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On the Relation Between Futures Price Movements and USDA Reports

by

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Introduction

The economic analysis of the information processing function of markets has received much attention in the theoretical literature in recent years. While providing interesting insights, this analysis has had few empirical applications, particularly in agricultural markets. One reason for this is the difficulty in reconciling the abstract notion of information as a signal with the data, reports and market analyses that real agents use. This difficulty has led many researchers to conduct studies which lack an explicit model of the role of information in determining market behavior. However, this lack has made the results of such studies difficult to interpret and evaluate.

In this paper I shall address the issue of the relationship between USDA crop production reports and futures price behavior in the corn and soybean markets. The nature of this relationship is important in evaluating both the efficiency of the markets in utilizing information and in assessing the value of the information contained in the reports. The efficiency issue has two parts. The first is whether the market price accurately

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incorporates all available information, in the sense that, following an initial price adjustment, the use of a specific piece of information will not enhance profits (or utility). The second issue concerns the speed with which that initial price adjustment occurs. Addressing the question of the value of crop reports raises welfare issues that will not be addressed in this paper, but also requires a careful examination of the way in which those reports are used by market participants.

A common method used to address these issues has been to examine price behavior before and after the release of a set of reports. This price data, together with the data contained in the reports themselves, is used to test various hypotheses and/or to quantify the relationship between the two variables. Examples of such studies in agricultural commodity markets are Gorman, Pearson and Houck, Miller, and Koontz et al. Of these, the first two examine grain markets, while the latter two the hog market.

In what follows these studies will be reviewed, with particular attention paid to their characterization of market response to information. Then an explicit model of market reaction to reports will be developed. This will be followed by an empirical examination of the corn and soybean futures markets and then by a section summarizing the results.

Previous Studies

All four of the studies mentioned in the first section share a common hypothesis which figures prominently in both their design and in the interpretations placed on their findings. This hypothesis is found in the following passage from Pearson and Houck:

> If traders guess correctly what the reports will say, then the market price adjusts before the release date. The price may not change much at all after the report is distributed. The only time a sizeable price adjustment will be observed is when the traders' expectations are wrong. The basic hypothesis is that price and quantity are negatively related; an increase in forecast quantity from one month to the next should lead to a decrease in price, and vice versa. (pp. 5-6)

This hypothesis is echoed in Gorman, who constructs the following example:

> Assume that a wheat crop forecast is made on the 10th of July, and that the market accepts this as the best available at that time. As the month progresses and rainfall becomes lighter than expected, private-information providers will adjust the July USDA forecast downward. To the extent that this downward adjustment is off the mark and the market is surprised by the new USDA forecast of August 10, the surprise will show up only in the August 11 price change. (p. 33)

In discussing his results Gorman suggests that an insignificant coefficient in a regression of the price change on the change in forecast production indicates that the "market does a very good job in anticipating changes in the soybean forecast," while a significant and negative coefficient indicates that the market does "a considerably poorer job in anticipating changes in the corn harvest"(p. 34). In Miller it is stated that "a futures price change opposite in direction from the change in production estimates between the new and the immediately preceding reports would be expected with the release of the new report" in the event that the report contains "surprises"(p. 68). Finally, in Koontz et al. this hypothesis provides the rationale for classifying reports as bullish, bearish or neutral, and for the conclusion that "[f]ailure to find a slope in the price change series for bullish (bearish) reports would indicate the markets to have already incorporated the information"(p. 5).

In both studies of the hog market evidence was found to support the hypothesized inverse relationship. In the grains the evidence was mixed, with a strong relationship existing in corn, a somewhat weaker one in wheat, and no significant relationship in soybeans.

While all four studies share this hypothesis, a few other issues were also investigated. Pearson and Houck contains a second hypothesis concerning the size of price fluctuations. They state:

> [O]ne can visualize a market filled with uncertainty in the days before a report is released....In this decision-making environment, the potential for price fluctuation is very great. However, after the report is released, uncertainty is reduced. Traders once again have a common point of reference in the quantity figures supplied by the report, so the range of expectations concerning the true location of the supply curve is narrowed....The price level may go up or down after distribution of the report, but it seems plausible to suppose that the degree of price flucuation might be lessened for several days afterward.(p.6)

Interestingly, this is the only discussion in any of the four papers on the size, as opposed to the sign of price movements.

They found, however, that the absolute size of price changes following the release of a report seems to increase.

Finally, two of the studies mentioned the question of the speed with which prices adjust to information in the reports. Koontz et al. state that "serial dependence on price changes around the release date of the reports would be expected if a report is a surprise and therefore contains new information. A series of price changes in the same direction would be required to adjust to a significant change in information."(p. 4). There was, however, little evidence of such serial dependence. Miller suggests "the possibility that constraints prevent immediate and complete futures price adjustments upon release of [a report]" (p. 68), and claimed his results provided evidence that such constraints do in fact exist.

A Model of Market Reaction to Information

In this section I will argue that the conclusions drawn in the studies discussed above are not as intuitively obvious as they might at first seem and may be somewhat misleading. The problem seems to stem from a lack of clarity about how the reports are used in the price adjustment process. A basic assumption of this paper is that the impact of a production report on price depends mainly on the extent to which traders adjust their expectations about production following the release of the report. Unfortunately, even if we assume that all traders believe that the report is correct, we cannot observe their beliefs prior to the report. The only information we have about what these expectations were is what is contained in the price record.

In order to utilize this record it is important to recognize that a report can influence traders' expectations in a number of possible ways, depending on what information was available prior to the release of a report and how this information had been used. This paper will concentrate on two such possibilities. The first is that the report contains new information that was not previously available, while the second is that traders make mistakes in their analysis of previously available information, which are corrected by the release of the report. Both of these possibilities will be explicitly modeled in order to derive hypotheses about the way in which readily observable variables, i.e., prices and production estimates, are related.

The model developed here will represent information as signals which traders observe and which influence their subjective expectations about price movements. A kind of efficiency in the market will be assumed, namely that an equilibrium price is established each day. However, the model will allow traders to make systematic mistakes in interpreting the impact on production of the information they receive between the release of crop reports.

Specifically, in this model the market is composed of identical traders, all with access to the same information set. We will define

$$p_t = \ln(\text{price}_t/\text{price}_{t-1}) \quad \text{and}$$

$$r_t = \ln(E_t[\text{production}]/E_{t-1}[\text{production}]).$$

The time subscipts denote a single trading day, and expectations are subjective. Capital letters will correspond to the cumulative sum of a variable over the period beginning two days after the last report was released. For example, if a report is released on July 10 and t refers to July 25, then P_t will be the log of the ratio of the July 25th price to the July 11th price.

Each day traders receive signals about forthcoming production and about other factors affecting price. For our purposes we can view the establishment of a new price expectation as occurring in two stages. In the first, traders revise r_t, while in the second they adjust price according to the rule

$$p_t = Ar_t + e_t$$

where e_t is a random variable that can be thought of as the effect on price of the non-production related signal, while $A<0$ and can be interpreted as a kind of price flexibility.

The information traders receive about production will take the form of two zero mean, serially uncorrelated signals, u_t and v_t. The first of these is received daily while the second is ontained in the production report and is independent of u_t. This ignal may be interpreted as the news contained in the report. We ill assume that, on the day following the release of a report, raders' production expectations coincide with those of the eport. Thus if t represents such a day then u_t is identically ero, while on any other day v_t is identically zero, and u_t has ome positive, constant variance. The cumulative variable, U_t, is efined as above. We will assume that the signals are defined so hat $R_t=U_t+v_t$ if t represents a day following a report release.

On other days, however, this will not be true. We will allow for the possibility that traders misjudge the significance of u_t on production. Though the true situation is that $r_t=u_t$ the market consensus reached is that $r_t=cu_t$. If $c>1$ then traders are overestimating the impact of u on production while if $0<c<1$ they are underestimating this impact.

This model, while simple, is sufficient to generate a number of interesting results. In the discussion that follows it will be helpful to bear two points in mind. First, unless otherwise stated, t will refer to a day following the release of a crop report. Second, all variables have mean zero and, therefore, uncentered and centered second moments are identical. From the variable definitions it immediately follows that:

$$r_t = v_t + (1-c)U_t$$

$$p_t = A(v_t + (1-c)U_t) + e_t$$

$$P_t = A(v_t + U_t) + E_t$$

$$P_{t-1} = A(cU_{t-1}) + E_{t-1},$$

where E is the cumulative associated with e. These results may, in turn, be used to analyze relationships between observable variables.

First let us examine the relationship between R_t and p_t, which has been a focus of inquiry in previous studies. We see that

$$E[p_tR_t] = A(Var(v_t) + (1-c)Var(U_t)).$$

This expectation need not be negative. Indeed, it will be positive if two conditions are met: first, if there is a tendency to overestimate the effect on production of the news received between releases of the production reports $(c>1)$ and second, if the amount of such news is large enough relative to the news contained in the report $(Var(u_t)>Var(v_t))$. Furthermore, a negative sign is no assurance that $Var(v_t)$ is large, i.e. that the report contains news. It may signal instead that there is a tendency to under-respond to information.

To see whether there is a systematic tendency for traders to over- or under-respond to information we may examine the relationship between p_t and P_{t-1}. We see that

$$E[p_t P_{t-1}] \quad = A^2(c(1-c)Var(U_{t-1})),$$

the sign of which will depend only on the sign of $1-c$, given that U_{t-1} is not degenerate. Thus, if traders systematically over-respond then we would expect to see an inverse relationship between these two variables, while an under-responsiveness would be indicated by a positive relationship. In either case we have a particular kind of inefficiency. By assumption markets are clearing every day, but we have the possibility that systematic mistakes are made in expectations.

It is possible, of course, that the market clearing assumption is not a good one. One way which this can be addressed is by examining the relationship between p_t and p_{t+i}, $i=1,2$, etc. This should indicate whether the information in the report is effectively incorporated into price on the day following the report release. In our model

$$E[p_t p_{t+1}] \quad = 0.$$

Hence, any significant relationship between these two variables is an indication that markets don't adjust in a day and that the model is not adequate in capturing all of the interesting features of the market. The relationship between p_t and p_{t-i}, i=1,2, etc., on the other hand, will depend on c. Specifically,

$$E[p_t p_{t-i}] = A^2(c(1-c)Var(u_{t-i})),$$

which will be non-zero when c does not equal 1.

Within the framework of the model the best overall indicator of the value of a crop production report is given by the variance of p_t following its release, especially relative to its variance for nearby days. This variance is given by

$$Var(p_t) = A^2(Var(v_t) + (1-c)^2 Var(U_t)) + Var(e_t) \quad \text{if t follows the release of a report}$$

$$= A^2(c^2 Var(u_t)) + Var(e_t) \quad \text{otherwise.}$$

Notice that the variance on the day following a report release measures both the new information and the correction needed due to misanalysis of previous information. If traders accurately analyze information (i.e., c=1), then the relative size of the variance on a day following a report release to that of other days will depend on whether $Var(v_t)$ is larger or smaller than $Var(u_t)$. Even if there is misanalysis of previous information, a large variance following a report release indicates that the report was useful in the price adjustment process.

Finally we may gain some insight into the relative size of various parameters by examining the relationship between P_t and R_t. In this case the square of the correlation coefficient will provide a measure of the proportion of the variance of the cumulative price change which is accounted for by the change in the production estimate. Furthermore, the coefficient of the regression of P_t on R_t provides an estimate of A.

Empirical Results

In the previous section a number of relationships were discussed that can be investigated empirically. In this section we shall examine these relationships in the December corn and November soybean futures markets. The data cover the July through November Crop Production reports from 1974 through 1982 (for soybeans and for corn in 1974 and 1982 the August report is the first to contain production estimates). This results in a data set with 34 observations for corn and 27 observations for soybeans on the variables R_t, P_t, and P_{t-1}, as well as p_{t-i}, i=-10,...,3. Because the magnitudes of these variables are rather small they have all been multiplied by 100 for ease of presentation and because they are then interpretable as percentages. Furthermore, it should be noted that all the variables defined above have mean zero by assumption. Therefore, in the following presentation, all results on second moments are uncentered sample averages.

The first statistics calculated are the sample variances of p_{t+i} for i=-10,...,3. These are given in Table 1 and provide evidence that price changes following report releases tend to be larger then usual. The sample variance of p_t is 5.868 and 4.541 in the soybean and corn markets, respectively. In both cases this is over half again as large as the largest of the variances of the other days. The overall means for the 10 days prior to report releases were 2.453 and 1.684, which suggests that the variance following a report release was nearly 2.5 times its usual size.

Table 1. Estimated Variances for Log Relatives of Soy and Corn Futures Prices

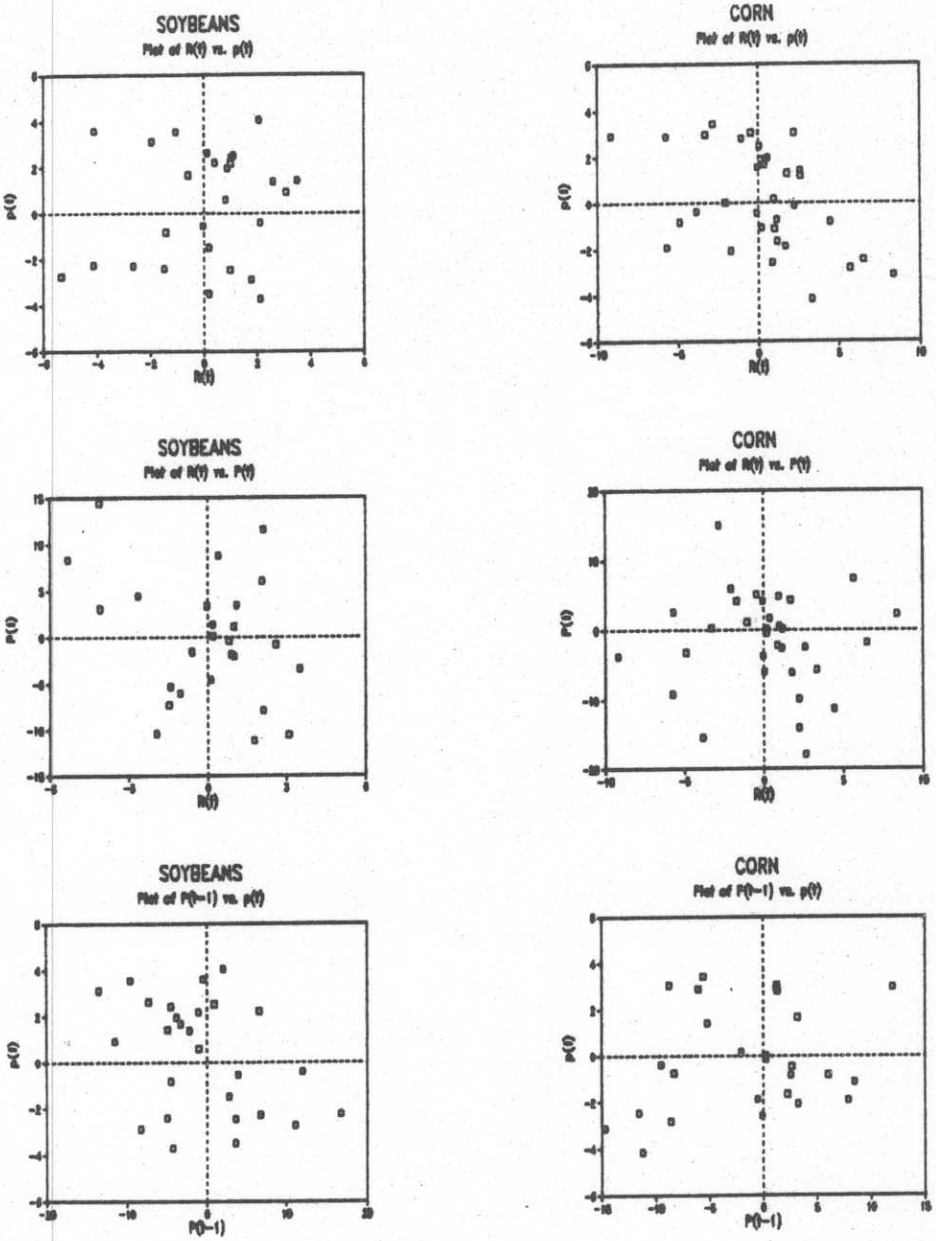
	SOYBEANS		CORN	
i	Var(p_{t+i})	max(p_{t+i})	Var(p_{t+i})	max(p_{t+i})
−10	2.980	11.611	2.439	11.925
−9	3.328	14.988	1.674	12.314
−8	2.031	14.988	1.700	8.793
−7	3.523	12.948	2.656	12.735
−6	2.900	11.013	1.413	7.593
−5	2.058	6.956	1.187	5.860
−4	2.827	11.351	2.362	13.728
−3	2.167	10.793	1.998	11.169
−2	1.473	8.690	0.777	3.401
−1	1.240	7.002	0.639	3.401
0	5.868	16.227	4.541	17.258
1	2.054	8.026	2.160	13.154
2	2.054	10.286	1.432	8.362
3	2.945	11.811	1.160	5.669

For a description of the data used see note to Table 2.

Although this evidence does not constitute a formal test, it strongly suggests that traders find the reports quite useful in adjusting their production expectations.

We now turn to the evidence provided by the relationships between the variables discussed in the previous section, namely those of R_t and p_t, R_t and P_t, and P_{t-1} and p_t. In Figure 1 scatterplots of these three pairs of variables are presented. For the most part evidence of a relationship between any of the three pairs is not striking. This is not terribly surprising in that one would expect the noise component of these variables to be fairly large. Only two of the plots are suggestive of a

Figure 1. Scatterplots for Selected Variables



For a description of the data used see note to Table 2.

relationship. The plot for P_{t-1},p_t for soybeans shows a tendency for the signs of the two variables to be opposite, which suggests that traders may overreact to news between report releases. The second plot is for R_t,P_t for corn, which suggests an inverse relationship, as would be expected.

These graphical impressions are reinforced by an examination of the frequency of sign pairs in each of the three relationships, which are given in Table 2. Two hypothesis tests were conducted with these figures. The first is that the probability of both variables of the pair having the same sign is equal to the probability that they don't. Using the sign test and the normal approximation to the binomial distribution it was

Table 2. Frequencies of Sign Pairs for Selected Variables

	SOYBEANS						CORN					
	I +,+	II +,−	III −,−	IV −,+	same sign	X^2	I +,+	II +,−	III −,−	IV −,+	same sign	X^2
R_t,P_t	8	9	5	5	13	1.15	8	13	4	9	12	3.11
R_t,p_t	11	6	6	4	17	1.56	9	12	5	7	14	0.73
P_{t-1},p_t	3	8	4	12	7	5.01	7	8	9	9	16	0.04

Data Definitions:

p_t = log relative closing futures price on the day following the release of a Crop Production report

P_t = cumulative of p_t, summed over the period since the release of the last report

R_t = log relative of the current estimate of production to the estimate from the previous report

The samples used cover the period 1974-1982.
The soybean sample contains 27 observations, while the corn sample contains 34.

found that only in the case of the soybean pair P_{t-1}, p_t could we reject this hypothesis with a significance level less than 0.05, while with a significance level of less than 0.1 we could also reject it for the corn pair R_t, P_t. Viewing the four quadrants as a 2x2 contingency table, we may also conduct a chi-squared (X^2) test of independence. The X^2 values are also given in Table 2. These should be compared to a X^2 distribution with 1 degree of freedom. Again, for the soybean P_{t-1}, p_t pair we can reject the null hypothesis of independence, now at a significance level of 0.025, while for the corn R_t, P_t pair, we may again reject at the 0.1 level. The other pairs again all have significance levels higher than 0.1.

Table 3 presents the sample covariances and correlations of the pairs of variables (these are calculated with the zero mean restriction). The same two pairs stand out as being related by this measure, but two others seem to have relatively high correlations as well. The soybean pair R_t, p_t has a correlation

Table 3. Covariances of Selected Variables (correlations in parentheses)

	SOYBEANS				CORN			
	R_t	P_t	P_{t-1}	p_t	R_t	P_t	P_{t-1}	p_t
R_t	4.832	-4.599 (-0.321)	-	0.841 (0.158)	12.504	-13.560 (0.544)	-	-3.372 (-0.447)
P_t		42.570	-	-		49.530	-	-
P_{t-1}			50.093	-6.700 (-0.391)			40.358	2.315 (0.171)
p_t				5.686				4.541

For a description of the data used see note to Table 2.

coefficient of -0.321, while for the corn pair R_t, p_t this coefficient is -0.447.

Also presented, in Table 4, are the results of three regressions. These provide a simple, widely used significance test based on the t-distribution, as well as a measure of the amount of the variance of the regressand that can be explained by the regressor. The most clearly related of these pairs using this method is the corn R_t, P_t pair with a significance level of less than 0.01 and an R^2 of nearly 0.3. Again the soybean pair P_{t-1}, p_t is seen to be related with a significance level of less than 0.05 and an R^2 of over 0.15. We see, however, that the relationship of the corn pair R_t, p_t cannot be dismissed. Here the significance level is under 0.05 and the R^2 is 0.2. This is in keeping with the findings of previous studies. Also, the soybean pair R_t, P_t has a weakly significant relationship, with an R^2 of about 0.1.

Table 4. Regression Results

	SOYBEANS			CORN		
	coeff	t-stat	R^2	coeff	t-stat	R^2
P_t on R_t	-0.9520 (0.5514)	-1.7265	.103	-1.0844 (0.2905)	-3.7327	.297
p_t on R_t	0.1740 (0.2134)	0.8152	.025	-0.2700 (0.0938)	-2.8741	.200
p_t on P_{t-1}	-0.1337 (0.0618)	-2.1630	.158	0.0574 (0.0575)	0.9970	.029

For a description of the data used see note to Table 2.

Finally, in Table 5, the covariances and correlations of p_t and p_{t-i}, $i=-10,\ldots 3$, are presented. In the previous section it was noted that our model predicts that these will equal zero for $i>0$, while they will have the same sign as $1-c$ for $i<0$. This result would provide one check of the assumption that markets are clearing each day. In neither market is there any clearly discernible or interpretable pattern to these results. While no formal tests were conducted, there is no compelling evidence indicating that the market clearing assumption need be further investigated.

Table 5. Covariance and Correlation of Log Relative Futures Prices Following a Crop Report with Prices on Surrounding Days

	SOYBEANS		CORN	
i	$\mathrm{cov}(p_t,p_{t-i})$	$\mathrm{corr}(p_t,p_{t-i})$	$\mathrm{cov}(p_t,p_{t-i})$	$\mathrm{corr}(p_t,p_{t-i})$
−10	−0.7046	−0.1685	0.4609	0.1385
−9	0.3608	0.0816	−0.7686	−0.2788
−8	−1.1467	−0.3322	−0.1525	−0.0549
−7	−0.8720	−0.1918	0.3347	0.0964
−6	0.7646	0.1854	0.5854	0.2311
−5	−0.1357	−0.0391	0.1894	0.0816
−4	−1.4965	−0.3674	0.4471	0.1365
−3	0.7572	0.2123	0.8290	0.2752
−2	−0.1977	−0.0672	−0.3517	−0.1872
−1	−0.2606	−0.0966	−0.3836	−0.2252
0	5.8684	1.0	4.5411	1.0
1	−0.1354	−0.0390	−0.9577	−0.3058
2	0.4459	0.1284	−0.5627	−0.2206
3	−1.3145	−0.3162	0.0113	0.0049

For a description of the data used see note to Table 2.

Summary and Conclusions

Questions concerning the value of USDA reports are continually arising and finding the proper way to measure their impact in the marketplace is an important part of answering such questions. What is suggested here is that there are two ways in which the reports impact on the market. The first is that they provide new information to market participants and the second is that they correct misanalysis of other available information.

It has been argued here that the single best measure of the impact of crop reports on the market is the ratio of the variance of the price change following the release of the report to the variance at other times. It was found that this ratio is approximately 2.5 in both of the markets examined, indicating that relatively large price adjustments do occur in response to the reports.

The evidence indicates, however, that the corn and soybean markets respond to the crop production reports in somewhat different fashions. In the corn market there is no evidence that traders systematically misjudge the information that they receive between the releases of production reports. Thus, the strong inverse relationship between the changes in the report estimates and the price following the release of the reports suggests that there is a large news component to the reports.

In the soybean market, on the other hand, this strong relationship does not exist. However, the conclusion that the reports therefore contain little information is not supported by other evidence. First, the variance of the price change is higher on days following the report releases than at other times. This alone suggests that traders are responding to the reports. Furthermore, the negative relation between p_t and P_{t-1} suggests that traders systematically over-respond to information that they receive between the release of reports, requiring a larger price adjustment to occur when a report becomes available.

This does not imply that the soybean market is somehow mysterious or even that it is, in general, inefficient. As we have seen, this market seems to adjust prices quickly to the information contained in crop reports. It is, however, an open question as to why the soybean market behaves as it does. A possible explanation may lie in the fact that the soybean market has had a relatively large proportion of small speculators, who would tend to be less well informed than large hedgers and speculators about crop conditions.

It would be unwise to jump to the hasty conclusion that the evidence presented indicates that traders act irrationally. However, there is sufficient evidence to counter the implication made in previous studies that USDA crop reports contain little information for the soybean market and that it is sufficient to only examine the relationship between the change in the production estimate and the change in price following the release of a report.

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