THE FORECASTING PERFORMANCE OF LIVESTOCK FUTURES PRICES: A COMPARISON TO USDA EXPERT PREDICTIONS

SCOTT H. IRWIN
MARY E. GERLOW
TE-RU LIU

The forecasting performance of livestock futures prices is a subject of considerable interest. A number of studies compare the accuracy of livestock futures prices and time-series models and/or econometric models in forecasting spot livestock prices [e.g., Leuthold and Hartmann

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- *Scott H. Irwin is a Visiting Scholar, Office for Futures and Options Research and Department of Agricultural Economics, University of Illinois at Urbana-Champaign and Associate Professor, Department of Agricultural Economics and Rural Sociology, The Ohio State University.*
- *Mary E. Gerlow is a Former Assistant Professor, Department of Agricultural Economics and Rural Sociology, The Ohio State University.*
- *Te-Ru Liu is a Former Graduate Research Assistant, Department of Agricultural Economics and Rural Sociology, The Ohio State University.*

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(1979); Koppenhaver, (1983); Shonkwiler (1986); Leuthold, Garcia, Adam, and Park (1989)]. Many studies find that livestock futures prices (live hogs and live cattle) perform poorly relative to ex post model forecasts, and hence, pricing efficiency is rejected.[1] Public policy concerns have been raised regarding the supposedly poor forecasting performance in these markets [e.g., Helmuth (1981)].

Given the efficiency implications of previous forecast comparison studies, a relevant issue is whether alternative comparisons yield similar results. One alternative is to compare the accuracy of livestock futures prices and expert predictions. This approach is appealing, in that ex ante futures prices are compared to ex ante forecasts, rather than ex post forecasts.[2] Note that expert predictions are based on the judgement of an analyst or group of analysts. Such predictions may be based entirely on expertise in a market, or they may incorporate information from a variety of sources, including time-series and econometric models [Brandt and Bessler (1983)].

Several studies compare the forecasting performance of livestock futures prices and ex ante expert predictions [e.g., Marquardt (1979); Moe (1985); Aldinger (1986); Irwin and Gerlow (1989); Bessler and Brandt (1992)]. Predictions in these studies are generated by experts employed in the public and private sectors. Interestingly, researchers generally find that the forecasting performance of livestock futures prices is equivalent to the performance of expert predictions, and hence, pricing efficiency is *not* rejected. This is markedly different than the outcome of studies based on ex post model forecasts.

While several studies compare the accuracy of forecasting livestock prices through the use of futures versus the predictions of experts, there are a number of reasons to consider further research. First, several of the expert studies are based on small samples. Monte Carlo analysis indicates that accuracy comparisons may be highly spurious in small samples [Williams (1993)]. In addition, small sample problems may be exacerbated by idiosyncratic events, especially those occurring during the mid-1970s. Second, several of the expert studies do not conduct formal statistical tests of the significance of differences in forecast accuracy. Third, some studies make basis adjustments to futures prices,

[1]Several authors point out that relative forecasting accuracy is a necessary, but not sufficient, condition for pricing efficiency [e.g. Garcia, Leuthold, Fortenbery, and Sarassoro (1988); Leuthold, Garcia, Adam, and Park (1989)].

[2]The ex ante classification of expert forecasts does assume knowledge of the dating of forecasts. If the release date of expert forecasts is unknown, then the expert forecasts cannot be matched to the corresponding futures price.

while other do not. The sensitivity of results to basis assumptions has not been investigated.

This study compares the forecasting accuracy of live hog and live cattle futures prices to U.S. Department of Agriculture (USDA) expert predictions. The USDA devotes considerable resources to preparing the predictions.[3,4] Hence, the predictions should provide a useful benchmark for assessing the forecasting performance of futures markets. The USDA hog and cattle price forecasts are quantitative and subject to little, if any, interpretation; and, the forecasts are issued at regular intervals, which facilitates comparison with futures prices.

The sample period is the 12-year period beginning in the first quarter of 1980 and ending with the fourth quarter of 1991. This provides a sufficient number of observations to conduct valid statistical tests [Williams (1993)], but avoids the idiosyncratic period of the mid-1970s. A test developed by Ashley, Granger, and Schmalensee (1980) is used to assess the significance of differences in forecasting performance. Both basis-adjusted and unadjusted futures prices are considered in the analysis.

DATA

USDA quarterly price forecasts for hogs and cattle are obtained from various issues of the *Livestock and Meat Situation Report*. Data are collected over the 12-year period 1980:I–1991:IV. It should be noted that the USDA did not report forecasts for all 48 quarters of the sample period. Three one-quarter ahead forecasts for both hogs and cattle are unavailable. Fourteen and thirteen two-quarter ahead forecasts for hogs and cattle, respectively, are not available.

All USDA forecasts are reported on a calendar quarter basis (e.g., first quarter: January, February, March). The price forecasts are quarterly average prices for Barrows & Gilts (7-market weighted price) and 900–1100 lb. Choice Steers (Omaha). Point estimates are generated as the mean of the reported forecast range.[5] The actual quarterly average

[3]In 1990, situation and outlook activities in the Economic Research Service of the USDA had a budget allocation estimated in the range of $10–11 million [O'Brian (1990)].

[4]Surls and Gajewski (1990) offer the following justification for USDA situation and outlook programs: (a) the USDA is uniquely situated to gather information on domestic and international commodity markets due to its large network of agricultural experts in the U.S. and throughout the world; (b) if all forecasting is left to private firms, then small market players may not have access to forecasts; (c) USDA forecasts are used as a benchmark by most private forecasters; and (d) USDA forecasts are used for planning by government and private decision makers.

[5]This calculation is based on the assumption that forecast prices within the forecast range follow a symmetric distribution.

cash prices corresponding to the USDA forecasts also are obtained from the *Livestock and Meat Situation Report*.

On the same day that the USDA report is issued, the closing futures price for the appropriate contract is found. These prices are obtained from various issues of the *Chicago Mercantile Exchange Statistical Annual* and *The Wall Street Journal*. Using the same procedure as Bessler and Brandt (1992), the live hog and live cattle futures price "forecast" for the first quarter is the price of the respective February contract; for the second quarter the average of prices of the respective April and June contracts; for the third quarter the price of the respective August contract; and for the fourth quarter the average of the prices of the respective October and December contracts.

A basis estimate is generated for each futures price. In the case of cattle, the daily difference between the price of the live cattle futures contract nearest to maturity (nearby contract) and the Omaha price of cattle is calculated for the period 1977:I–1990:IV. Then, the daily basis (futures–cash) is averaged for each quarter. Following the procedure in Leuthold, Garcia, Adam, and Park (1989), a three-year historical moving average of the quarterly nearby cattle basis is subtracted from the live cattle futures prices. For example, if the forecast quarter is 1980:I, then the basis adjustment is calculated as the average of the nearby basis in 1977:I, 1978:I, and 1979:I.

The same procedure is followed for making the basis adjustment to live hog futures prices, with one exception. Since the 7-market average hog price is only available weekly, the basis in the first step is calculated as the difference between the weekly average of the live hog futures contract nearest to maturity and the weekly 7-market hog price. Then, weekly basis is averaged for each quarter.

On average, the above procedures generate relatively small basis levels: $0.30 per cwt. for live cattle futures prices and $0.70 per cwt. for live hog futures prices. However, the range of basis estimates is substantial; $-5.11 to $+2.93 per cwt. for live cattle futures prices and $-5.20 to $+4.96 per cwt. for live hog futures prices.

EVALUATION OF FORECAST ACCURACY

Descriptive Analysis

Graphs of the futures and USDA forecast errors are presented in Figures 1–4. To conserve space, only basis-adjusted futures errors are

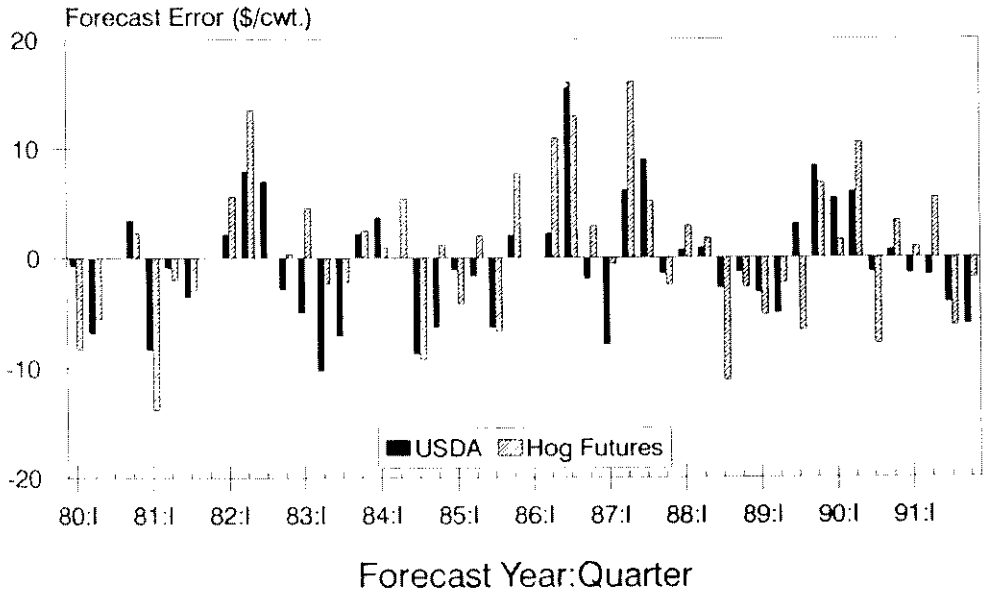

FIGURE 1
Hog price forecast errors, one-quarter ahead, 1980:I–1991:IV.
Note: Error = Actual − Forecast.

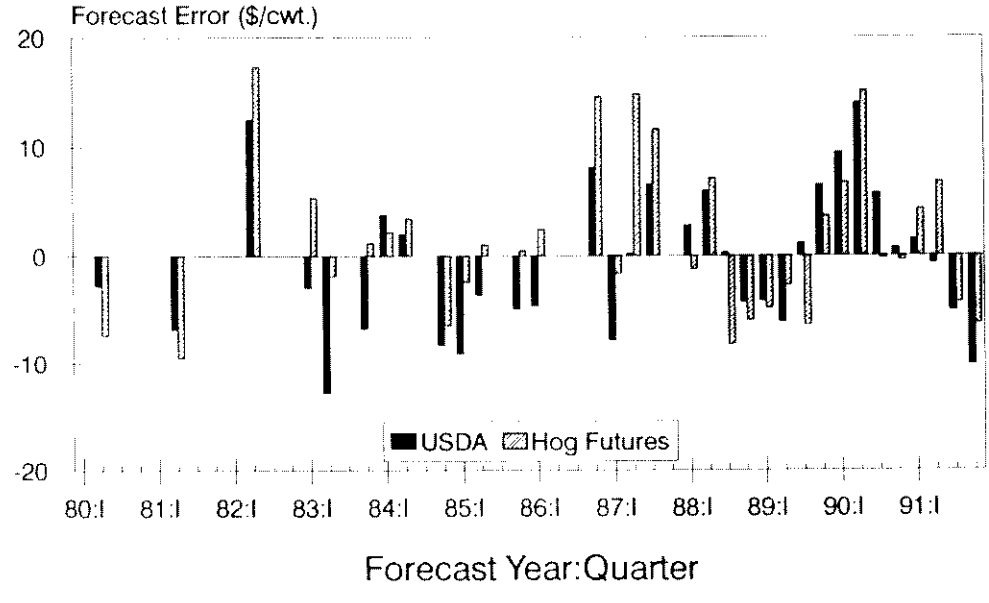

FIGURE 2
Hog price forecast errors, two-quarters ahead, 1980:I–1991:IV.
Note: Error = Actual − Forecast.

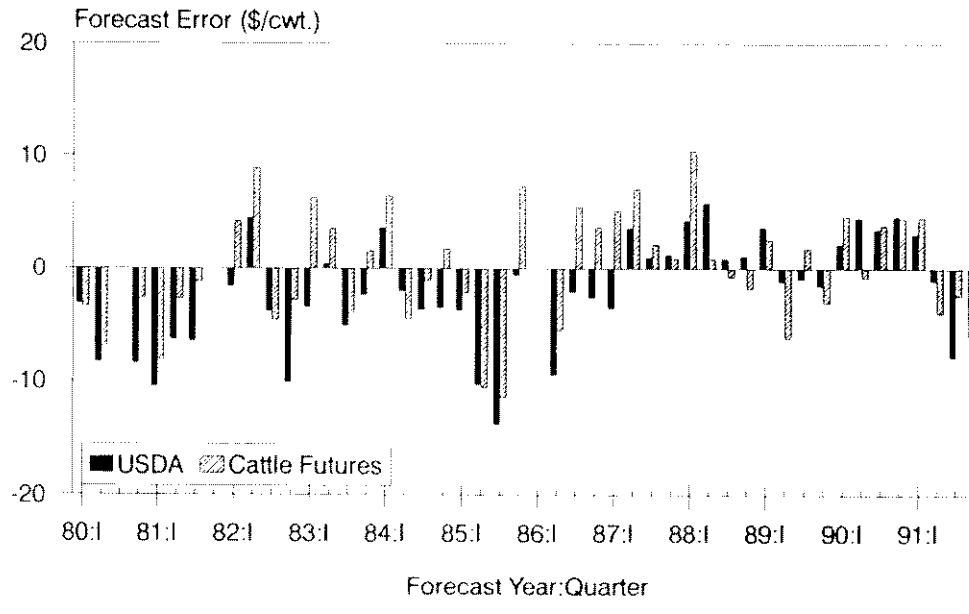

FIGURE 3
Cattle price forecast errors, one-quarter ahead, 1980:I–1991:IV.
Note: Error = Actual − Forecast.

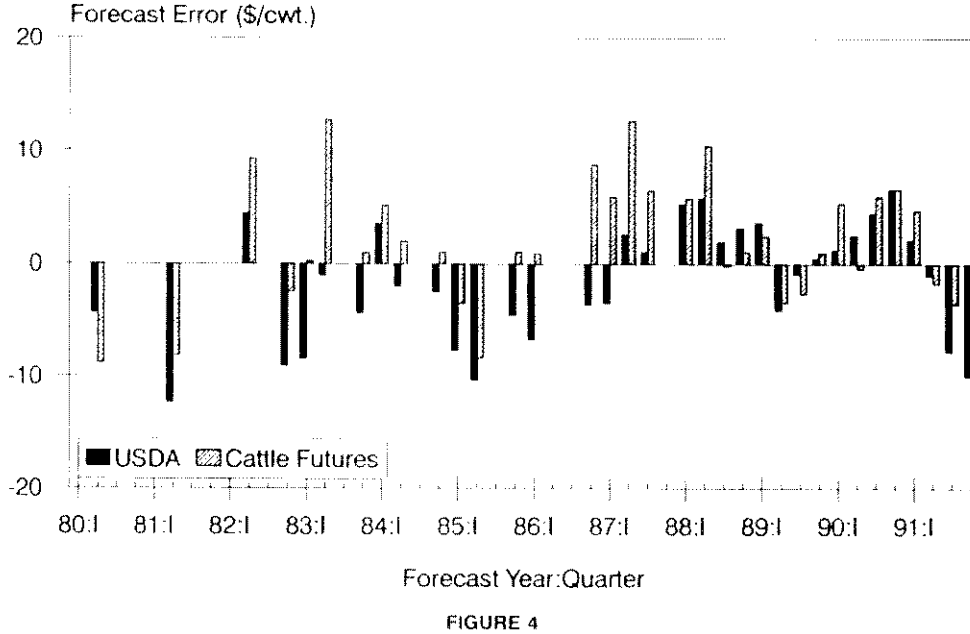

FIGURE 4
Cattle price forecast errors, two-quarters ahead, 1980:I–1991:IV.
Note: Error = Actual − Forecast.

presented. The errors associated with futures and USDA forecasts are computed by subtracting the forecast price from the actual price.

The graphs suggest several interesting observations.[6] First, the pattern of forecast errors in each graph appears to be quite similar for both series. This is borne out by the cross-correlations of basis-adjusted futures and USDA forecast errors, which range from 0.69 to 0.72. This is clear evidence that futures and USDA forecasts are not independent, an important point for assessing the significance of differences in forecasting accuracy. Second, the time-series behavior of the various series seems to indicate autoregressive components are present, whereby positive errors tend to be followed by positive errors and vice versa. However, statistical tests for autocorrelation confirm significant autoregressive behavior for only one of the eight graphed forecast error series.[7] USDA one-quarter ahead cattle price forecast errors have a significant autoregressive component, evident in a first-order autocorrelation coefficient of +0.51.

Descriptive accuracy statistics for all forecast series are presented in Table I. Mean error measures the bias in a forecast series. In general, the absolute level of bias is not large, although, it is generally smaller for hogs as compared to cattle. The largest bias is associated with USDA one-quarter ahead forecasts of cattle prices, which, in absolute terms, is over 3% of the average cattle price for the sample period.

One measure of absolute error (mean absolute error) and two measures of squared errors (root mean squared error and root mean squared percent error) also are presented in Table I. For one- and two-quarter ahead hog prices, these accuracy measures generally are highest for futures (basis-adjusted and unadjusted). The largest difference in accuracy between futures and USDA forecasts occurs at the one-quarter ahead horizon. Mixed results are indicated for cattle. For one-quarter ahead cattle prices, absolute and squared forecast errors are highest for the USDA. For two-quarter ahead cattle prices, absolute and squared forecast errors are highest for basis-adjusted futures, next highest for the USDA, and lowest for unadjusted futures. As with hogs, the largest difference in accuracy for cattle occurs at the one-quarter ahead horizon.

[6]These general observations also hold for unadjusted futures errors.

[7]The statistical tests are based upon Ljung–Box Q-statistics. Twelve autocorrelations are used in calculating each Q-statistic.

TABLE I

Descriptive Accuracy Statistics for Livestock Futures and USDA Expert Forecasts, 1980:I–1991:IV

Commodity/Horizon/Forecast	*ME* ($/cwt.)	*MAE* ($/cwt.)	*RMSE* ($/cwt.)	*RMSPE* (%)	N
Hogs					
One-quarter ahead					
Basis-adjusted futures	0.40	5.18	6.57	13.47	45
Unadjusted futures	0.36	4.30	5.78	12.11	45
USDA	0.47	4.35	5.46	11.09	45
Two-quarters ahead					
Basis-adjusted futures	1.34	5.55	7.26	14.39	33
Unadjusted futures	0.29	5.25	6.80	14.26	33
USDA	0.64	5.52	6.60	13.64	33
Cattle					
One-quarter ahead					
Basis-adjusted futures	0.12	4.22	5.01	7.97	45
Unadjusted futures	−0.11	3.69	4.45	7.11	45
USDA	−2.13	4.27	5.28	8.63	45
Two-quarters ahead					
Basis-adjusted futures	1.77	4.54	5.67	8.43	34
Unadjusted futures	1.41	4.31	5.38	8.02	34
USDA	−1.65	4.52	5.43	8.39	34

Note: ME is mean error, MAE is mean absolute error, RMSE is root mean squared error, and RMSPE is root mean squared percent error.

It is also interesting to compare the forecast accuracy statistics across the two futures series. In every case, the statistic for basis-adjusted futures is larger than the statistic for unadjusted futures.[8] This suggests the basis adjustment only adds noise to the underlying futures price, and may bias accuracy comparisons against futures.

As a final point, all of the absolute and squared error statistics are higher for hog price forecasts than for the corresponding cattle price forecasts. This tendency is particularly evident in the root mean squared percentage errors, which, on average, are over one-and-a-half times larger for hog price forecasts. Hence, hog prices are more difficult to forecast in this sample. This contrasts with Bessler and Brandt's (1992) finding that cattle prices are more difficult to forecast than hog prices.[9]

[8] Mean error comparisons are based on absolute values.

[9] Bessler and Brandt suggest that differences in information availability may explain their results, as the hog and cattle price forecasts in their sample are released on different dates. It is not likely that differences in information availability explain the finding in this study, as the hog and cattle forecasts are released on the same dates. Since different sample periods are considered in the two studies, the relative difficulty of forecasting hog and cattle prices may be sample specific.

Statistical Tests

A test developed by Ashley, Granger, and Schmalensee (1980) is used to assess the significance of differences in forecasting performance.[10] This test accounts for the cross-correlation found between futures and USDA forecast errors. The Ashley, Granger, and Schmalensee (AGS) test is based on a decomposition of the difference between the mean squared error (MSE) for futures and USDA forecasts. For a given commodity and forecast horizon, the decomposition is,

$$\text{MSE}(e_1) - \text{MSE}(e_2) = [\text{Var}(e_1) - \text{Var}(e_2)] + [\bar{e}_1^2 - \bar{e}_2^2] \qquad (1)$$

where e_1 is the vector of N forecast errors for futures, $e_1 = [e_{11}, e_{12}, \ldots, e_{1N}]$, e_2 is the vector of N forecast errors for the USDA, $e_2 = [e_{21}, e_{22}, \ldots, e_{2N}]$, $\text{Var}(e_1)$ is the variance of forecast errors for futures, $\text{Var}(e_2)$ is the variance of forecast errors for the USDA, $\bar{e}_1$ is the mean forecast error for futures, and $\bar{e}_2$ is the mean forecast error for the USDA.

Next, Δ and Σ are defined as the difference and the sum of errors, respectively,

$$\Delta = [e_1 - e_2] \qquad (2)$$

and

$$\Sigma = [e_1 + e_2] \qquad (3)$$

In eq. (1), the difference of the two error variances can be rearranged as the covariance of the difference of errors and the sum of errors. Thus, eq. (1) can be rewritten as,

$$\text{MSE}(e_1) - \text{MSE}(e_2) = [\text{Cov}(\Delta, \Sigma)] + [\bar{e}_1^2 - \bar{e}_2^2] \qquad (4)$$

where $\text{Cov}(\Delta, \Sigma)$ represents the covariance between the difference of errors and the sum of errors. The null hypothesis of no difference in performance between futures and USDA forecasts is $\text{Cov}(\Delta, \Sigma) = 0$ and $(\bar{e}_1 - \bar{e}_2) = 0$. The alternative hypothesis of an improvement of USDA

[10] As indicated in the previous section, there are several dimensions of forecast performance. The AGS test assesses the significance of differences in one important dimension, mean squared error. Recent research suggests that another important dimension of forecast performance is directional accuracy [Leitch and Tanner (1991)]. Tests of directional accuracy are not considered in this study because USDA forecasts usually are released six to nine weeks before the end of a quarter. Therefore, the cash price for the current quarter is not fully known at the time USDA forecasts are released. Directional accuracy tests are based on the predicted direction of price change, which cannot be specified without knowledge of the quarterly cash price at the time the forecast is released.

forecasts over futures is that both quantities are non-negative and at least one is positive.

The hypothesis tests can be performed based on the following regression,

$$\Delta_t = \alpha + \beta[\Sigma_t - \bar{\Sigma}] + \mu_t \tag{5}$$

where $\bar{\Sigma}$ is the mean of Σ_t and μ_t is a white noise disturbance term.[11] The OLS coefficient estimates are,

$$\alpha = \bar{\Delta} = \bar{e}_1 - \bar{e}_2 \tag{6}$$

$$\beta = \frac{\text{Cov}(\Sigma, \Delta)}{\text{Var}(\Sigma)} = \frac{\text{Var}(e_1) - \text{Var}(e_2)}{\text{var}(\Sigma)} \tag{7}$$

The null hypothesis is $\alpha = \beta = 0$. The alternative hypothesis is that $\alpha \geq 0$, $\beta \geq 0$ and at least one coefficient is positive. Rejection of the null hypothesis implies that USDA forecast performance is superior to futures forecast performance.

The specific application of hypothesis tests is as follows. If either α or β is significantly negative, then the null hypothesis is not rejected. If one of the coefficients is negative but not significant, a one-tailed t test on the other coefficient is used. If both α and β are positive, an F-test of the null hypothesis is employed. However, the F-test is four-tailed in order to take into account the sign of the coefficients.

AGS test results are shown in Table II. For hogs, the α coefficient is insignificant in all four regressions, which indicates no significant difference in bias between live hog futures and USDA forecasts of spot hog prices. Only one of the four β coefficients is significant for the hog regressions. A significantly positive β is indicated for the regression of one-quarter ahead, basis-adjusted hog futures and USDA hog forecasts. In this case, the variance of basis-adjusted futures errors is significantly higher than the variance of USDA forecast errors. The importance of this finding is minimized by the fact that the F-statistic for the same regression is insignificantly different from zero, which implies no significant difference in the MSEs. Note that F-statistics are insignificant for the other three hog regressions. Hence, the null hypothesis of no difference in futures and USDA performance in forecasting hog prices is not rejected for three of

[11] Note that a necessary condition for estimating regression (5) is that the mean of forecast errors should be positive; otherwise, all forecast error series must be multiplied by (−1) before estimation.

TABLE II

AGS Test Results for Livestock Futures and USDA Expert Forecasts, 1980:I–1991:IV

Commodity/Comparison/Horizon	Regression Estimates		
	α	β	F-statistic for H_0: $\alpha = \beta = 0$
Hogs			
Basis-adjusted futures vs. USDA predictions			
One-quarter ahead	0.08	0.60[a]	1.51
	(0.05)	(1.74)	
Two-quarters ahead	0.70	0.30	0.26
	(0.30)	(0.66)	
Unadjusted futures vs USDA predictions			
One-quarter ahead	0.11	0.03	0.24
	(0.22)	(0.66)	
Two-quarters ahead	0.36	0.16	0.06
	(0.16)	(0.31)	
Cattle			
Basis-adjusted futures vs. USDA predictions			
One-quarter ahead	−2.00	0.13	1.10
	(−1.44)	(0.36)	
Two-quarters ahead	0.12	0.13	0.05
	(0.07)	(0.31)	
Unadjusted futures vs. USDA predictions			
One-quarter ahead	−2.02[a]	−0.04	10.90[a]
	(4.58)	(−0.90)	
Two-quarters ahead	−0.23	0.01	0.01
	(0.14)	(0.14)	

Note: The α coefficient indicates the difference in bias (mean forecast error) between the two forecast series. The β coefficient indicates the difference in forecast error variances between the two forecast series. The figures in parentheses are t-statistics.

[a]Indicates statistical significance at the 5% level.

the four regressions, and the rejection for the remaining regression is weak.

For cattle, the α coefficient is significant for only one of the four cattle regressions. A significantly negative α is indicated for the regression of one-quarter ahead, unadjusted cattle futures and USDA cattle forecasts. As noted earlier, the null hypothesis of no difference in forecast performance is not rejected in this case. The β coefficients are insignificant in all four cattle regressions, indicating no significant difference in forecast error variance between live cattle futures and USDA forecasts of spot cattle prices. These results indicate the null

hypothesis that there is no difference in futures and USDA performance in forecasting cattle prices cannot be rejected for any of the four regressions.[12]

Overall, the AGS test results indicate few significant differences between the MSEs of livestock futures and USDA expert predictions. Only one case of significant difference is found, but it is not robust to alternative basis assumptions. Hence, there is no meaningful difference between the forecasting performance of livestock futures and USDA expert predictions. This supports the efficiency of livestock futures prices.

SUMMARY AND CONCLUSIONS

A number of studies find that livestock futures prices (live hogs and live cattle) perform poorly relative to ex post model forecasts. Given the efficiency implications of these studies, a relevant issue is whether alternative comparisons yield similar results. One alternative is to compare the accuracy of livestock futures prices and expert predictions. This approach is appealing because ex ante futures prices are compared to ex ante forecasts, rather than ex post forecasts.

This study compares the forecasting accuracy of live hog and live cattle futures prices to U.S. Department of Agriculture (USDA) expert predictions. The sample period is the 12-year period beginning in the first quarter of 1980 and ending with the fourth quarter of 1991. This provides a sufficient number of observations to conduct valid statistical tests [Williams (1993)], but avoids the idiosyncratic period of the mid-1970s. A test developed by Ashley, Granger, and Schmalensee (1980) is used to assess the significance of differences in forecasting performance. Both basis-adjusted and unadjusted futures prices are considered in the analysis.

While nominal differences in forecast performance are evident, test results indicate few significant differences between the forecasting performance of livestock futures and USDA expert predictions. Only one case of significant difference is found, but it is not robust to alternative basis assumptions. Hence, there is no meaningful difference between the forecasting performance of livestock futures and USDA expert predictions. Overall, the results support the efficiency of livestock futures prices.

[12] It should be noted that if the specification of the null hypothesis is reversed (USDA-futures), then the significantly lower bias of unadjusted live cattle futures at the one-quarter ahead horizon would indicate superior performance compared to USDA forecasts. This is also evident in the significant F statistic for the same regression.

There are several potential hypotheses regarding the difference in results between this study and previous studies based on ex post model forecasts. The first hypothesis is that results based upon ex post model forecasts reflect "data-snooping" biases [Merton (1987); Lo and MacKinlay (1990)].[13] Such biases may arise if ex post model forecasts are generated in-sample [e.g., Koppenhaver (1983); Shonkwiler (1986)]. Data-snooping biases also may be due to a more subtle form of specification searching. Specifically, a sequence of empirical studies can be viewed as a form of specification searching, where researchers build upon the successful specifications in previous studies. Merton notes that this " . . . creates a fertile environment for both unintended selection bias and for attaching greater significance to otherwise unbiased estimates than is justified." (p. 104)

The second hypothesis is that studies based upon ex post model forecasts suffer from small sample biases. Williams (1993) uses Monte Carlo simulations to determine the necessary sample size required to compare the forecasting accuracy of futures and model forecasts. For non-storable commodities, such as live hogs and live cattle, his analysis suggests that at least four years of forecasts are needed to reduce Type I error to 10%. Many studies based upon ex post model forecasts do not analyze forecast samples of this size.

The third hypothesis is that expert predictions contain biases that are not found in ex post model forecasts. A large literature suggests that psychological biases are endemic to subjective expert prediction [e.g., Kahneman, Slovic, and Tversky (1982)]. An example is non-regressive prediction, whereby experts tend to make too many extreme predictions. There is some evidence that simple models, even when mispecified, may outperform subjective expert predictions [e.g., Dawes (1979); Dawes, Faust, and Meehl (1989)]. If this hypothesis is true, a comparison of futures prices and expert predictions is a weaker test of forecast efficiency than a comparison of futures prices and ex post model forecasts.

This discussion suggests further research is needed in several areas. First, the accuracy of livestock futures prices, expert predictions, and ex post model forecasts should be compared directly. This would provide valuable evidence towards explaining the different results in expert prediction and model studies. Second, it would be interesting

[13]A point originally made by Lo and MacKinlay (1990) should be noted. That is, usage of the term "data snooping" does not imply or infer any sort of intentional misrepresentation or dishonesty on the part of individual researchers.

to determine if the results of the current study are robust with respect to a broader sample of expert predictions. Finally, it would be interesting to examine whether the relative accuracy of livestock futures and expert predictions follows a pattern over time that can be related to market fundamentals.

BIBLIOGRAPHY

Aldinger, L. (1986): "An Analysis of Iowa State University Cattle Price Forecasts and Prices Indicated by Live Cattle Futures," Working Paper, Department of Economics, Iowa State University.

Ashley, R., Granger, C.W.J., and Schmalensee, R. (1980): "Advertising and Aggregate Consumption: An Analysis of Causality," *Econometrica*, 48:1149–1167.

Bessler, D.A., and Brandt, J.A. (1992): "An Analysis of Forecasts of Livestock Prices," *Journal of Economic Behavior and Organization*, 18:249–263.

Brandt, J.A., and Bessler, D.A. (1983): "Price Forecasting and Evaluation: An Application from Agriculture," *Journal of Forecasting*, 2:237–248.

Chicago Mercantile Exchange Statistical Annual, various issues, 1980–1991.

Dawes, R. (1979): "The Robust Beauty of Improper Linear Models in Decision Making," *American Psychologist*, 34:571–582.

Dawes, R., Faust, D., and Meehl, P. (1989): "Clinical Versus Actuarial Judgement," *Science*, 243:1668–1674.

Garcia, P., Leuthold, R.M., Fortenbery, T.R., and Sarassoro, G.F. (1988): "Pricing Efficiency in the Live Cattle Futures Market: Further Interpretation and Measurement," *American Journal of Agricultural Economics*, 70:162–169.

Helmuth, J. (1981): "A Report on the Systematic Downward Bias in Live Cattle Futures Prices," *The Journal of Futures Markets*, 1:347–358.

Irwin, S.H., and Gerlow, M.E. (1989): "On The Value of Outlook Economists' Price Forecasts," in *Proceedings of the NCR-134 Conference on Applied Commodity Price Analysis, Forecasting and Market Risk Management*, pp. 220–231.

Kahneman, D., Slovic, P., and Tversky, A. (1982): *Judgement Under Uncertainty: Heuristics and Biases*. Cambridge: Cambridge University Press.

Koppenhaver, G. (1983): "The Forward Pricing Efficiency of the Live Cattle Futures Market, *The Journal of Futures Markets*, 3:307–320.

Leitch, G., and Tanner, J.E. (1991): "Economic Forecast Evaluation: Profits Versus the Conventional Error Measures," *American Economic Review*, 81:580–590.

Leuthold, R.M., Garcia, P., Adam, B.D., and Park, W.I. (1989): "An Examination of the Necessary and Sufficient Conditions for Market Efficiency: The Case of Hogs," *Applied Economics*, 21:193–204.

Leuthold, R.M., and Hartmann, P.A. (1979): "A Semi-Strong Form Evaluation of the Efficiency of the Hog Futures Market," *American Journal of Agricultural Economics*, 63:482–489.

Livestock and Meat Situation Report. U.S. Department of Agriculture, Economic Research Service, various issues, 1979–1991.

Lo, A., and MacKinlay, A.C. (1990): "Data-Snooping Biases in Tests of Financial Asset Pricing Models," *Review of Financial Studies*, 3:431–467.

Marquardt, R. (1979): "An Evaluation of the Relative Price-Forecasting Accuracy of Selected Futures Markets," in *Commodity Markets and Futures Prices*, Leuthold, R. (ed.), Chicago: Chicago Mercantile Exchange, pp. 125–142.

Merton, R. (1987): "On the Current State of the Stock Market Rationality Hypothesis," in *Macroeconomics and Finance: Essays in Honor of Franco Modigliano*, Dornbush, R., Fisher, S., and Bossons, J. (eds.), Cambridge, MA: M.I.T. Press, pp. 93–124.

Moe, J. (1985): "An Analysis of Iowa State University Hog Price Forecasts and Price Indicated by Live Hog Futures," Working Paper, Department of Economics, Iowa State University.

O'Brian, P. (1990): U.S. Department of Agriculture, Economic Research Service, personal communication.

Shonkwiler, J.S. (1986): "Are Livestock Futures Prices Rational?" *Western Journal of Agricultural Economics*, 11:123–128.

Surls, F., and Gajewski, G. (1990): "How Accurate Are USDA Forecasts?" *Agricultural Outlook*, October, 2–5.

The Wall Street Journal, various issues, 1980–1991.

Williams, J. (1993): "The Forecasting Ability of Futures Markets Compared to Econometric Models," Working Paper, Food Research Institute, Stanford University.