481). A sequential rationality test of USDA preliminary price estimates for selected program crops: Rice, soybeans, and wheat.	The USDA estimates are unbiased in the short-run, but they are not rational in the long-run.
Sanders & Manfredo (2002: 123-126). USDA production forecasts for pork, beef, and broilers: an evaluation.	The USDA forecasts are unbiased, but they are not efficient. The reason is USDA do not completely consider the information from the previous forecasts.
Sanders & Manfredo (2003a: 331-333). USDA livestock price forecasts: A comprehensive evaluation.	The USDA forecasts are not optimal. Broiler price forecast is biased and overall all the forecasts repeat errors.
Sanders & Manfredo (2005: 4-7). A Test of Forecast Consistency Using USDA Livestock Price Forecasts.	The USDA quarterly livestock price forecasts are not consistent in the long run.
Sanders & Manfredo (2008: 59-65). Multiple horizons and	Although the USDA forecasts are not rational, they provide useful information for their users. Likewise, turkey and milk forecasts show the most consistent performance, but beef provides little information.

information in USDA production forecasts.	
Sanders & Manfredo (2003b: 21-22). Keep up the good work? An evaluation of the USDA's livestock price forecasts.	USDA Broiler price forecasts are biased. Overall, the USDA price forecasts are not optimal, and almost in all the forecasts it repeats errors.
Schaefer & Myers (1999: 9-12). Forecasting accuracy, rational expectations, and market efficiency in the US beef cattle industry.	The USDA forecasts are inefficient and biased.
Von Bailey & Brorsen (1998: 520-524). Trends in the accuracy of USDA production forecasts for beef and pork.	The USDA forecast underestimates production in the 1980s, but the bias disappears later. So, the accuracy of the forecasts is improved and even though the USDA forecasts are not optimal in 1980s, they show optimality after then.
Xiao et al. (2014: 17-18). USDA and private analysts' forecasts of ending stocks: how good are they?	The USDA forecasts are unbiased, but both of the USDA and private forecasts are inefficient. Also, the accuracy of both of the USDA and private forecasts is the highest for wheat and the lowest for soybeans.
Researcher & Topic (Market Reactions to the USDA forecasts)	**Summary of study**
Aulerich et al. (2007: 16-18) The Impact of Measurement Error on Estimates of the Price Reaction to USDA Crop Reports.	Implication of Identification by Censoring (ITC) method shows that market reactions to unanticipated information in the USDA forecasts are significantly high.
Colling & Irwin (1990: 93) The reaction of live Hogs futures prices to USDA Hogs and Pigs reports.	Live Hogs future prices do not react to anticipated changes in the USDA forecasts, but considerably react to unanticipated changes in the reports. However, the Hogs prices adjust to unanticipated reports on the day following release of the forecasts.
Colling et al. (1992: 268) Weak-and strong-form rationality tests of market analysts' expectations of USDA Hogs and Pigs reports.	Expectations of Pigs and Hogs reports are strong-form rational.
Colling et al. (1996: 134-136) Reaction of Wheat, Corn, and Soybean Futures Prices to USDA" Export Inspections" Reports.	Soybean prices respond substantially to unanticipated information in "Export Inspections" reports. Also, corn prices react notably to unanticipated information during the December to February quarter, but soybean prices respond to

	such an unanticipated information during June to August quarter.
Colling et al. (1997: 396-400) Future price responses to USDA's Cold Storage report.	Live Hogs and pork belly prices react significantly to unanticipated information from the USDA forecasts. Therefore, the forecasts provide information to the markets.
Darby (2015: 22-24) Information Content of USDA Rice Reports and Price Reactions of Rice Futures.	The USDA forecasts provide useful information to the rice markets and rice futures react to the USDA information consistently.
Fortenbery et al. (1993: 171-172) The effects of USDA reports in futures and options markets.	The effects of the USDA forecasts are minimal, but regression tests show that market participants cannot forecast market future.
Good & Irwin (2005: 10-15) Understanding USDA corn and soybean production forecasts: Methods, performance and market impacts over 1970-2005.	The USDA corn and soybeans production forecasts are reasonably well.
Irwin at al. (2001: 16-17) The value of USDA outlook information: an investigation using event study analysis.	The USDA forecasts have significant impacts in soybeans and corn markets. Also, the reports reduce uncertainty of the expected distribution of the prices which improves the market participants' welfare.
Isengildina-Massa et al. (2004: 12-13) Does the Market Anticipate Smoothing in USDA Crop Production Forecasts?	Except for some cases market participants are aware of USDA smoothing practices and efficiently apply this information into their own forecasts.
Fortenbery & Sumner (1993: 171-172) The effects of USDA reports in futures and options markets.	During the time, market participants have learned how to digest the USDA reports. Hence, forecasts do not cause abnormally large price changes.
Hoffman et al. (2015: 156-169) Forecast performance of WASDE price projections for US corn	The USDA WASDE projections of corn season-average price provide valuable information to the market and improves the efficiency of the United States agricultural sector.
Karali (2012: 94-95) Do USDA Announcements Affect Comovements Across Commodity Futures Returns?	On the release days of the grain stocks, feed outlooks, and Hogs and Pigs report the largest movements in covariances happen.
McKenzie (2008: 365) Pre-harvest price expectations for corn: The information content of USDA reports and new crop futures.	Results indicate that the USDA forecasts are newsworthy. Also, price reactions to the reports are rational.

Patterson & Brorsen (1993: 373-377) USDA Export Sales Report: Is It News?	The USDA forecast doesn't provide new information to the market and indeed the traders predict the reports.
Pruitt et al. (2014: 30-32) End user preferences for USDA market information.	Results show preference for farm level forecasts by Extension agents.
Roberts (2006: 17) The value of plant disease early-warning systems: A case study of USDA's soybean rust coordinated framework	The USDA forecasts provide valuable information to the market. Probably in 2005 the value of information by the USDA forecasts exceeds the cost of getting information.
Schroeder et al. (1990: 303) Abnormal returns in livestock futures prices around USDA inventory report releases.	The USDA forecasts do not have consistent upward or downward influences on the prices, but the volatility of returns increases around the report release time which suggests forecasts provide new information to the market. Also, comparing to the other markets the forecast contains less information for the Hogs market. Hence, the Hogs prices are more volatile after the release of the USDA forecasts.
Summer & Mueller (1989: 5-7) Are harvest forecasts news? USDA announcements and futures market reactions.	There are significant differences between the means and variances of prices following a USDA announcement and the means and variances of prices of the other days.

2.2. Accuracy of the USDA Forecasts

As the summery of the relevant studies above show, not all the researchers agree about accuracy of the USDA forecasts. On the one hand some studies maintain that USDA estimates are *unbiased* (e.g. No and Salassi[4], 2009: 480-481; Sanders and Manfredo[5], 2002: 123-126; Xiao et al[6]., 2014: 17-18; Irwin et al[7]., 2014: 52-59) and on the other hand, other studies claim that USDA forecasts are *biased* (e.g. Sanders and Manfredo[8], 2003a: 21-22; Sanders and Manfredo, 2003b: 331-333; Schaefer and Myers, 1999: 9-12).

multiple studies maintain that the USDA forecasts are *inefficient* (e.g. Schaefer and Myers, 1999: 9-12; Sanders and Manfredo, 2002: 123-126; Xiao et al., 2014: 17-

[4] No and Salassi (2009: 480-481) argue that USDA forecasts are unbiased in the short-run, but not rational in the long run.
[5] Sanders and Manfredo (2002: 123-126) maintain that USDA forecasts are unbiased but not efficient.
[6] Xiao et al. (2014: 17-18) argue that USDA forecasts are unbiased but inefficient.
[7] Irwin et al. (2014: 59) maintain that USDA NASS forecasts for corn are unbiased.
[8] Sanders and Manfredo (2003a: 21-22) and Sanders and Manfredo (2003b: 331-333) indicate that USDA forecasts of Broiler price is biased.

18), *not optimal* (e.g. Von Bailey and Brorsen, 1998: 520-524; Sanders and Manfredo, 2003a: 21-22; Sanders and Manfredo, 2003b: 331-333), or *not rational in the long run* (e.g. Also, Sanders and Manfredo, 2008: 59-65; No and Salassi, 2009: 480-481).

Some of the studies report an *improvement in accuracy* of USDA forecasts (e.g. Gunnelson et al[9]., 1972: 640; Egelkraut et al., 2003: 92-94; Good and Irwin[10], 2005: 10-15; Irwin et al[11], 2014: 52-59).

Some studies *compare* the accuracy of the USDA forecasts with that of other forecasts (e.g. Kastens et al., 1998: 259; Manfredo and Sanders, 2004: 128-130). Furthermore, at least two studies indicate that USDA forecasts are *more accurate in case of corn production*, but this is not the case for soybeans production (e.g. Egelkraut et al., 2003: 92-94; Irwin et al., 2014: 52-59).

Figure 2. A represents the summary of major findings of the studies that focus on evaluation of accuracy of USDA forecasts. Overall the authors of 4 studies believe that at least for some of the Agriculture products the forecasts are unbiased, 4 studies point out that the accuracy of the forecasts have improved, and 2 studies maintain that USDA does a better job about corn forecasts comparing to soybeans forecasts. However, 3 studies indicate that the USDA forecasts are biased, 3 of them report inefficiency, another 3 studies specify that the forecasts are not optimal, and 2 studies argue that they are not rational.

3. Methodology

In this section we discuss the methodology of data-analyzing and that of the meta-analysis respectively.

3.1. Methodology of Data-analysis

To answer the first and the second questions, we summarize the findings of the relevant studies, and then we refine the results to find the patterns of their findings. To do meta-analysis we apply the metaphor package which provides functions to do the analysis in R. The package enables us to study the fixed and random effect models (Viechtbauer, 2010: 1-42). Then we test for heterogeneity and publication bias which enable us to tackle the third and the fourth questions.

3.2. Methodology of Meta-analysis

In a meta-analysis study usually two models are discussed: fixed-effect and random-effect models. In a fixed-effect model the assumption is that the dataset in not random and the individuals are from a same population while in random effect models the dataset is from a hierarchy of different populations and the differences among the dataset observations relates to that hierarchy. As an example, the dataset which is collected from a same population in a same library may qualify for the

[9] Gunnelson et al. (1972: 640) report a moderate improvement in USDA forecasts.
[10] Good and Irwin (2005: 10-15) report an improvement in accuracy of USDA forecasts for soybeans.
[11] Irwin et al. (2014: 52-59) maintain that USDA NASS forecasts for corn are improved.

fixed-effect model. A fixed-effect model doesn't account for heterogeneity and if the dataset is from different populations it overestimates the effect sizes. In that condition applying the random-effect models is suggested. When there is heterogeneity in the dataset the calculated Confidence Intervals (CI) are much wider if the researcher applies the random-effect models, but if the dataset is homogeneous the CI is the same as the estimated CI using fixed-effect models.

To determine heterogeneity in the sample sizes we calculate Q-statistic. The null hypothesis for the Q-statistic test is that 'all of the studies share a same effect size' and the alternative hypothesis is that 'the studies do not examine a common effect size'. In other words, a statistically significant Q-statistic means that the studies do not share a common effect size. However, a non-significant Q-statistic does not prove that the dataset is homogeneous.

An alternative test for heterogeneity applies I2-statistic. I2-statistic is a percentage that shows that the proportion of variance is from actual differences between studies rather than within the study variance. Higgins and Thompson (2002: 1540-1557) provide thresholds of 25%, 50%, and 75% which indicate low, moderate and high variance for I2-statistic.

Another important concept in meta-analysis literature is publication bias which indicates that the studies with stronger effect-sizes are more probable to get published. In other words, the publisher looks at the findings of the research and the studies with strong and positive results have more chances to get published. Funnel plot is a helpful tool to determine publication bias. In this plot the vertical axis shows individual effect sizes while the horizontal axis represents standard errors. A symmetric Funnel plot indicates the possibility of unbiased publication while an asymmetric plot shows the possibility of publication bias. If the plot shows a negative correlation, then it is likely that the studies with small and negative results do not get published and they are missed from the left corner of the plot.

4. Results and Discussion

In this section, first we discuss the market reactions to the USDA forecasts and then we focus on the meta-analysis.

4.1. Market Reactions to the USDA Forecasts

Market reactions to the USDA forecasts are not unambiguously identified. While on the one hand some researchers argue that the forecasts are newsworthy and provide new and useful information to the market (e.g. Summer and Mueller, 1989: 5-7; Schroeder et al., 1990: 303; Fortenbery and Sumner, 1993: 171-172; Roberts, 2006: 17; McKenzie, 2008: 365; Darby, 2015: 22-24, Hoffman et al., 2015: 156-169), on the other hand other researchers maintain that the USDA forecast are not newsworthy and in fact market participants predict the reports (e.g. Patterson and Brorsen, 1993: 373-377; Isengildina-Massa et al., 2004: 12-13).

Also, several studies note that the USDA forecasts cause market reaction or movement in the prices (e.g. Colling and Irwin, 1990: 93; Colling et al., 1996: 134-136; Colling et al., 1997: 396-400; Irwin at al., 2001: 16-17 (corn and soybeans);

Aulerich et al., 2007: 16-18; McKenzie, 2008: 365; Karali, 2012: 94-95). Furthermore, Colling and Irwin (1990: 93), Colling et al. (1996: 134-136), Colling et al. (1997: 1396-400), Aulerich et al., (2007: 16-18) argue that market reacts to the unanticipated changes in the forecasts. Fortenbery and Sumner, (1993: 171-172) believe that USDA forecasts do not cause uncertainty. In addition, Colling et al., (1992: 268) maintain that expectations of Pigs and Hogs reports are strong-form rational. Other researchers such as McKenzie (2008: 365) claim that reactions to prices are rational.

Figure 2. B represents the summary of major findings of the studies that focus on the market reactions to the USDA forecasts. All in all, 2 studies claim that the forecasts are not newsworthy, while 7 of them argue that they are newsworthy. 7 studies specify that USDA forecasts cause market reactions. 4 of them maintain that markets react to unanticipated information, 2 studies argue that market expectations are rational, and 1 study maintain that the forecasts do not cause uncertainty.

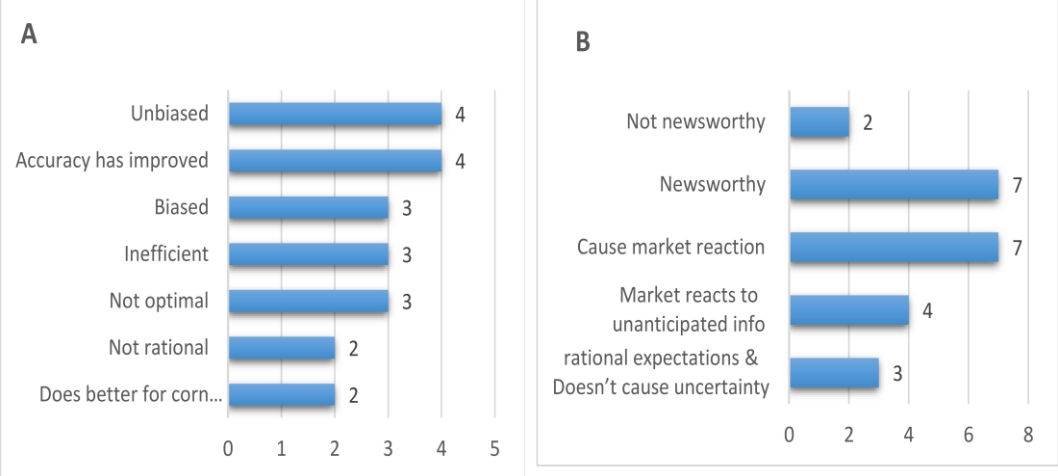

Figure 2. Summary of the Major Findings of the Published Studies.

Note: A represents a summary of main findings of the studies which focus on analyzing the accuracy of the USDA forecasts, while B shows the ones which study market reactions to the USDA forecasts.

4.2. Meta-analysis

A possible problem with the USDA forecasts can be repeating the past errors or over-correcting them. A correlation with the past errors represents the forecasts tendency to repeat or overcorrect the past errors. Positive correlation with past forecasts means that the new forecasts repeat the same errors, while negative correlation represents over-correction of the errors (Isengildina-Massa et al., 2013a: 105-106). Multiple studies calculate the Pearson correlation of the USDA forecasts using their past errors (e.g. Sanders and Manfredo, 2002: 123-126, Sanders and Manfredo, 2003: 21-22; Isengildina-Massa et al., 2004: 12-13; Isengildina-Massa et al., 2006: 1101-1102; Isengildina-Massa et al., 2012: 111, Isengildina-Massa et al., 2013b: 5101-5102; Good and Irwin, 2005: 10-15; and McKenzie, 2008: 365). We apply their findings which are represented in Table 1 to do meta-analysis in this study.

Table 1. The Dataset to do meta-analysis

	Authors	Year of publication	Time Period studies	Item studied	Pearson Correlation	Forecast
1	Sanders & Manfredo	2002	1982-2000	beef	0.31	USDA
2	Sanders & Manfredo	2002	1982-2000	pork	0.15	USDA
3	Sanders & Manfredo	2002	1982-2000	broiler	0.25	USDA
4	Sanders & Manfredo	2002	1982-2000	beef	-0.12	AR4
5	Sanders & Manfredo	2002	1982-2000	pork	-0.02	AR4
6	Sanders & Manfredo	2002	1982-2000	broiler	0.03	AR4
7	Sanders & Manfredo	2003	1982-2002	cattle	0.24	USDA
8	Sanders & Manfredo	2003	1982-2002	Hogs	0.18	USDA
9	Sanders & Manfredo	2003	1982-2002	broiler	0.31	USDA
10	Sanders & Manfredo	2003	1982-2002	cattle	0.02	AR4
11	Sanders & Manfredo	2003	1982-2002	Hogs	-0.21	AR4
12	Sanders & Manfredo	2003	1982-2002	broiler	0.17	AR4
13	Isengildina et al.	2004	1970-2002	corn	0.45	USDA
14	Isengildina et al.	2004	1970-2002	soybeans	0.22	USDA
15	Good & Irwin	2005	1970-2005	corn	0.54	USDA
16	Good & Irwin	2005	1970-2005	soybeans	0.35	USDA
17	Isengildina et al.	2006	1970-2002	corn	0.23	USDA
18	Isengildina et al.	2006	1970-2002	soybeans	-0.8	USDA
19	McKenzie	2008	1970-2005	corn	0.66	USDA
20	Isengildina et al.	2012	1985-2009	corn	-0.31	USDA
21	Isengildina et al.	2013	1987-2010	soybeans	0.11	USDA
22	Isengildina et al.	2013	1987-2010	wheat	0.16	USDA

Note: AR4 which is a time series model represents a substitute method of forecasting.

To determine heterogeneity in the sample sizes we calculate Q-statistic. A statistically significant Q-statistic means that the studies do not share a common effect size. However, a non-significant Q-statistic does not prove that the dataset is homogeneous. The test for heterogeneity results show that Q-statistic is 77.3 and p-value < 0.0001 which means that the studies do not share a common effect size and the dataset is heterogeneous.

An alternative test for heterogeneity applies I2-statistic. I2-statistic is a percentage that shows that the proportion of variance is from actual differences between studies rather than within the study variance. As mentioned before, Higgins and Thompson (2002: 1540-1557) provide thresholds of 25%, 50%, and 75% which indicate low, moderate and high variance for I2-statistic. For our dataset I2-statistic is 70.3% (95% CI: 48.5, 83.8) which represents moderate to high variance.

Even though the mentioned tests show that there is heterogeneity in the dataset, but they don't provide any clue that which studies may disproportionally affect heterogeneity. Instead, Baujat plot which introduced by Baujat et al. (2002: 2642-2651) makes it possible to see which studies contribute to the heterogeneity. The horizontal axis in Baujat plot shows the study heterogeneity while the vertical axis indicates the influence of studies on the overall results. Figure 3 represents Baujat plot.

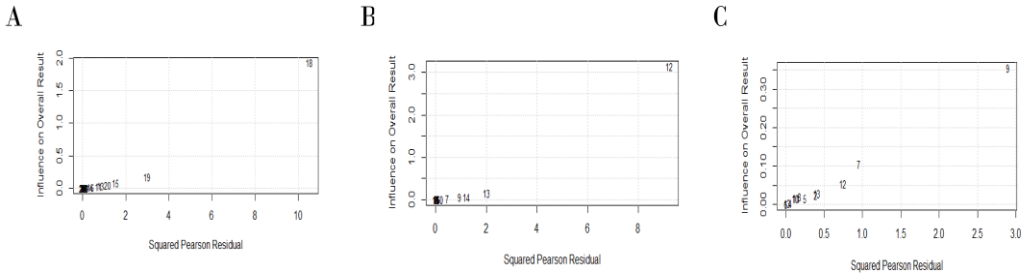

Figure 3: Baujat plot to identify the studies that contribute to heterogeneity.

Note: Each number represents a study. Studies on top right have greater influence on the results and have a bigger contribution to heterogeneity. plot A considers all of the studies. As can be seen in the graph, study 18 which is Isengildina-Messa et al. (2006: 1101-1102) for soybeans contributes the most to heterogeneity of the results. In plot B, the AR4 models are eliminated and only the studies which focus on USDA forecasts are left. Here study 12 is in the right corner above. In plot C the studies with biggest variation and small effect size are eliminated.

As discussed before another important concept in meta-analysis literature is publication bias. Funnel plot is a helpful tool to determine publication bias. In this plot the vertical axis shows individual effect sizes while the horizontal axis represents standard errors. A symmetric Funnel plot indicates the possibility of unbiased publication while an asymmetric plot shows the possibility of publication bias. If the plot shows a negative correlation, then it is likely that the studies with small and negative results do not get published and they are missed from the left corner of the plot. Figure 4 represents Funnel plot for our dataset. As can be seen in most of the cases the plot shows positive correlations.

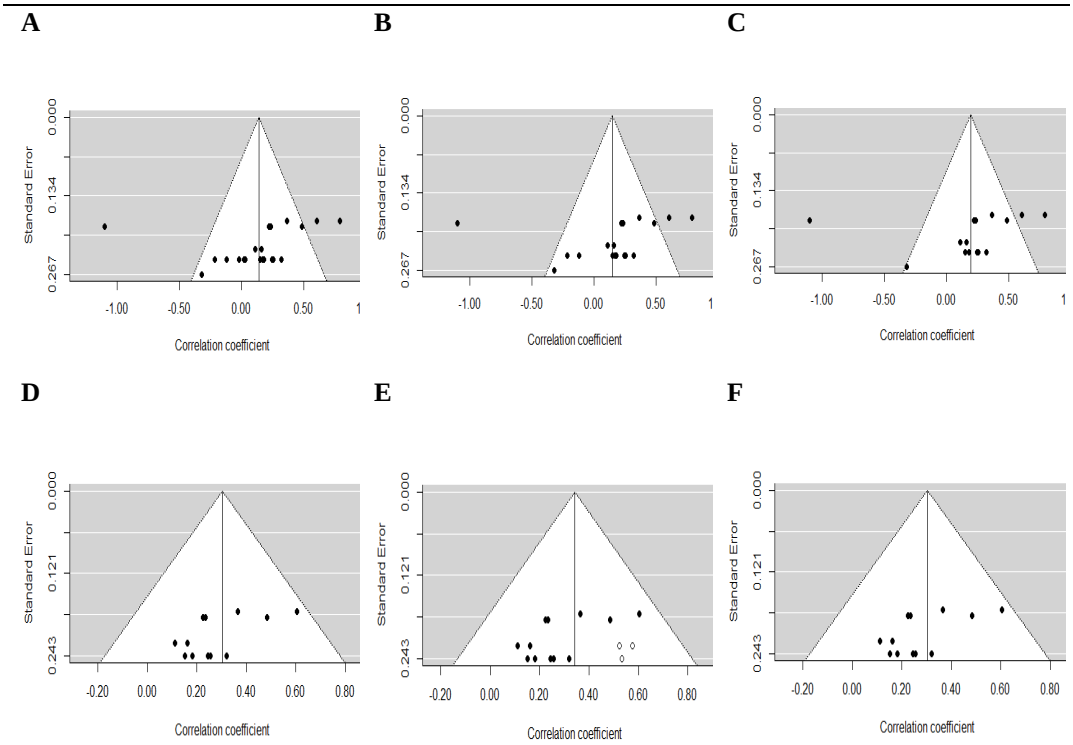

Figure 4. Funnel Plot to represent publication bias.

Note: Plot A which includes all of the studies in Table 1 shows a positive correlation and therefore the dataset can be interpreted as asymmetric. In plots B and C, we remove the studies with small effect sizes and big variations. Funnel Plot D includes all of the studies in plot A except the AR4 models. Plot E simulates three removed studies of plot D which if they were there the plot would be symmetric. In Funnel Plot F, the studies with small effect sizes and big variations are removed from Plot D which again sounds like an asymmetric plot. Overall, the Funnel Plot in all of the scenarios is asymmetric which demonstrates the possibility of publication bias.

A weakness of Funnel Plot is that it is only a subjective measure of possibility of publication bias. We apply Rank Correlation and Egger's tests as objective tools to test for publication bias. Begg and Mazumdar (1994: 1097-1098) propose Rank Correlation test. Based on their method $P<0.05$ is consistent with asymmetrical Funnel plot. However, Rank Correlation test cannot be fully trusted for analyses with less than 25 studies (Sterne at al., 2000: 1120-1127). An alternative test which is more useful for meta-analysis with less than 25 studies is Egger's Test represented by Egger et al. (1997: 630-634). Our results suggest that p value from the Egger's test equals to 0.2408 which is not statistically significant. This finding suggests that the studies are not symmetric in the Funnel plot. In other words, based on the results of the Egger's test there in no evidence of publication bias

5. Conclusion

Many researchers have studied USDA forecasts, but the academic publications in this area can be divided in two groups. The studies which evaluate the accuracy of the USDA forecasts and the ones that evaluate the market reactions to the USDA forecasts. These groups of studies provide a variety of results and in many cases

their findings contradict. Therefore, in this study we do a meta-analysis on the published studies to answer the following questions:

1) how the academic published studies evaluate accuracy of the USDA forecasts?

2) how the academic published studies evaluate market reactions to the USDA forecasts?

3) Is there heterogeneity in the results of the studies?

4) Is there any publication bias in the published studies?

After aggregating and synthesizing all published papers that we could find, we figured out that some of the studies maintain that the forecasts are unbiased, while most of the studies point out that at least for some of the products the USDA forecasts are not efficient, they are biased, and they are not optimal.

About market reactions to the USDA forecasts, we found a few studies that claim that the forecasts are not newsworthy, and the market participants could predict the reports. However, most of the studies argue that the forecasts are newsworthy, they provide useful information to the market participants, and they cause market reactions and affect the prices. We did meta-analysis using a package named "metaphor" in R to answer the third and the fourth questions. We applied Q-statistic, I2-statistic, and Baujat plot to test for heterogeneity in the findings of the academic papers discussed in Table 1. Based on the findings from the mentioned tests the results of the studies are heterogeneous. Also, we applied Funnel plot, Rank Correlation test, and Egger's test to test for publication bias. Funnel plot and Rank Correlation test results show publication bias. However, as we already mentioned Egger's test findings are more accurate for small datasets and the results of this test does not confirm publication bias.

References

Aulerich, N., Irwin, S., Nelson, C. (2007), "The Impact of Measurement Error on Estimates of the Price Reaction to USDA Crop Reports", *NCCC-134 Conference on Applied Commodity Price Analysis, Forecasting, and Market Risk Management*, Chicago, Illinois, USA. No. 1313-2016-102638.

Baujat, B., Mahé, C., Pignon, J. P., Hill, C. (2002), "A Graphical Method for Exploring Heterogeneity in Meta-analyses: Application to A Meta-analysis of 65 Trials", *Statistics in Medicine*, 21(18): 2641-2652.

Begg, C., Mazumdar, M. (1994), "Operating Characteristics of a Rank Correlation Test for Publication Bias", *Biometrics*, 50(4): 1088-1101.

Colling, P. L., Irwin, S. H. (1990), "The Reaction of Live Hog Futures Prices to USDA Hogs and Pigs' Reports", *American Journal of Agricultural Economics*,72(1): 84-94.

Colling, P. L., Irwin, S. H., Zulauf, C. R. (1992), "Weak-and Strong-form Rationality Tests of Market Analysts' Expectations of USDA Hogs and Pigs Reports", *Review of Agricultural Economics*, 14(2): 263-270.

Colling, P. L., Irwin, S. H., Zulauf, C. R. (1996), "Reaction of Wheat, Corn, and Soybean Futures Prices to USDA "Export Inspections" Reports", *Review of Agricultural Economics*, 18(1): 127-136.

Colling, P., Irwin, S., Zulauf, C. (1997), "Future Price Responses to USDA's Cold Storage Report", *Agribusiness*, 13(4): 393-400.

Darby, J. L. (2015), *Information Content of USDA Rice Reports and Price Reactions of Rice Futures*, (Doctoral dissertation, University of Arkansas).

Egelkraut, T. M., Garcia, P., Irwin, S. H., Good, D. L. (2003), "An Evaluation of Crop Forecast Accuracy for Corn and Soybeans: USDA and Private Information Agencies", *Journal of Agricultural and Applied Economics*, 35(01): 79-95.

Egger, M., Smith, G. D., Schneider, M., Minder, C. (1997), "Bias in Meta-analysis Detected by A Simple, Graphical Test", *British Medical Journal*, 315(7109): 629-634.

Flora, C. (1993), "Revisiting the USDA Reports: Context, Capital and Organization", *American Journal of Alternative Agriculture*, 8(4): 155-157.

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

Glass, G. V. (1976), "Primary, Secondary, and Meta-analysis of Research", *Educational researcher*, 5(10): 3-8.

Good, D. L, Irwin, S. H. (2005), "Understanding USDA Corn and Soybean Production Forecasts: Methods, Performance and Market Impacts Over 1970-2004", AgMAS Project Research Reports: 1-48, Department of Agricultural and Consumer Economics, University of Illinois at Urbana Champaign.

Good, D. L., Irwin, S. H. (2006), "Understanding USDA Corn and Soybean Production Forecasts: Methods, Performance and Market Impacts Over 1970-2005", AgMAS Project Research Reports 37514, Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign.

Gunnelson, G., Dobson, W. D., Pamperin, S. (1972), "Analysis of the Accuracy of USDA Crop Forecasts", *American Journal of Agricultural Economics*, 54(4 Part 1): 639-645.

Higgins, J. P., Thompson, S. G. (2002), "Quantifying Heterogeneity in A Meta-Analysis", *Statistics in Medicine*, 21(11): 1539-1558.

Hoffman, L. A., Etienne, X. L., Irwin, S. H., Colino, E. V., Toasa, J. I. (2015), "Forecast Performance of WASDE Price Projections for US Corn", *Agricultural Economics*, 46(S1): 157-171.

Irwin, S. H., Good, D. L., Gomez, J. K., Isengildina, O. (2001). "The Value of USDA Outlook Information: An Investigation Using Event Study Analysis", *NCR Conference on Applied Commodity Price Analysis, Forecasting, and Market Risk Management*, St. Louis MO. No. 1265-2016-101891: 1-40.

Irwin, S. H., Sanders, D. R., Good, D. L. (2014), "Evaluation of Selected USDA WAOB and NASS Forecasts and Estimates in Corn and Soybeans", Marketing and Outlook Research Report 1: 1-140, Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign.

Isengildina-Massa, O., Irwin, S. H., Good, D. L. (2004), "Does the Market Anticipate Smoothing in USDA Crop Production Forecasts?", *American Agricultural Economics Association (New Name 2008: Agricultural and Applied Economics Association) Annual Meeting*, August 1-4, 2004, Denver, CO (No. 20145). No. 377-2016-21017: 1-19.

Isengildina-Massa, O., Irwin, S. H., Good, D. L. (2013a), "Do Big Crops Get Bigger and Small Crops Get Smaller? Further Evidence on Smoothing in US Department of Agriculture Forecasts", *Journal of Agricultural and Applied Economics*, 45(01): 95-107.

Isengildina-Massa, O., Irwin, S., Good, D. (2006), "Are Revisions to USDA Crop Production Forecasts Smoothed?", *American Journal of Agricultural Economics*, 88(4): 1091-1104.

Isengildina-Massa, O., Irwin, S., Good, D., Massa, L. (2011), "Empirical Confidence Intervals for USDA Commodity Price Forecasts", *Applied Economics*, 43(26): 3789-3803.

Isengildina-Massa, O., Karali, B., Irwin, S. H. (2013b), "When do the USDA forecasters make mistakes?", *Applied Economics*, 45(36): 5086-5103.

Isengildina-Massa, O., Macdonald, S., Ran, X. (2012), "A Comprehensive Evaluation of USDA Cotton Forecasts", *Journal of Agricultural and Resource Economics*, 37(1): 98-113.

Isengildina-Massa, O., Tysinger, D., Gerard, P., MacDonald, S. (2011), "What Can We Learn from our Mistakes? Evaluating the Benefits of Correcting Inefficiencies in USDA Cotton Forecasts", *Southern Agricultural Economics Association Annual Meeting*, February 5-8, 2011, Corpus Christi, Texas (No. 98811): 1-20.

Isengildina-Messa, O., Mattos, F. (2015), "Accuracy-Informativeness Tradeoff for Interval Forecast Comparison", *NCR-134 Conference on Applied Commodity Price Analysis, Forecasting, and Market Risk Management*, St. Louis, Missouri. 1-13.

Jarrell, S. B., Stanley, T. D. (1990), "A Meta-analysis of the Union-nonunion Wage Gap", *ILR Review*, 44(1): 54-67.

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

Kastens, T. L., Schroeder, T. C., Plain, R. (1998), "Evaluation of Extension and USDA Price and Production Forecasts", J*ournal of Agricultural and Resource Economics*, 23(1): 244-261.

Keegan, C. E., Morgan, T. A., Wagner, F. G., Cohn, P. J., Blatner, K. A., Spoelma, T. P., Shook, S. R. (2005), "Capacity for Utilization of USDA Forest Service, Region I Small-diameter Timber", *Forest Products Journal*, 55(12): 143-147.

Lee, Robert D, Nieman, David C, Rainwater, Marvin. (1995), "Comparison of Eight Microcomputer Dietary Analysis Programs with the USDA Nutrient Data Base for Standard Reference", *Journal of the American Dietetic Association*, 95(8): 858-867.

Manfredo, M. R., Sanders, D. R. (2004), "The Value of Public Price Forecasts: Additional Evidence in the Live Hog Market", *Journal of Agribusiness*, 22(2): 119-131.

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.

Meyer, S. R., Lawrence, J. D. (1988), "Comparing USDA Hogs and Pigs Reports to Subsequent Slaughter: Does Systematic Error Exist?", *NCR 134 Conference Proceedings*: 19-35.

No, S. C., Salassi, M. E. (2009), "A Sequential Rationality Test of USDA Preliminary Price Estimates for Selected Program Crops: Rice, Soybeans, and Wheat", *International Advances in Economic Research*, 15(4): 470-482.

Olkin, I. (1995), "Meta-Analysis: Reconciling the Results of Independent Studies", *Statistics in Medicine* 14(5-7): 457–472.

Papendick, R. (1993), "Revisiting the USDA Reports: Some Additional Observations", *American Journal of Alternative Agriculture*, 8(4): 154-155.

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

Pruitt, J. R., Tonsor, G. T., Brooks, K. R., Johnson, R. J. (2014), "End User Preferences for USDA Market Information", *Food Policy*, 47: 24-33.

Ray, D. (2008), "USDA Top Officials vs. USDA Data", *Review of African Political Economy*, 35(117): 514-516.

Roberts, M. J., Schimmelpfennig, D. E., Ashley, E., Livingston, M. J., Ash, M. S., Vasavada, U. (2006), *The Value of Plant Disease Early-warning Systems: A Case Study of USDA's Soybean Rust Coordinated Framework*, United States Department of Agriculture, Economic Research Service, Washington, DC, USA.

Sanders, D. R., Manfredo, M. R. (2002), "USDA Production Forecasts for Pork, Beef, and Broilers: An Evaluation", *Journal of Agricultural and Resource Economics*, 27(01): 114-127.

Sanders, D. R., Manfredo, M. R. (2003a), "Keep up the Good Work? An Evaluation of the USDA's Livestock Price Forecasts", *NCR-134 Conference on Applied Commodity Price Analysis, Forecasting, and Market Risk Management*, St. Louis, Missouri.

Sanders, D. R., Manfredo, M. R. (2003b), "USDA Livestock Price Forecasts: A Comprehensive Evaluation", *Journal of Agricultural and Resource Economics*, 28(2): 316-334.

Sanders, D. R., Manfredo, M. R. (2005), "A Test of Forecast Consistency Using USDA Livestock Price Forecasts", *NCR-134 Conference on Applied Commodity Price Analysis, Forecasting, and Market Risk Management*, St. Louis, Missouri.

Sanders, D. R., Manfredo, M. R. (2008), "Multiple Horizons and Iinformation in USDA Production Forecasts", *Agribusiness*, 24(1): 55-66.

Schaefer, M. P., Myers, R. J. (1999), *Forecasting Accuracy, Rational Expectations, and Market Efficiency in the US Beef Cattle Industry*, (Master's thesis, Michigan State University. Dept. of Agricultural Economics). 1-16.

Schroeder, T., Blair, J., Mintert, J. (1990), "Abnormal Returns in Livestock Futures Prices Around USDA Iinventory Report Releases", *North Central Journal of Agricultural Economics*, 12(2): 293-304.

Shapley, D. (1976), "Crops and Climatic Change: USDA's Forecasts Criticized", *Science*, 193(4259): 1222-1224.

Sterne, J. A. C, Gavaghan, D., Egger, M. (2000), "Publication and Related Bias in Meta-analysis: Power of Statistical Tests and Prevalence in the Literature", *Journal of Clinical Epidemiology*, 53(11): 1119-1129.

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

Viechtbauer, W. (2010), "Conducting Meta-analyses in R With the Metafor Package", *Journal of Statistical Software*, 36(3): 1-48.

Von Bailey, D., Brorsen, B. W. (1998), "Trends in the Accuracy of USDA Production Forecasts for Beef and Pork", *Journal of Agricultural and Resource Economics*, 23(02): 515-525.

Xiao, J., Lence, S., Hart, C. (2014), "USDA and Private Analysts' Forecasts of Ending Stocks: How Good are They?" In 2014 Annual Meeting, July 27-29, 2014, Minneapolis, Minnesota, USA, No. 170642. 1-25.