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Market Reactions to USDA Reports: State Analysis of Corn Price Response

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*Selected Paper prepared for presentation at the Agricultural & Applied Economics
Association's 2012 AAEA Annual Meeting, Seattle, Washington, August 12-14, 2012*

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Abstract

This article reviews the current literature on USDA farm-level data reports and looks at the impact of information contained in the USDA *Crop Production* report on U.S., Iowa, Illinois, Nebraska, North Carolina, and Wisconsin corn prices. A hypothesis is tested concerning the significance of the reaction to the corn basis from the report. The hypothesis is tested using maximum-likelihood parameter estimates of the effect of stocks data, previous year's production number, and separate dummy variables for the August, September, October, and November release of the USDA *Crop Production* report on the absolute percent change of the corn basis from the month before the report is released to the month in which the report is released. Evidence is found that supports the hypothesis that USDA reports significantly affect the corn market at the national level and in Illinois, Iowa, and Nebraska. August and October are found to be the most significant month for market reactions to the report for the states affected. No evidence is found of a price reaction in the North Carolina and Wisconsin corn markets. The study period is 1949-2011.

Introduction

USDA reports provide important sources of information to U.S. agricultural markets. A wide body of literature has developed that has studied the impact of these reports on commodity markets. Previous research on the effect of USDA reports on commodity markets has, however, not considered both local variation in response to reports and a time series sufficient to incorporate changes in market structure dynamics. In this paper, I develop a model to address these considerations.

The literature studying market reactions of USDA reports has been mixed. The effects of the *Hogs and Pigs* and the *Cattle on Feed* reports on their respective markets have been examined by Miller (1979), Hoffman (1980), Kootz, Hudson, and Purcell (1984), and Colling and Irwin (1990). Miller and Colling and Irwin found significant futures price reactions following the release of the *Hog and Pigs* report. Hoffman and Kootz, Hudson, and Purcell, on the other hand, found no evidence of a significant futures price reaction to the *Hogs and Pigs* report.

Hoffman also looked at the *Cattle on Feed* report and found no evidence of a significant reaction of the futures price. Milonas (1987), Fackler (1985), Sumner and Mueller (1989), Fortenbery and

Sumner (1993), and McNew and Espinosa (1994) evaluated the effects of the *Crop Production* report on the corn, soybean, and wheat markets. Milonas, Fackler, and Sumner and Mueller examined the impact of the report on futures prices for corn and soybeans, determining that there is a significant impact. Fortenbery and Sumner and McNew and Espinosa also included options in their analysis, with Fortenbery and Sumner being the first to do so. Fortenbery and Sumner found a partially significant market reaction, while McNew and Espinosa found a significant reaction, in general. Taylor (2008), being the first to examine market reactions at the regional level, found no evidence for a significant reaction in the honey market.

Although the market effects of USDA reports have been well studied, there is a gap in the literature in that there has not been an analysis of the way these reports impact the market regionally and thus the impact on local basis levels.¹ This is an important subject because it could be that cash markets are greatly impacted in one state, while these impacts are dampened by relatively little price movement and variation in other states. In addition, individual state impacts could be offsetting, resulting in a finding of little impact at the national level. There could, for example, have been a bumper crop the previous year in Iowa that decreased regional cash prices around the time of the report and pulled down prices at the national level, thus making it appear that the report was driving down prices.

Another gap with the current literature is that the studies encompass study periods that are less than twenty years. This narrow time frame, however, neglects important changes made in production and marketing technology, price discovery mechanisms, communications networks, and the like. One goal of this paper is to bridge this gap.

Empirical Model

I start off by considering the following time series data-generating process:

$$y_t = \mathbf{x}_t' \beta + \varepsilon_t \tag{1}$$

¹Basis is the difference between a local market price and the national price generally using the nearby future price.

where \mathbf{x}_t is a vector of relevant variables that generate the dependent variable in a linear fashion and $\varepsilon_t \sim N(0, \gamma^2)$ (that is ε_t is Gaussian white noise). When y_t comes from a time series process that is stationary and weakly dependent, the central limit theorem and the law of large numbers can be used to justify the assumption of normality of the residual for a wide variety of distributions of the dependent variable (Woolridge, 2009).

When y_t is necessarily positive problems can occur in the model due to the expected value of y_t being negative, which is theoretically invalid. One way to overcome this issue, given that the dependent variable of interest is highly peaked at values close to 0 is to assume that y_t is lognormally distributed (Greene, 2011).

A lognormally distributed random variable with parameters μ and σ^2 has the following probability density function:

$$f(y_t) = \frac{1}{\sqrt{2\pi}\sigma y_t} e^{-(1/2)[(\ln(y_t) - \mu)/\sigma]^2} \quad (2)$$

This implies that the log-likelihood function for the estimation of the most likely parameters for the given variable y_t 's observed distribution is:

$$l(y_t|\mu, \sigma) = \sum_{t=1}^T \left(-\ln(\sqrt{2\pi}\sigma y_t) - (1/2) [(\ln(y_t) - \mu)/\sigma]^2 \right) \quad (3)$$

In addition, that y_t is lognormally distributed with parameters μ and σ^2 means that

$$E[y_t] = e^{\mu + \sigma^2/2} \quad (4)$$

Note also that the time series data-generating process implies that

$$E[y_t|\mathbf{x}_t] = \mathbf{x}_t' \beta \quad (5)$$

Combining (4) and (5) results in

$$\mu = \ln(\mathbf{x}_t' \beta) - \sigma^2/2 \quad (6)$$

which substituted into the log-likelihood function yields

$$l(y_t|\mathbf{x}_t, \beta, \sigma) = \sum_{t=1}^T \left(-\ln(\sqrt{2\pi}\sigma y_t) - (1/2) \left[\left(\ln(y_t) - \left(\ln(\mathbf{x}_t' \beta) - \sigma^2/2 \right) \right) / \sigma \right]^2 \right) \quad (7)$$

I can then use maximum likelihood techniques to obtain estimates for the parameters in the original data-generating process that are consistent, asymptotically normal, asymptotically efficient, and invariant (Greene, 2011).

A major focus of this paper is to test a hypothesis concerning the significance of reactions to the USDA *Crop Production* report through the corn market. This hypothesis is operationalized in the following way:

H_o : The (Iowa, Illinois, Nebraska, North Carolina, Wisconsin, U.S.) corn price does not react to the (August, September, October, November) *Crop Production* report.

Iowa, Illinois, and Nebraska were chosen for this study because they have conspicuously been the top three corn producing states over the last 100 years. As a result, production and market conditions in these states greatly influence the national market. North Carolina was chosen because it is a state that has had many structural changes in its grain industry in the past 50 years.² Wisconsin was chosen for the analysis because it is and has consistently been a medium-sized state in terms of corn production. This means corn production is important to Wisconsin, but Wisconsin is less critical in determining national production.

Changes in basis reflect both risk faced and information available to agricultural producers in local markets. As a result, the dependent variable used here is the absolute value of the percent change in the basis from month-to-month, or

$$AbsPercentDeltaBasis_t = \left| \frac{Basis_{t-1} - Basis_t}{Basis_{t-1}} \right| \quad (8)$$

The time series data-generating processes for the state-specific dependent variables are of the form

²Most of this structural change is due to the relocation of a large part of the hog industry to North Carolina in the form of vertically-integrated hog production. From 1960 to 1980, for example, total December 1 hog and pig inventories for North Carolina increased by 96% (1,246 to 2,460 thousand head), while December 1 hog and pig inventories for the U.S. as a whole only increased by only 16% (55,560 to 64,462 thousand head). And from 1980 to 2000, December 1 hog and pig inventories for North Carolina increased by 278% (2,460 to 9,300 thousand head), while December 1 hog and pig inventories for the U.S. as a whole decreased by only 8% (64,462 to 59,110 thousand head).

$$\begin{aligned}
AbsPercentDeltaBasis_{s,t} = & \beta_0 + \beta_1 NearestStock_{s,t} + \beta_2 NearestStock_{U.S.,t} \\
& + \beta_3 PrevYearProd_{s,t} + \beta_4 PrevYearProd_{U.S.,t} \\
& + \beta_m D_{m,t} + \varepsilon_t
\end{aligned} \tag{9}$$

and the time series data-generating process for the U.S. dependent variables are of the form:

$$\begin{aligned}
AbsPercentDeltaBasis_{s,t} = & \beta_0 + \beta_2 NearestStock_{U.S.,t} + \beta_4 PrevYearProd_{U.S.,t} \\
& + \beta_m D_{m,t} + \varepsilon_t
\end{aligned} \tag{10}$$

where $t = (\text{December 1949, January 1950, } \dots, \text{December 2011})$ denotes the month and the year for the data value, $Basis_t$ denotes the basis for the current month, $Basis_{t-1}$ denotes the basis for the previous month, $s = (\text{IA, IL, NE, NC, WI, U.S.})$ denotes the region of interest, $NearestStock_{s,t}$ denotes the current stocks held in the market at time t for region s , $PrevYearProd_{s,t}$ denotes the previous year's official production number at time t for region s , $m = (\text{August, September, October, November})$ denotes the month that a relevant *Crop Production* report comes out, $D_{m,t}$ denotes the dummy variable for the m th month's *Crop Production* release, and $\varepsilon_t \sim N(0, \gamma^2)$ (that is ε_t is Gaussian white noise).

I use the BHHH algorithm (Berndt et al., 1974) to obtain the maximum likelihood parameter estimates. The asymptotic estimator for the variance-covariance matrix for the resulting parameter estimates is thus $\left[\sum_{t=1}^T \left(\frac{\delta l_t}{\delta \beta} \right) \left(\frac{\delta l_t}{\delta \beta} \right)' \right]^{-1}$ (Judge et al., 1988).

The measure used to test the null hypothesis will be the marginal effect of the release of the report on y_t . Due to the setup of the data-generating process, the marginal effect of the release of the m th month's report is β_m .

Data

The corn price data used is the USDA monthly price received by farmers for corn series. Data for this series is available monthly for both the U.S. and the individual state level all the way back to 1908. This price data incorporates both cash and contract price components. This series is one

of the most highly regarded price series, as is evidenced by the fact that it is used in determining counter-cyclical payments, and because it has been available for such a long time.

The futures data corresponding to the USDA corn prices received by farmers data is from the Chicago Mercantile Exchange (CME) Group³. Monthly data for the months July 1961 through December 2011 were calculated as the mean of the closing prices for every business day during the month. As data was not available every day for the months of December 1949 through June 1961, the 15th of the month prices for these months were used.

The basis data was calculated by subtracting a particular month's USDA corn price received from the nearest-expiring contract futures data. In the event that the calculated variable $AbsPercentDeltaBasis_t$ was 0, it was transformed into a very small positive number in order to facilitate estimation of the maximum likelihood algorithm.

The stocks and production data are also taken from USDA, its quarterly stocks data available at the U.S. and state-level starting in December 1949. It is for this reason that the start of the study period is December 1949 - December 2011. The yearly production data is available at the U.S. and state-level all the way back to 1866. The stocks variable was chosen to control for any price fluctuations due to market saturation and/or voids. The production variable was chosen to control for the differences among goal markets.

Results

Point estimates with standard errors in parentheses for the marginal effects from the maximum-likelihood estimation are presented in Table 1. Table 2 simplifies these results by simply indicating the extent of the significance of the estimate. Because of the way the time series data-generating process was originally set up, the marginal effect is given the following interpretation: the absolute value represents the percentage change in basis resulting from new information hitting the market in the month of interest. As the *Crop Production* report is the major source of this new information, especially in the U.S. corn market, I can conclude that a significant percent change in the basis from one month to the next is due to the *Crop Production* report.

It is thus apparent that Illinois, Iowa, Nebraska, and the U.S., in general, have significant

³The corn futures price used to be derived at the Chicago Board of Trade (CBOT). The CME and the CBOT merged in 2007 to become CME Group, Inc.

reactions to the USDA *Crop Production* report. North Carolina and Wisconsin, on the other hand, do not have significant market reactions. It is further noted that based on these results, August and October seem to be the most important months in terms of information, as they have the most significant reactions. This is likely due to the fact that the August and October estimates are the most informative mix of new and accurate information for the market. That is, September and November estimates are not new enough information to be more useful in the price setting process.

Table 1: Marginal Effects Estimates from BHHH Maximum Likelihood Algorithm

	D_A	D_S	D_O	D_N
IL	-0.29** (0.05)	0.72* (0.41)	0.66* (0.32)	-0.21 (0.29)
IA	0.11 (0.08)	0.06 (0.11)	0.21* (0.11)	0.13 (0.12)
NE	0.28* (0.14)	0.15 (0.16)	0.06 (0.19)	0.05 (0.19)
NC	0.22 (0.31)	0.58 (0.44)	0.49 (0.48)	-0.02 (0.26)
WI	0.44 (0.33)	1.32 (1.05)	0.15 (0.42)	0.66 (0.58)
U.S.	0.32* (0.15)	0.21 (0.15)	0.20* (0.11)	0.08 (0.17)

* Significant at the $\alpha = 0.05$ level. ** Significant at the $\alpha = 0.01$ level.

Table 2: Summary of Marginal Effects Market Reaction to *Crop Production* Report

	D_A	D_S	D_O	D_N
IL	highly significant	significant	significant	— — —
IA	— — —	— — —	significant	— — —
NE	significant	— — —	— — —	— — —
NC	— — —	— — —	— — —	— — —
WI	— — —	— — —	— — —	— — —
U.S.	significant	— — —	significant	— — —

Summary and Conclusions

In this paper, I develop a model to study the regional market effects of the USDA *Crop Production* report. Based on the maximum likelihood estimates, significant basis responses are found for the August and October releases in the Illinois, Iowa, Nebraska, and the U.S. corn markets. There are

also significant market reactions in the September release for Illinois. As a result of this evidence, the null hypothesis of no local response is rejected for the Illinois, Iowa, Nebraska, and the U.S. corn markets. This supports the efficient markets hypothesis of Sumner and Mueller (1989). That is, the Crop Production report does, indeed, provide a useful source of information to the Illinois, Iowa, Nebraska, and the U.S. corn markets. A report effect is not found, however, in the North Carolina and Wisconsin corn markets.

The point estimates for the marginal basis effect of the *Crop Production* report is close to ranges from an absolute value of a 20% to 72% change. This means that in the markets where a marginal basis effect is significant, there is a significant change in risk that ranges from 20% to 72%.

The findings here for Illinois, Iowa, Nebraska, and the U.S. agree with the wide body of literature that supports the claim that USDA reports affect commodity market prices in some way: Colling and Irwin (1990), Fackler (1985), Fortenbery and Sumner (1993), Gorham (1978), Garcia et al. (1997), McNew and Espinosa (1994), Miller (1979), Milonas (1987), and Sumner and Mueller (1989). Thus, USDA reports, on the national level, and in Illinois, North Carolina, and Wisconsin are a valuable means of informing the corn market. This agrees with the literature that says that USDA reports are valuable: Bullock (1976), Bradford and Kelejian (1978), Byerlee and Anderson (1982), Garcia et al. (1997), Gorham (1978), Hyami and Peterson (1972), and Just (1983).

The findings for the North Carolina and Wisconsin corn markets, however, do not support the hypothesis that USDA reports affect commodity market prices. One possible explanation for this is that the North Carolina and Wisconsin corn markets are so small and local that they do not have to rely on external information such as that in the USDA *Crop Production* report to determine their market price. Farmers and agribusinesses in these corn markets, for example, may already have a good sense of what production in the local area is going to be like for the year. Or they may simply not let the release of the report affect their pricing decisions.

For the largest states in terms of production, however, the national market is quite important. As local producers do not have much information about what is going on in other areas of the country and the world, USDA production estimates are valuable in terms of price determination.

One issue requiring discussion is whether the effects shown to be significant here are upward or downward affects on the basis. One hypothesis is that the effects are downward because of a disappearance in risk premiums. Markets with less production should, theoretically, have more risk

due to less acres being planted to corn.

The results obtained here clearly call into question whether it can be said that USDA farm-level data reports affect the market of a particular commodity in all regions. The reports may affect the national market price in one period significantly, but that effect can be skewed by larger markets, such as those in Illinois, Iowa, and Nebraska, that are more affected by the new information. The results presented here showed that doing a state-by-state modeling of price movement proved worthwhile. One possible idea for future research pertaining to this could investigate the exact cause of these results.

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