THE REACTION OF LIVE HOG FUTURES PRICES TO USDA HOGS AND PIGS REPORTS

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Strong concerns about how efficiently live hog futures prices react to USDA Hogs and Pigs Reports have been raised by livestock producer groups. Using market survey data, direct tests of the efficient markets hypothesis are performed for the live hog futures market. Two-limit tobit models account for institutional price limits. Results support the efficient market hypothesis in that live hog futures prices: (1) do not react to anticipated changes in reported information, (2) do react significantly and in the expected direction to unanticipated changes in reported information and (3) generally adjust to unanticipated information on the day following release of the Reports.
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THE REACTION OF LIVE HOG FUTURES PRICES TO USDA HOGS AND PIGS REPORTS

A market is efficient if prices discovered in that market fully reflect all available information (Fama). Therefore, in an efficient market price changes should only occur as the result of new information. Old information is already incorporated into price and should therefore lead to no further price changes. In addition, price changes as the result of new information should occur rapidly, perhaps instantaneously.

Prices on various markets often react sharply after the release of new major information. For example, stock prices often change substantially after the release of reports on trade, inflation, unemployment, and capacity utilization. Commodity futures prices often change after the United States Department of Agriculture (USDA) releases various crop and livestock reports. However, prices sometimes do not change or change only slightly after the release of reports. In such cases, the market may have accurately anticipated the report information. In an efficient market, price changes should only reflect differences between market expectations of new information and the actual information upon release.

A controversial example of the release of important new information is the quarterly USDA Hogs and Pigs Report, where estimates of the size of the total hog inventory, breeding and market hog inventories and farrowing intentions are reported. Livestock producer groups have voiced strong concerns that live hog futures prices do not react efficiently to the information contained in the Hogs and Pigs Reports. The purpose of this paper is to test the hypothesis of market efficiency for the live hog futures market.

Previous studies of the effect of Hogs and Pigs Reports on live hog futures prices (USDA; Miller; Hoffman; Hudson, Koontz and Purcell) do not use survey data of market expectations to distinguish between anticipated and unanticipated information. Hence, direct tests of market efficiency are not possible. In this study, survey data of market analyst's expectations of changes in breeding and market hog inventories are used to distinguish between anticipated and unanticipated information. The survey data are tested to determine their appropriateness with regard to unbiasedness, efficiency, and forecast performance. Then, maximum-likelihood estimation of two-limit tobit models and likelihood-ratio tests are used to determine if anticipated and unanticipated information has subsequent effects on prices after the Report release. The possibility of predictable price patterns up to four days after the Reports is also examined.

Throughout the paper, reference is made to three categories of information. These include expectations, Report, and unanticipated information. Expectations information refers to the pre-Report expectations of reported information. This is sometimes referred to as "anticipated" information. Report information refers to the information contained in the USDA Hogs and Pigs Reports. Unanticipated information refers to the difference between expectations and Report information.

REVIEW OF PREVIOUS RESEARCH

Previous studies of the effects of USDA reports on commodity futures prices provide only indirect evidence to support the efficient markets hypothesis. Like most studies of stock price behavior (i.e. Fama, Fisher, Jensen and Roll; Castanias), they observe the behavior of futures prices around the announcement date. Gorham studies the changes in soybean, wheat and corn prices after the releases of monthly USDA crop production forecasts. He observes the changes in prices after the announcements given the differences in the most recent forecasts and the forecasts of the previous month. Results indicate that changes in production harvest forecasts, and to a lesser degree wheat production forecasts, have a significant effect on subsequent price changes. Since changes in soybean production forecasts do not have a significant effect on price, he concludes that traders are better able to anticipate forecasts for soybean production as compared to corn or wheat production. Fackler, comparing the variance of price changes of corn and soybean futures after the release of reports to all other times, finds that variance is 2.5 times greater after the release of those reports for both contracts. This indicates that price adjustments occur in response to the reports supporting the notion of market efficiency.

Miller, USDA (1977), and Hoffman study the short-term behavior of live hog futures prices before and after the release of USDA Hogs and Pigs Reports. Miller examined price changes one day before and after the release of Reports, whereas USDA (1977) and Hoffman used weekly averages of prices before and after the release of the Reports. The results of the three studies suggest that futures prices generally react quickly to new information, but some exceptions are noted, especially for deferred contracts. Hudson, Koontz and

Purcell study longer-term behavior of live hog futures prices by using prices twenty days before and after the release of Hogs and Pigs Reports. They concluded that live hog futures prices "adjust to new information in the Hogs and Pigs Reports rapidly and, in general, move in the appropriate direction" (p. 36). However, they also argue that the market is efficient but that it lacks sufficient information. Like most studies of stock market behavior, the above studies do not discriminate between anticipated and unanticipated components of new market information. It also appears that price limits are not accounted for, which would bias the results.

Barnhart's study is unique in that survey data of market participants' expectations of changes in fundamental variables are used to construct measures of anticipated and unanticipated changes in information. He estimates the effects of anticipated and unanticipated changes in the money supply, the Federal Reserve discount and surcharge rates, the consumer price index, the producer price index, the unemployment rate and the U.S. industrial production index on futures price changes for several commodity futures contracts. The sample runs from 1977 through 1984 and is broken into three subsamples to account for different monetary policy regimes over the period. For some contracts, it is found that prices do not adjust immediately to unanticipated information. This is possibly attributable to transactions costs, information costs, or institutional characteristics. It is unclear as to whether price limits are considered.

THEORETICAL CONSIDERATIONS

The following general model (Pearce and Roley) is used to investigate the response of live hog futures prices to anticipated and unanticipated information and to test basic hypotheses of efficient markets:

$$(1)\quad \Delta FP_t = a + x_t^u{*}b + x_t^e{*}c + \sum_{i=1}^{m} x_{t-i}^u{*}d + \mu_t$$

where ΔFP_t is the percent change in closing futures prices from day t - 1 to day t; x_t^e is a (1 X k) vector of expected informational components given information known on the close of trading on day t - 1; x_t^u is a (1 X k) vector of unanticipated informational components, derived as the difference between announced components, x_t^a, and expected components, x_t^e; x_{t-i}^u is a (1 X k) vector of unanticipated components occurring i days prior to day t; μ_t is a stochastic error term; a is a constant and **b**, **c**, $\mathbf{d}_i$ are (k X 1) vectors of parameters. If market expectations are rational, then

$$(2)\quad x_t^e = E(x_t^a | \Omega_{t-1})$$

where x_t^a is a (1 X k) vector of announced information and Ω_{t-1} is the information set on the close of day t-1 in order that $(x_t^a - x_t^e)$ is uncorrelated with Ω_{t-1}.

Under the efficient markets hypothesis, each element of **c** should not be significantly different from zero because all known information, Ω_{t-1}, should be reflected in the previous day's closing futures price, FP_{t-1}. Also, each element of $\mathbf{d}_i$ should not be significantly different from zero because non-zero elements would imply that futures prices adjust slowly to new information. Therefore, if the market is efficient, model (1) becomes

(3) $\Delta FP_t = a + X_t^u * b + \mu_t$

and model (3) should not be rejected in favor of equation (1). If this holds, then equation (3) becomes the relevant model to determine the effect on futures price changes after unanticipated information is realized.

Given the nature of the major information released in the USDA Hogs and Pigs Reports, the independent variables for this study ideally would include anticipated and unanticipated changes in breeding and market hog inventories as well as farrowing intentions. However, survey data are unavailable for anticipated changes in farrowing intentions. Hence, the model for this study includes only anticipated and unanticipated changes in breeding and market hog inventories. However, correlation coefficients for actual changes in breeding hog inventories and farrowing intentions are quite high. The correlation coefficient for actual changes in breeding hog inventories and farrowing intentions during the quarter including the month of and the two months following the survey date is 0.94. The correlation coefficient for actual changes in breeding hog inventories and farrowing intentions during the quarter four to six months after the survey date is 0.88. This suggests that correlations between unanticipated changes in those categories might also be high. Therefore, much of the impact of unanticipated changes in farrowing intentions likely is captured by unanticipated changes in breeding hog inventories.

Based on the specified model, anticipated information concerning changes in breeding and market hog inventories should be fully reflected in live hog futures prices before the release of the Hogs and Pigs Reports. Therefore, after the Reports are released, anticipated information should lead to no further price changes. Price changes should only reflect new information associated with the Reports.

In general, the relationship between live hog futures prices and unanticipated changes in hog inventories should be negative. That is, if a Report shows that hog inventories are higher than expected just before the release of the Report, or that supply is higher than expected, then prices should drop after the release of the Report, and vice versa. Prices should adjust rapidly after the release of Reports.

More specifically, prices of nearby futures contracts should be more responsive to unanticipated changes in market hog inventories, because this unanticipated supply will be ready for market in the near-term. Contracts which expire at a time approximately equal to a hog production cycle (approximately eight to ten months) should be more responsive to unanticipated changes in breeding hog inventories. This would reflect unanticipated changes in the potential nearby pig crop which would be ready for market at that time. It is somewhat how distant contracts, beyond a production cycle, would be affected by surprises in breeding and market hog figures. However, the negative relationship between unanticipated figures and futures prices for those contracts should exist.

DATA

Closing live hog futures prices are collected on the days the Hogs and Pigs Reports are released, along with those one through four trading days after and two days prior to the release of the Reports. Various time-horizons of live hog futures contracts are defined corresponding to the approximate number of months from the time the Hogs and Pigs Reports are released until the contracts expire. Because futures contracts do not exist for every month of the year, it is impossible to obtain a perfectly balanced design. Five time-horizons are defined, with the nearby time-horizon contracts expiring approximately two to three months after the Report releases and with the distant time-horizon contracts expiring in about twelve to thirteen months. Table 1 lists the futures contracts used for each time-horizon along with the corresponding number of months after the release of the Reports until expiration of the contracts. The various time-horizons allow for comparison of the specific effects of anticipated and unanticipated changes in breeding and market hog inventories across a wide spectrum of futures contracts.

An average of market analysts' expectations is used as the proxy for market expectations of reported changes in breeding and market hog inventories from year-ago levels. Analyst expectations are collected in a survey by Futures World News. Specifically, 15 analysts on average are canvassed regarding their expectations of changes in total, breeding and market hog inventories. Survey results are released after the close of trading two days before the USDA Hogs and Pigs Report is announced. Subsequent actual changes in ten-state breeding and market hog inventories from year-ago levels are published in quarterly USDA Hogs and Pigs Reports.[1] The USDA Report is released after the close of trading on the announcement day. The sample period runs from the September 1981 through the June 1988 Reports, providing 28 observations.

To examine the suitability of the market survey data with respect to unbiasedness, efficiency and forecast performance, four tests are performed, following the methodology set forth by Pearce and Roley. If these tests are passed, then the data are deemed appropriate for testing the efficient markets hypothesis. The first test is designed to determine if the survey data are unbiased. No systematic bias should be revealed if the survey data are rational. The following models are estimated using ordinary least squares:

$$(4)\quad BRD_t^a = \beta_0 + \beta_1 BRD_t^e + \mu_t \text{ and}$$

$$(5)\quad MKT_t^a = \beta_0 + \beta_1 MKT_t^e + \mu_t$$

where BRD denotes changes in breeding hog inventories from the year-ago level, MKT denotes changes in market hog inventories from the year-ago level, a superscript e denotes expected information, a superscript a denotes actual information, and a subscript t denotes the Report release date. A paired F-test is performed to test the null hypothesis H_0: $\beta_0 = 0$, $\beta_1 = 1$ for both breeding and market hogs. The marginal significance levels reported in table 2 indicate that unbiasedness can not be rejected.

Because important new information could affect live hog futures prices in the two days between the release of the survey of market analysts and the release of the Hogs and Pigs Reports, a second test of unbiasedness is conducted. Following Pearce and Roley, new information is assumed to be reflected by the percentage change in closing futures prices from the release date of the market analysts' survey to the release date of the USDA Hogs and Pigs Report. Hence, the following models are estimated using ordinary least squares:

$$(6)\quad BRD_t^a = \beta_0 + \beta_1 BRD_t^e + \beta_2 \Delta FP_t^i + \mu_t \text{ and}$$

(7) $MKT_t^a = \beta_0 + \beta_1 MKT_t^e + \beta_2 \Delta FP_t^i + \mu_t$

where ΔFP_t^i is the difference between the natural logarithms of the closing futures prices on the release dates of the market analysts' survey and the USDA Report for time-horizon i (i = 1,..,5). This price change is simply a proxy for new information. All other variables are defined for equations (4) and (5). If either of the β_2 coefficient estimates from (6) and (7) are significantly different from zero, this would indicate that new information consistently enters the market in a non-random fashion between the release of the survey and the Report. In such a case, the survey data of market expectations could be consistently biased. The data then would need to be adjusted to reflect that bias. In none of the ten estimated equations is the β_2 coefficient significant, or the β_0 and β_1 coefficients substantially changed from estimates presented in table 2.[2] Thus, on average, no new important information is released between the survey and the USDA Report. As a result, there is no need to adjust the survey expectations to reflect a revised market expectation.

In the third test the efficiency of the survey data is tested by estimating the following models:

(8) $BRD_t^u = \beta_0 + \beta_1 BRD_{t-1}^u + \mu_t$ and

(9) $MKT_t^u = \beta_0 + \beta_1 MKT_{t-1}^u + \mu_t$

where a superscript u denotes unanticipated information, computed as the difference between changes reported in the Hogs and Pigs Reports and analysts' survey data. Using the Final Prediction Error (FPE) criteria of Akaike, one lag is chosen for both models in which a total of four lags are allowed to enter. Pearce and Roley, citing Modigliani and Shiller, note that "the basic notion behind this concept is that if announced data are generated by an autoregressive process, the market's expectation should be generated by the same process" (p.57). Lag coefficients should not be significantly different from zero. As table 3 indicates, the null hypothesis is not rejected.

The fourth test determines if forecasting autoregressive models can outperform the survey data. The following autoregressive models are estimated:

(10) $BRD^a_t = \beta_0 + \beta_1(BRD^a_{t-1}) + \beta_2(BRD^a_{t-2}) + \mu_t$ and

(11) $MKT^a_t = \beta_0 + \beta_1(MKT^a_{t-1}) + \beta_2(MKT^a_{t-2}) + \mu_t$.

Again, the FPE criteria is used to select the number of lags where up to four lags are allowed to enter. From table 4, the forecast root mean square error is lower for the survey data than for the autoregressive models for both breeding and market hogs, indicating that the survey data is a better forecaster than the models. The results are especially significant when it is noted that the model forecast errors are generated in-sample and the survey forecast errors are generated <u>ex ante</u> out-of-sample. As the forecasting accuracy of univariate time-series models is well-known, this raises the interesting question of whether model-based forecasts of hog inventory categories (Blanton, Johnson, Brandt and Holt) are economically valuable.

Based on the previous four tests, it is concluded that the survey data have desirable properties and are appropriate for direct tests of the efficient markets hypothesis. But before moving on to such tests, an important econometric problem must be addressed.

ECONOMETRIC MODEL

A problem encountered in this research deals with institutional price-limits of the Chicago Mercantile Exchange. Live hog futures prices are allowed to move by no more than \$1.50/cwt. during a trading day from the previous day's closing price. If the price hits the limit, trades may still take place at that price. However, if the closing price is at the limit this indicates an imbalance in supply and demand, and hence the closing price is not an equilibrium free market price. As a result, daily closing prices may be inappropriate for testing market efficiency and predicting price changes after Report releases given unanticipated information. For example, if ordinary least square is applied to equation (3), the estimated coefficients of b would be biased toward zero because the dependant variable can take on only limited values or values between the limits. In this study, closing prices on days after the Reports are limit moves for at least one-half of the 28 observations for all five time-horizons. Therefore, alternative measurement techniques must be examined in order to examine and test models (1) and (3).

To deal with this problem, maximum-likelihood estimation of the two-limit tobit model as presented by Rosett and Nelson is used to estimate parameters and test hypotheses. This allows for estimates of true price changes in light of price limits and the limited-dependent variable problem. Maddala notes that when the dependent variable is truncated on two sides, but is allowed to vary freely within the two limits, the classical linear model becomes

$$(12)\quad y_i^* = \beta' x_i + \mu_i$$

where y_i^* is the latent or sometimes unobserved variable. Denoting y_i as the observed variable, we have

$$\begin{aligned}(13)\quad y_i &= L_{1i} \quad \text{if } y_i^* \le L_{1i} \\ &= y_i^* \quad \text{if } L_{1i} < y_i^* < L_{2i} \\ &= L_{2i} \quad \text{if } y_i^* \ge L_{2i}\end{aligned}$$

where L_{1i} and L_{2i} are lower and upper limits, respectively, of the dependent variable for observation i. This model's likelihood function is given by

$$(14)\quad L(\beta,\sigma | y_i, x_i, L_{1i}, L_{2i})$$

$$= \underset{y_i=L_{1i}}{\pi} \Phi\left[\frac{L_{1i}-\beta' x_i}{\sigma}\right] \underset{y_i=y_i^*}{\pi} \frac{1}{\sigma} \phi\left[\frac{y_i-\beta' x_i}{\sigma}\right] \underset{y_i=L_{2i}}{\pi} \left[1-\Phi\left[\frac{L_{2i}-\beta' x_i}{\sigma}\right]\right]$$

where ϕ and Φ are the density function and distribution function of the standard normal, respectively. This likelihood function accounts for all three possibilities given in (13). A modification of the Davidson, Fletcher and Powell algorithm is used to optimize the likelihood function, as suggested by Gruvaeus and Joreskog. The covariance matrix is computed from analytic first derivatives of the likelihood function.

The potential for heteroscedasticity in futures price changes is well-known (Hall, Brorsen and Irwin). Hence, tests for heteroscedasticity are performed for all estimations. ML estimates of the following model, as specified by Rutemiller and Bowers, and outlined in Maddala are obtained:

$$(15)\quad \sigma_i^2 = (\tau + \delta Z_i)^2$$

where σ^2 denotes a vector of squared error terms from the tobit models, τ denotes a constant, δ denotes a vector of parameters, and Z includes all independent variables. Likelihood-ratio tests of the restriction $\delta = 0$ are performed.

RESULTS

To test the hypothesis that anticipated information of USDA Hogs and Pigs Reports has no effect on price changes after they are released, the following model is estimated for each time-horizon:

$$(16)\quad Ln(FP_t^1) - Ln(FP_t^0) = \beta_0 + \beta_1(BRD_t^u) + \beta_2(MKT_t^u) + \beta_3(BRD_t^e) + \beta_4(MKT_t^e) + \mu_t$$

where FP denotes closing live hog futures price, a superscript 0 denotes the day of the Report release, a superscript 1 denotes one trading day after the

Report release, and all other terms are as defined earlier. Unanticipated components are computed as the difference between actual and expected percent changes in inventories from the year-ago level. Price changes are computed as differences in natural logs so that they will represent fractional changes. The lower and upper limits for this tobit model are given by

(17) $LL_t = Ln(FP_t^0 - LPC) - Ln(FP_t^0)$ and

(18) $UL_t = Ln(FP_t^0 + LPC) - Ln(FP_t^0)$,

where LL and UL denote lower limit and upper limit, respectively, and LPC denotes limit price change. For model (16), this is \$1.50 because we are dealing with one-day price changes. To test the efficient markets hypothesis, a likelihood-ratio test of the linear restriction, $H_0: \beta_3 = \beta_4 = 0$, is performed and t-statistics and standards errors of the estimated coefficients are observed.

Coefficient estimates of equation (16) are shown in Table 5. No evidence of heteroscedasticity is found for any of the estimated equations. Likelihood-ratio tests and t-tests indicate that estimates of β_3 and β_4 coefficients of the expected components are not significantly different from zero. Therefore, anticipated information has no significant effect on live hog futures price changes after the release of the USDA Hogs and Pigs Reports. This result indicates that anticipated information is incorporated into price before the release of the Reports, supporting the efficient market hypothesis. At this point, the first test of market efficiency has been passed and c in (1) becomes zero causing that term to be deleted from the model.

To estimate the impact of unanticipated information on one-day futures price changes, β_3 and β_4 are dropped from (16) and the following model is estimated:

$$(19)\quad Ln(FP_t^1) - Ln(FP_t^0) = \beta_0 + \beta_1(BRD_t^u) + \beta_2(MKT_t^u) + \mu_t$$

for all time-horizons where LPC from (17) and (18) is also \$1.50. Standard errors and t-statistics of the estimated coefficients are examined to determine their significance. A likelihood-ratio test of the linear restriction, $H_0{:}\beta_1 = \beta_2 = 0$, is performed to determine the joint significance of unanticipated information with regard to breeding and market hog inventory changes.

Coefficient estimates of equation (19) are presented in the first three columns of Table 6. Again, evidence of a serious heteroscedasticity problem is not found. As expected, all signs of the estimated coefficients β_1 and β_2 are negative. Of the t-statistics for unanticipated market herd changes, only that of time-horizon 1 is significant at the five-percent level. This supports the hypothesis that those changes have the greatest impact on nearby futures contracts. The t-statistics for unanticipated breeding herd changes are significant at the five-percent level for time-horizons 1 and 2 and at the one-percent level for time-horizons 3 through 5. Of the coefficient estimates for unanticipated breeding herd changes, that of time-horizon 1 is least in absolute magnitude (0.562). The magnitude increases substantially at time-horizon 2 (1.241). The absolute magnitudes of the unanticipated breeding herd coefficients are greatest for the models reflecting a time to expiration of the contracts approximately equal to a hog-production cycle (1.577 and 1.489 for time-horizons 3 and 4, respectively). Beyond a hog production cycle (time-horizon 5), the absolute value of the coefficient estimate drops to 0.796.

The likelihood-ratio tests, shown in the first column of Table 7, indicate that β_1 and β_2 for equation (19) are jointly significantly different from zero at the one-percent level for all time-horizons. This result indicates that unanticipated information significantly influences futures prices along the entire spectrum of time. In sum, the results from one-day price change models support the hypothesis that live hog futures prices react quickly and efficiently to new information.

To further test the efficient markets hypothesis, it is necessary to determine if predictable price patterns exist for several days beyond one day after the Report releases, given the unanticipated information. Ideally, it would be desireable to test for one day price changes beyond the first day after release of Reports. This could be accomplished by changing the left-hand side of (19) to $Ln(FP_t^2) - Ln(FP_t^1)$, and $Ln(FP_t^3) - Ln(FP_t^2)$, and so forth. However, as mentioned earlier, about one-half of all closing prices one day after Report releases are limit moves as are several closing prices two days following Reports. Therefore, the procedure mentioned above would lead to biased results and is not performed. As an alternative, the following models for all time-horizons are estimated:

(20) $Ln(FP_t^2) - Ln(FP_t^0) = \beta_0 + \beta_1(BRD_t^u) + \beta_2(MKT_t^u) + \mu_t$,

(21) $Ln(FP_t^3) - Ln(FP_t^0) = \beta_0 + \beta_1(BRD_t^u) + \beta_2(MKT_t^u) + \mu_t$ and

$$(22) \quad Ln(FP_t^4) - Ln(FP_t^0) = \beta_0 + \beta_1(BRD_t^u) + \beta_2(MKT_t^u) + \mu_t$$

where superscripts 2, 3 and 4 represent trading days two, three and four after the Report releases. LPC from (17) and (18) are \$3.00, \$4.50 and \$6.00 for (20), (21) and (22) respectively. This alternative is followed because the dependent variables in (20) through (22) represent cumulative price changes. For example, the dependent variable in (20) represents the change in price from the close of trade on the day of the Report release to the closing price two trading days later. Since prices are permitted to move by \$1.50 per day, the effective cumulative two-day price limit is \$3.00 in this case. The effective cumulative three-day and four-day price limits are therefore \$4.50 and \$6.00, respectively. The independent variables in (19) through (22) are identical.

Parameter estimates of (20) through (22) appear in Table 6 under the columns for cumulative two-day, three-day and four-day price changes. A heteroscedastic error structure is not evident for any of the estimated equations. Most of the coefficient estimates for unanticipated changes in inventories are significant for the cumulative two, three and four-day price-change models, as is the case for one-day price changes. However, this does not imply that prices continue to adjust after day-one. A significant cumulative price change may be the result of a large and significant price change on a single day and small and insignificant price changes on the other days in the summation. To determine if prices continue to adjust after the first day following the Report, coefficient estimates between days must be compared. A significant change in β_1 and/or β_2 between days for any given time-horizon may indicate that information is re-interpreted in a systematic fashion.

As a formal test of the hypothesis that price patterns cannot be predicted on days beyond the first day following release of the Hogs and Pigs Reports, likelihood-ratio tests are performed where β_1 and β_2 in (20), (21) and (22) are restricted to their estimated values in (19), (20) and (21), respectively. The test results, presented in the last three columns of Table 7, offer further evidence in support of the efficient markets hypothesis. Test statistics were insignificant beyond day one for four of the five time horizons. Predictable price patterns are indicated only for time-horizon 4 contracts. As shown by the test statistics, prices at this time horizon continue to adjust through the third day following Report releases.

The specific pattern of price movements for time-horizon 4 contracts is suggested by the changing magnitude of the estimated coefficients for this horizon (row four, Table 6). Since β_1 equals -1.489 for day one, -0.948 for day two and -0.801 for day three, an over-reaction price pattern is suggested with respect to unanticipated changes in breeding inventories. Because β_2 is equal to -0.436 for day one and increases to -0.713 for day three, an under-reaction price pattern is indicated for unanticipated changes in market inventories. The relatively large change in the magnitude of coefficients for unanticipated breeding inventory changes suggests that over-reaction is the dominant price pattern for time-horizon 4 contracts. Finally, the results do not necessarily imply that a profitable trading strategy could be developed to exploit the apparent price patterns. This is due to the existence of price limits and the high execution costs of trading in deferred futures contracts (Thompson and Waller).

CONCLUDING COMMENTS

Live hog futures prices often react sharply after the release of USDA Hogs and Pigs Reports. Strong concerns about how efficiently live hog futures prices react to those Reports have been raised by livestock producer groups. Under the efficient markets hypothesis, live hog futures price changes after the release of Hogs and Pigs Reports should only reflect unanticipated changes in hog inventories and no predictable price patterns should be found.

Using market survey data as a proxy for expected changes in breeding and market hog inventories contained in quarterly USDA Hogs and Pigs Reports, unanticipated changes in those figures are constructed. Therefore, expected and unanticipated changes are clearly differentiated allowing for a direct test of the efficient markets hypothesis in the live hog futures market. After showing that the survey data have desirable properties of unbiasedness, efficiency, and superior forecast performance, a direct test of the efficient markets hypothesis is performed. Maximum likelihood estimation of two-limit tobit models is used to account for institutional price limits.

The results offer strong support for the efficient markets hypothesis. First, it is found that expected changes in Hogs and Pigs inventories are incorporated into live hog futures prices before the release of the Reports, and hence, the expected changes have no effect on price changes after the release of the Reports. Second, live hog futures prices across the spectrum of time react significantly and in the expected direction to unanticipated information. It is found that nearby contract prices are most responsive to time-horizon approximating one hog production cycle are most responsive to unanticipated breeding hog inventory changes. Third, predictable price patterns beyond the first day following the release of Hogs and Pigs Reports are not evident for four of the five contract time horizons examined in the study. Prices for one of the deferred contract time horizons adjust through the third day following Report releases. However, this does not imply that a profitable trading strategy can be constructed to exploit the apparent price pattern. The existence of price limits and high execution costs of trading in deferred live hog futures contracts are likely to preclude such a possibility.

ENDNOTES

1. Prior to the June, 1982 USDA Hogs and Pigs Report, quarterly data were based on 14 states. Therefore, in our sample, the first three observations are based on 14-state data. To determine if this biased the results, all estimations were re-estimated with the first three observations deleted. The results were virtually identical indicating that no substantial bias exists. Results presented are those of the full sample period (28 observations).

2. These results are available from the authors upon request.

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Table 1. Futures Contracts Used for Each Time Horizon.

	Futures Contracts[a]			
	Quarterly Report			
Time Horizon	March	June	Sept.	Dec.
1	June (3)	Aug. (2)	Dec. (3)	Feb.+ (2)
2	July (4)	Oct. (4)	Feb.+ (5)	Apr.+ (4)
3	Oct. (7)	Feb.+ (8)	Apr.+ (7)	July+ (7)
4	Feb.+ (11)	Apr.+ (10)	July+ (10)	Oct.+ (10)
5	Apr.+ (13)	June+ (12)	Oct.+ (13)	Dec.+ (12)

[a]A (+) indicates that the corresponding contract month is used for the year following the Hogs and Pigs Reports. Numbers in parentheses are the approximate number of months after the Report release to the expiration of the futures contract.

Table 2. Tests of the Unbiasedness of the Survey Data.

Report Figure of:	Coefficient Estimates		Summary Statistics[a]			H_0: $\beta_0 = 0$, $\beta_1 = 1$	
	β_0	β_1	Adj R^2	S.E.	D-W	F(2,26)	M.S.[b]
Breeding Hogs	-.908 (.617)	.997 (.089)	.82	3.15	1.95	1.152	.332
Market Hogs	.332 (.392)	.950 (.054)	.92	2.00	2.09	1.075	.356

Note: Standard errors of the estimated coefficients are in parentheses.

[a]Adj R^2 = adjusted R^2; S.E. = standard error; D-W = Durbin-Watson d.

[b]M.S. = marginal significance level.

Table 3. Tests of the Efficiency of the Survey Data.

Report Surprise in:	Coefficient Estimates		Summary Statistics[a]			Test H_0: $\beta_1 = 0$	
	β_0	β_1	Adj R^2	S.E.	D-W	F(1,27)	M.S.[b]
Breeding Hogs	-.753 (.534)	.025 (.074)	-.04	2.51	1.59	.118	.735
Market Hogs	.381 (.417)	-.052 (.060)	-.01	2.02	2.07	.744	.398

Note: Standard errors of the estimated coefficients are in parentheses.

[a]Adj R^2 = adjusted R^2; S.E. = standard error; D-W = Durbin-Watson d.

[b]M.S. = marginal significance level.

Table 4. Tests of the Forecast Performance of the Survey Data.

Report Figure of:	Coefficient Estimates			Summary Statistics[a]			Forecast RMSE[b]	
	β_0	β_1	β_2	Adj R^2	S.E.	D-W	Auto	Survey
Breeding Hogs	-.498 (.807)	1.231 (.169)	-.616 (.163)	.72	3.69	1.57	3.23	3.17
Market Hogs	-.033 (.617)	1.322 (.141)	-.718 (.140)	.81	2.93	1.65	2.56	2.00

Note: Standard errors of the estimated coefficients are in parentheses.

[a]Adj R^2 = adjusted R^2; S.E. = standard error; D-W = Durbin-Watson d.

[b]RMSE = root mean square error.

[c]Autoregressive model

[d]Survey data

Table 5. Tests of the Significance of Anticipated Information On Live-Hog Futures Price Changes One Day After Report Releases.[a]

Time Horizon	Coefficient Estimates					Likelihood Ratio Test; $H_0:\beta_3=\beta_4=0$
	β_0	β_1	β_2	β_3	β_4	Chi-SQ(2)
1	1.322 (.884)	-.357 (.373)	-1.284* (.657)	.256 (.228)	-.265 (.240)	1.267
2	.953 (1.352)	-1.059* (.602)	-1.153 (.802)	.210 (.267)	-.211 (.296)	.620
3	.735 (1.264)	-1.501** (.578)	-.630 (.747)	.114 (.261)	-.101 (.296)	.218
4	.506 (.755)	-1.407** (.427)	-.328 (.504)	-.039 (.189)	.048 (.206)	.053
5	1.255* (.750)	-.791* (.362)	-.582 (.436)	.033 (.176)	-.016 (.187)	.078

Note: Standard errors of the estimated coefficients appear in parentheses.

[a]One and two asterisks represent significance at the 5% and 1% levels respectively. One sided t-tests are performed for coefficient estimates β_1 and β_2.

Table 6. Response of Live-Hog Futures Prices to Unanticipated Information One, Two, Three and Four Days After Report Releases.[a]

	Coefficient Estimates for One-Day and Cumulative Two, Three and Four-Day Models											
	One-Day Price Changes			Cumulative Two-Day Price Changes			Cumulative Three-Day Price changes			Cumulative Four-Day Price Changes		
Time Horizon	β_0	β_1	β_2	β_0	β_1	β_2	β_0	β_1	β_2	β_0	β_1	β_2
1	.983	-.562*	-.903*	1.216	-.564*	-.968**	1.216	-.532*	-.884*	.917	-.562	-.843
	(.776)	(.320)	(.475)	(.706)	(.281)	(.391)	(.781)	(.307)	(.429)	(.926)	(.421)	(.513)
2	.631	-1.241*	-.819	1.457	-.817**	-1.114*	.979	-.768**	-.998*	.954	-.750*	-1.170*
	(1.335)	(.669)	(.774)	(.917)	(.340)	(.621)	(.762)	(.282)	(.466)	(1.033)	(.446)	(.599)
3	.575	-1.577**	-.473	1.049	-.996**	-.592	.915	-1.068**	-.563	.466	-1.023**	-.648*
	(1.133)	(.572)	(.674)	(.551)	(.296)	(.373)	(.586)	(.265)	(.359)	(.654)	(.298)	(.349)
4	.623	-1.489**	-.436	.955*	-.948**	-.501	1.382**	-.801**	-.713**	1.139*	-.859**	-.761**
	(.818)	(.427)	(.434)	(.460)	(.250)	(.333)	(.456)	(.226)	(.299)	(.492)	(.205)	(.274)
5	1.211	-.796**	-.560	.617**	-.662**	-.407	1.741**	-.639**	-.529*	1.513**	-.626*	-.608*
	(.650)	(.319)	(.342)	(.409)	(.191)	(.286)	(.486)	(.192)	(.306)	(.525)	(.295)	(.309)

Note: Standard errors of the estimated coefficients appear in parentheses.

[a]One and two asterisks represent significance at the 5% and 1% levels, respectively. One sided t-tests are performed for coefficient estimates β_1 and β_2.

Table 7. Likelihood Ratio Tests of the Response of Live Hog Futures Prices to Unanticipated Information.[a]

Time-Horizon	$H_0:\beta_1,\beta 2$ (Day 1)=0	$H_0:\beta_1,\beta_2$(Day 2)= β_1,β_2(Day 1)	$H_0:\beta_1,\beta_2$(Day 3)= β_1,β_2(Day 2)	$H_0:\beta_1,\beta_2$(Day 4)= β_1,β_2(Day 3)
	Chi-Square(2)	Chi-Square(2)	Chi-Square(2)	Chi-Square(2)
1	13.783**	2.334	4.979	1.984
2	11.414**	.323	2.841	.475
3	14.161**	5.261	4.924	4.263
4	15.889**	7.364*	6.623*	1.213
5	11.961**	.335	3.912	.480

Note: One and two asterisks represents significance at the 5% and 1% levels, respectively.

[a]For the day-one models, likelihood ratio tests are performed to determine if β_1 and $_2$ are jointly different from zero at significant levels. For the cumulative two, three and four-day models, likelihood ratio tests are performed to determine if β_1 and β_2 are jointly different from estimated parameter values from one-day and cumulative two and three-day models, respectively.