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USDA Hogs and Pigs Reports: Futures Prices, Information, and Forecasting

by

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USDA Hogs and Pigs Reports: Futures Prices, Information, and Forecasting

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Following the release of the quarterly USDA Hogs and Pigs reports (HPRs), Chicago Mercantile Exchange (CME) live hog futures prices usually move at least one cent the following trading day and more than 50% of the time at least one contract moves to the trading limit (see Table 1). The objectives of this paper are: first, to identify critical variables in the report that cause this price movement; second, to examine the informational content of the futures prices relative to the information in the HPRs; and, third, to forecast variables in the report within a state space framework.

The HPR[1] is a major source of information for live hog producers and futures traders. Released in March, June, September, and December[2], the report contains estimates of breeding herd inventories, market hogs and pigs inventories by weight, pig crop, pigs per litter, sows farrowing, and first and second sows farrowing intentions. Presently, ten hog producing states are reported each quarter. These states account for about 85% of total hogs produced and slaughtered in the United States. The HPR contains three types of numbers: first estimates, revisions, and intentions. In this paper we shall only be concerned with first estimates and intentions.

When the reports are released, all seven futures contracts usually move in the same direction but not necessarily by the same amount. First, referring to Table 1, we see that for those futures contracts closest to the release date of the HPRs, four out of seven had on average at least 40% limit moves after the release of the HPRs (*e.g.*, the February contract price movement following the December HPR averaged the "limit" 40% of the time). Considering that once hogs are over 60 lbs. the supply in the delivery month can be estimated without much error (*e.g.*, using biological coefficients such as average daily weight gain) these limit moves are somewhat puzzling. The limit moves on the contracts furthest from the delivery month also are puzzling in that there is enough time for producers to change their farrowing plans before the delivery month. We would expect the HPRs to have the greatest impact on those "intermediate" futures contracts maturing approximately 6-8 months after the release of the HPR.

Turning to Table 2, we see that out of the sixty reports studied, 73% of the releases resulted in all futures contracts moving in the same direction. In attempting to explain price movement caused by the release of the report, it appears that direction of price change is not determined by the distance of the HPR from the delivery month.

In examining the movement of futures prices following the release of the report, past studies have looked at "new information" revealed by the report. Miller, Hoffman, and Hudson, *et al.*, examine this question, but from different perspectives. Examining the release of 36 HPRs (from

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[1]Before June 1968, the report was called the Pig Crop Report.

[2]Beginning with the January 6, 1989 report, the fourth quarter report is released in January.

Table 1. Futures Price Movement Day After Release of Hogs and Pigs Reports: 1971-85

(Reports are organized starting from nearest to furthest from delivery month)

Contract	Date of Hogs & Pigs Report	% limit moves	% moves ≥ 1 cent[a]	% moves positive	% moves negative[b]
Feb	Dec	40	60	60	40
Feb	Sep	47	60	33	67
Feb	Jun	53	80	73	27
Feb	Mar	60	67	53	47
Apr	Mar	47	47	40	60
Apr	Dec	40	60	60	40
Apr	Sep	53	67	27	73
Apr	Jun	40	87	67	33
Jun	Mar	47	53	40	60
Jun	Dec	40	60	60	40
Jun	Sep	40	60	27	73
Jun[c]	Jun	53	67	50	42
Jul	Jun	27	33	73	80
Jul	Mar	53	67	47	33
Jul	Dec	47	60	60	53
Jul	Sep	40	60	20	20
Aug	Jun	33	53	73	27
Aug	Mar	53	67	53	47
Aug	Dec	47	67	53	47
Aug	Sep	47	60	27	67
Oct	Sep	20	53	40	60
Oct	Jun	33	67	73	27
Oct	Mar	67	69	47	53
Oct	Dec	53	60	53	47
Dec	Sep	40	60	33	67
Dec	Jun	40	69	73	27
Dec	Mar	60	67	47	53
Dec[d]	Dec	40	60	53	47

[a]Includes limit moves.

[b]Note: The positive and negative moves may not sum to 100% because of days when the price did not change.

[c]June contract for the year following the release of the June report.

[d]December contract for the year following the release of the December report.

Table 2. Release of Hogs and Pigs Reports: 1971-1985. Summary of Effects on Futures Price Movement

(Percentage of Contracts that move in a positive or negative direction)

HPR Report	% moves positive	% moves negative	HPR Report	% moves positive	% moves negative
Mar 71	43	57	Mar 78	100	0
Jun 71	0	100	Jun 78	100	0
Sep 71	86	14	Sep 78	100	0
Dec 71	100	0	Dec 78	0	100
Mar 72	100	0	Mar 79	0	100
Jun 72[a]	86	0	Jun 79	100	0
Sep 72	100	0	Sep 79	0	100
Dec 72	100	0	Dec 79	71	29
Mar 73	0	100	Mar 80	0	100
Jun 73	100	0	Jun 80	100	0
Sep 73	0	100	Sep 80	0	100
Dec 73	0	100	Dec 80	0	100
Mar 74	0	100	Mar 81	100	0
Jun 74[a]	86	0	Jun 81[b]	71	0
Sep 74	57	43	Sep 81	0	100
Dec 74	100	0	Dec 81	100	0
Mar 75	100	0	Mar 82	100	0
Jun 75	86	14	Jun 82	100	0
Sep 75	71	29	Sep 82	100	0
Dec 75[b]	0	86	Dec 82	100	0
Mar 76	100	0	Mar 83	0	100
Jun 76	86	14	Jun 83	0	100
Sep 76	0	100	Sep 83	14	86
Dec 76	100	0	Dec 83	29	71
Mar 77	0	100	Mar 84	100	0
June 77[a]	86	0	June 84	0	100
Sep 77	100	0	Sep 84	0	100
Dec 77	100	0	Dec 84	100	0
			Mar 85	57	43
			Jun 85	14	86
			Sep 85[a]	14	71
			Dec 85	100	0

[a]June contract price not available.

[b]At least one contract did not change price.

September 1970 through June 1978), Miller found that the new information in the reports affected both nearby and distant futures. "New information" was defined for nearby contracts as the difference between sows farrowing second intentions and first estimates, and for distant contracts as the difference between first intentions and second intentions. Hoffman examined the effect of 37 quarterly HPR releases (between March 1970 and March 1979) on nearby and distant futures contracts. Running regressions of the form:

$$P_a - P_b = a + b \% \Delta Q + e$$

where P_a = price after the report (average of first five days after report), P_b = price before report (average of day of report and four days before), and $\% \Delta Q$ = the percentage change from a year earlier in a quantity variable reported in the HPR. Hoffman found no significant coefficients on HPR quantities for either nearby or distant futures prices. For quantities, he used total inventory, sows farrowing, sows farrowing-second intentions, and hogs by weight categories. Hudson, Koontz, and Purcell examined the impact of the release of the HPRs (March 1974 through December 1982) on the futures market. They found some evidence that futures price changes around the report were influenced by information in the reports. However, they found little evidence of market inefficiency when examining the mean of 38 different price changes around the report.

There is also the question of the accuracy of the information revealed in the reports. Among the studies that have examined the accuracy of the HPRs are Blanton, *et al.*, and Meyer and Lawrence. These studies have found that the HPR numbers are not consistent with slaughter figures. The implications of these studies is that futures traders should make adjustments to the reports when using them as a basis for a trading strategy. It also implies that any forecasting of the HPR variables should explicitly deal with the errors in the variables.

We shall build on these studies by examining the following questions. First, does the futures market react to all categories in the HPR? That is to say, are contracts affected by HPR categories that do not affect the supply of live hogs in the relevant delivery month? For instance, hogs resulting from an increase in the pig crop will not be going to market during the period represented by nearby contract months. Given the non-storability of live hogs, if it can be demonstrated that pig crop numbers affect nearby futures, then the market is inefficient. Second, we shall examine the effect of the HPRs on the ability of the futures price around the reports to predict the futures price in the delivery month of the contract. Third, we shall forecast HPR variables using a time-series method that allows for errors in the variables.

Data

We collected data from the USDA Hogs and Pigs and Pig Crop reports for the period from 1966 to 1987. Within this period, the USDA has changed the states that it surveys. Until March 1973, the USDA surveyed the following ten states: (A) Illinois, Indiana, Iowa, Kansas, Minnesota, Missouri, Nebraska, Ohio; (B) South Dakota, and Wisconsin. From March 1973 to March 1982, the USDA surveyed the original 10 states plus: (C) Georgia, Kentucky, North Carolina, and Texas. Beginning with June 1982, the USDA reduced its coverage to ten states: the eight listed in (A) plus two in (C): Georgia and North Carolina. In order to have a continuous series from the 1966 to 1987, we have constructed series based upon totals of the eight states listed in (A). Construction of the series was accomplished by entering individual state numbers into a computerized spreadsheet and then calculating the 8 state totals within the spreadsheet.

Until December 1978 report, there was a market herd category of 180-219 lbs. and a category of 220 lbs. and over. Beginning with the December 1978 report, these were combined into a market herd category of 180 lbs. and over. In order to have a continuous series, we have created a

180 lbs. and over category for the reports before the change. Construction of the series was accomplished from the spreadsheet described above.

Trading of live hogs futures contracts on the Chicago Mercantile Exchange opened on February 28, 1966. As shown in Table 3, the early years of live hog contracts were marked with contracts of various months. Starting in 1969, the market settled with seven contracts: February, April, June, July, August, October, and December.

Table 3. Delivery Date of Live Hog Contracts, 1966-1986

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1966					X	X	X	X	X	X		
1967		X		X		X	X	X	X	X	X	X
1968	X	X	X	X	X	X	X	X	X	X	X	X
1969 to 1986		X		X		X	X	X		X		X

In analyzing the contracts, we have organized them into three series (nearby, intermediate, and distant) related to the release of the HPRs as suggested by Hudson, Koontz, and Purcell. Table 4 shows the relationship between the reports and the three time categories.

Table 4. Construction of Futures Contract Series

HPR Report	Futures Contract Nearby	Intermediate	Distant
March	June	October	December
June	August	December	April
September	December	April	June
December	February	June	October

Given the varying starting dates in the earlier years of the contracts and the change in federal live hog standards, we decided to begin our series with the February 1972 contracts and 1971 reports. Futures data used for this study was kindly provided by The Center for the Study of Futures Markets[3], the Commodity Futures Trading Commission, and the Chicago Mercantile Exchange.

[3]Graduate School of Business, Columbia University, New York.

Results

A. Impact of the Separate HPR Components

We start with the specification

$$P_a - P_b = a + b\ \%\ \Delta\ Q + e,$$

where, P_a is the futures contract price the day after the release of the report, P_b is the futures contract price the day of the release of the report, $\%\ \Delta\ Q$ is the percentage change from a year earlier in a quantity variable reported in the HPR. Since there are both upper and lower limits to futures price movements, this suggests a two-limit tobit model as suggested by Maddala (pp. 160-161). Letting $y_i = P_a - P_b$, our model becomes

$$y_i^* = a + b\ \%\ \Delta\ Q + e$$

where y_i^* is the latent variable and y_i is our observed dependent variable such that

$$\begin{aligned} y_i &= -1.50 && \text{if } y_i^* \leq -1.50 \\ &= y_i^* && \text{if } -1.50 < y_i^* < 1.50 \\ &= 1.50 && \text{if } y_i^* \geq 1.50 \end{aligned}$$

Results for nearby, intermediate, and distant futures contracts are presented in Table 5. Using a two-tailed t-test with a 95% confidence level, we find that for nearby contracts we do not reject as insignificant the coefficients for breeding herd, market herd under 60 lbs., and pig crop when used as explanatory variables in separate regressions. The negative sign on the coefficients indicates increases in supply will decrease price. The other HPR variables (market herd weights: 60-119 lbs., 120-179 lbs., 180 lbs. and over; pigs per litter, sows farrowing, sows farrowing: first and second intentions; percentage change from (a) second intentions to first intentions, (b) first intentions to sows farrowing) were rejected with a 95% confidence level in separate regressions. These insignificant results are not reported in Table 5 due to space limitations. For intermediate contracts we ran the same tests and found as statistically significant the coefficients for the three variables above plus two additional: sows farrowing and first intentions of sows farrowing. From a biological and economic standpoint, these variables (except for first intentions) make sense. For distant contracts, the same results held as with intermediate contracts, except that second intentions were also significant. We would expect the distant contracts to be affected primarily by first intentions. Overall, we find the breeding herd, market herd under 60 lbs. and pig crop to be variables affecting all three categories: nearby, distant, and intermediate contracts.

The reaction of nearby contracts to breeding herd, market herd under 60 lbs., and pig crop information is surprising because hogs in these categories will be marketed after the expiration of the nearby contracts. A priori we expected the HPRs to have no discernible impact on the nearby futures prices because, as stated earlier, once one has the under 60 lb. numbers, the larger weight categories (which will be marketed in the nearby delivery month) are easier to predict. However, if any component of the HPR is to affect nearby contracts, we expect it would be the larger weight categories. The coefficients on the larger weight categories, though, were rejected as insignificant. This indicates these categories did not contain enough new information to cause price movement. Recall from Table 2 the observation that all contracts generally move in the same direction. The results for nearby contracts indicate that futures traders react to news in the HPRs regardless of its effects on the marketable supply of hogs in the nearby delivery month.

Table 5. Tobit Results: Impact of Hogs and Pigs Reports on Futures Prices

Dependent Variable Futures Price[a]	Explanatory Variable HPR Category[b]	Intercept	Coefficient	Log-Likelihood
Nearby	Breeding Herd	-0.0452 (-0.184)	-6.4737 (-2.272)	-97.391
Nearby	Mkt Herd Under 60 lbs.	-0.1279 (-0.529)	-5.7748 (-2.209)	-97.565
Nearby	Pig Crop	-0.1575 (-0.649)	-4.8957 (-2.004)	-97.996
Intermediate	Breeding Herd	-0.0507 (-0.166)	-9.0326 (-2.513)	-94.798
Intermediate	Mkt Herd Under 60 lbs.	-0.1741 (-0.581)	-8.2636 (-2.591)	-94.839
Intermediate	Pig Crop	-0.2099 (-0.697)	-7.3145 (-2.395)	-95.155
Intermediate	Sows Farrowing	-0.1822 (-0.605)	-7.1749 (-2.369)	-95.227
Intermediate	Sows Farrowing: 1st Intentions	-0.2134 (-0.698)	-6.1289 (-2.233)	-95.497
Distant	Breeding Herd	-0.0967 (-0.327)	-10.0739 (-2.817)	-84.790
Distant	Mkt Herd Under 60 lbs.	-0.1916 (-0.642)	-8.4192 (-2.604)	-85.440
Distant	Pig Crop	-0.2376 (-0.791)	-7.7053 (-2.538)	-85.611
Distant	Sows Farrowing	-0.2056 (-0.682)	-7.3011 (-2.390)	-85.995
Distant	Sows Farrowing: 2nd Intentions	-0.2154 (-0.708)	-7.2129 (-2.317)	-86.147
Distant	Sows Farrowing: 1st Intentions	-0.2407 (-0.800)	-6.7627 (-2.528)	-85.638

[a]Difference in price between the day of the release of the Hogs and Pigs report and day after release.

[b]Percentage difference between variable in HPR four quarters ago and current HPR - 8 state totals.

Note: Tobit Limits are –1.50 and 1.50. HPR categories are totals of 8 states: Illinois, Indiana, Iowa, Kansas, Minnesota, Missouri, Nebraska, and Ohio. Prices are cents per lb., other units are as listed in reports. T-statistics in parentheses. Estimation periods: Nearby: 1971.1-1986.2, Intermediate: 1971.1-1986.2, Distant = 1972.2-1986.2.

B. Informational Content of HPRs

The second question studied was: How well do futures prices around the reports predict the futures price in the delivery month?

We used the following specification:

$$FP_d = a + bFP_{t+j} + e \quad \text{for } j = -2, -1, 1, 2,$$

where FP_d is the average of the first 5 days in the delivery month,

FP_{t-2} is the average of days five through nine before the release of the report,

FP_{t-1} is the average of the day of the release of the report and four days prior,

FP_{t+1} is the average of first five days following the report,

FP_{t+2} is the average of days six through ten following the report.

As before, we divided up the contracts into nearby, intermediate, and distant contracts.

The results are presented in Table 6. For nearby futures, as we go from two weeks before the release of the report to two weeks after the release, we obtain a higher R^2. This suggests that perhaps both time and the reports themselves influence the informational content of futures prices. Elam and Dixon, however, warn against the use of F-tests with small samples. For intermediate futures, the same pattern is seen as in the nearby contracts. For distant futures, neither time nor the reports seemed to improve the fit between the futures price around the report and the futures price in the delivery month. Further empirical work is required to separate out the influence of time, the HPRs on the informational content of futures, and small sample bias, before a more definitive conclusion can be made regarding the informational content of the HPRs.

C. State Space Estimation of Market Herd Under 60 lbs.

In this section we forecast market herd under 60 lbs. - an HPR component found to be significant in explaining futures price movement following the release of the HPRs. We used a state space framework of the following form:

(1) $x_{t+1} = Fx_t + Gu_{t+1} + Kw_t$ (state equation)

(2) $y_t = Ax_t + w_t$ (observation equation)

where y_t is an $r \times 1$ vector of observed values (adjusted to have zero-mean) found in the HPRs, x_t is a $p \times 1$ state vector of unobserved values, w_t is a $r \times 1$ vector of error terms, A is a $r \times p$ design matrix, F is a $p \times p$ transition matrix, G is a $p \times q$ exogenous effects matrix, u_{t+1} is a $q \times 1$ zero-mean vector of exogenous variables, and K is $p \times r$ Kalman filter. The state vector can be thought of as the underlying values such that if there were no errors we would directly observe the process. The system is driven by a first-order Markos process, *i.e.*, the immediate past contains all the information necessary to forecast the future. Using the information from $t - 1$, our forcast of y_t is

(3) $y_{t|t-1} = Ax_t$.

Table 6. Futures Prices Surrounding Hogs and Pigs Reports as Predictors of Futures Prices in Delivery Month

Dependent Variable Futures Price[a]	Explanatory Variable Futures Price around Report	Intercept	Coefficient	R^2	Adj R^2
Nearby	2 weeks before	9.486 (3.055)	0.802 (11.400)	0.69	0.68
Nearby	1 week before	7.452 (2.908)	0.848 (12.877)	0.74	0.73
Nearby	1 week after	5.579 (2.237)	0.888 (15.789)	0.81	0.80
Nearby	2 weeks after	4.587 (1.960)	0.908 (17.253)	0.83	0.83
Intermediate	2 weeks before	14.821 (3.426)	0.6658 (6.546)	0.42	0.41
Intermediate	1 week before	14.113 (3.294)	0.6815 (6.778)	0.44	0.43
Intermediate	1 week after	11.320 (2.870)	0.7449 (8.089)	0.53	0.52
Intermediate	2 weeks after	12.225 (3.065)	0.721 (7.771)	0.51	0.50
Distant	2 weeks before	18.044 (3.106)	0.5961 (4.523)	0.27	0.26
Distant	1 week before	19.368 (3.225)	0.5652 (4.150)	0.24	0.23
Distant	1 week after	19.247 (3.070)	0.5639 (3.992)	0.23	0.21
Distant	2 weeks after	20.313 (3.251)	0.5384 (3.834)	0.21	0.20

[a]Prices are average of first days in delivery month.
Estimation period: Nearby = 1971.1-1985.4, Intermediate = 1971.1-1985.4, Distant = 1972.1-1985.4.

Rewriting equation (2) we have

(4) $y_t = y_{t|t-1} + w_t,$

so that w_t can be seen as the vector of step-ahead forecast errors. The Kalman gain matrix minimizes the length of the forecast error vector.

An overview of state space applications is found in several sources including Shumway (1988), Mehra and Harvey. Havenner and Aoki also use state space models. Dempster, Laird, and Rubin describe how to estimate the model. Other descriptions are found in Shumway (1983), Watson, and Kalman. Identification in state space form has the advantage over Box-Jenkins methods in that complicated ARMA structures are easier to express. State space forms can be put into ARMA forms, however, such a conversion means that after parameters have been estimated, an additional computational step must be used in converting from one form to another. Note that state space forms are not unique.

The model was estimated by modifying the program in Shumway (1988). We used second intentions of sows farrowing, lagged once, as an exogenous variable in the system. If we had used any HPR variable as a contemporary exogenous variable, then we would have had to "predict" it as well. Our exogenous variable does not need forecasting. Because of seasonality and nonstationarity of the series, several transformations were performed. A log transformation was performed on both the market herd under 60 lbs. (MHU60) and second intentions of sows farrowing (SF-2I). SF-2I was also differenced once. In addition, both the MHU60 and SF-2I were deseasonalized using an ARMA method as outlined in Shumway (1988). Our results are in Table 7.

Table 7. State Space Estimation of Market Herd - Under 60 lbs.[a] Out of Sample Forecasts.

Estimation Period	Forecast Period	Actual Number Minus Forecast	Actual Number Minus Forecast (% herdsize)	Actual Increase or Decrease of Herd from Previous Qtr.	Forecasted Increase or Decrease of Herd from Previous Qtr.
1966.1-1984.1	1984.2	-56	0.40	+	+
1966.1-1984.2	1984.3	-482	3.56	–	–
1966.1-1984.3	1984.4	-44	0.33	–	–
1966.1-1984.4	1985.1	+44	0.39	–	–
1966.1-1985.1	1985.2	+128	0.92	+	+
1966.1-1985.2	1985.3	+133	1.00	–	–
1966.1-1985.3	1985.4	+721	5.81	–	–

[a]Market Herd under 60 lbs. is the total of the following 8 states:
Illinois, Indiana, Iowa, Kansas, Minnesota, Missouri, Nebraska, Ohio. Units are in 1000 Head.

For the period from 1966.2 to 1985.3 we obtained the following

$$x_{t+1} = 0.7502x_t + 0.3845u_t + 0.5711w_t$$

$$y_t = 1.000x_t + w_t$$

with an adjusted R^2 of 0.85. Since we are interested in forecasting, we truncated the series and performed one-quarter ahead forecasts. Each forecast was made only with the information available at the time. Our primary objective was to forecast whether the herd increased or decreased in size. We succeeded in this goal. Our second objective was to forecast the size of the herd. Two of the seven forecasts had errors greater than 1%. Five forecasts had errors less than or equal to 1%.

Summary and Conclusions

The trading day following the quarterly USDA Hogs and Pigs reports are released, the CME live hog futures prices move to the limit over 50% of the time. In addition, all contracts will tend to move in the same direction. Breeding herd, market herd under 60 pounds, and pig crop were found to be significant explanatory variables for this price movement. These results were a surprise because *a priori* we expected the HPRs to have a greater influence on futures prices 6 to 8 months away compared to either nearby or distant futures contracts.

Futures prices surrounding the reports for nearby, intermediate, and distant futures contracts were found to have mixed results as a predictor of the futures price in the delivery month. For nearby futures, the closer the week was to the delivery month, the better the explanatory power of the futures prices. Intermediate futures had similar results, but the fit was not as good. The forecasting accuracy of distant futures was found to be unaffected by the HPRs or the passage of a four week interval around the reports. These results suggest that both the passage of time and the HPRs themselves impact on the informational content of the futures prices. However, these results may be due to small sample bias.

Finally, state space modeling of the market herd under 60 lbs. was successful. For out-of-sample one-period ahead forecasts of June 1984 through December 1985, we were able to accurately forecast the direction of the herd size. Five out of the seven forecasts had forecast errors less than or equal to 1%.

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