Outlook vs. Futures: Three Decades of Evidence in Hog and Cattle Markets

by

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Abstract

The purpose of this paper is to provide a comprehensive evaluation of the accuracy of outlook forecasts relative to futures prices in hog and cattle markets. Published forecasts from four prominent livestock outlook programs are available for analysis. Most of the series begin in the mid- to late-1970s and end in 2007. Root mean squared error (RMSE) comparisons indicate the difference between outlook and futures RMSE is relatively small in most cases. In directional terms, outlook forecasts beat futures prices only 2 out of 11 times in hogs and 1 out of 7 times in cattle. However, the null hypothesis that futures forecasts encompass outlook forecasts is rejected in 5 of 11 cases for hogs and 4 of 7 cases for cattle. In sum, the results show that a combination of futures and outlook forecasts generally has a lower RMSE than futures alone, and therefore, outlook forecasts of hog and cattle prices provide incremental information relative to futures prices.

Key Words: cattle, encompassing, forecast, futures prices, hogs, outlook, RMSE

Outlook vs. Futures: Three Decades of Evidence in Hog and Cattle Markets

Price forecasting has long been an important part of agricultural economists' work. As one example, the USDA's annual Agricultural Outlook Forum has been held for over 80 years. The importance of price forecasting is not surprising given that agricultural prices are more volatile compared to prices in many other economic sectors (Tomek and Robinson 2003, p.4). Forecast (expected) prices affect the business decisions of producers, processors, traders, and market participants in general, and therefore, are important determinants of resource allocation and economic welfare.

A number of approaches can be used to evaluate the performance of price forecasts issued by public outlook programs (e.g., Sanders and Manfredo 2003; Isengildina, Irwin, and Good 2006). When available for comparison, futures prices are considered the "gold standard" for evaluating forecast accuracy. This is based on the logic of the efficient market hypothesis. Specifically, futures prices in an efficient market provide forecasts of subsequent spot prices that are at least as accurate as any other forecast (Tomek 1997). In other words, it should not be possible to "beat the market" in terms of forecast accuracy. A number of empirical studies compare the accuracy of outlook forecasts and futures prices (e.g., Just and Rausser 1981; Bessler and Brandt 1992; Irwin, Gerlow, and Liu 1994; Bowman and Husain 2004; Sanders and Manfredo 2004 2005). With few exceptions, these studies find that outlook forecasts are no more accurate, and often less accurate, than comparable futures prices.

Taken at face value, the weight of the existing evidence indicates that outlook forecasts cannot beat futures prices in terms of forecasting accuracy. This raises serious questions about the performance and economic value of public outlook programs. McCloskey (1992, pp. 28-29) provides a colorful rendition of the argument against public programs:

> An economist who claims to know what is going to happen to the price of corn is claiming to know how to make money. Many models printed for free in the journals of agricultural economics imply knowledge of the price of corn. With a little borrowing on the equity of his home or his reputation for sobriety, the agricultural economist can make enormous sums. If an agricultural economist could forecast the price of corn better than the futures markets, he would be rich. Yet he does not put his money where his mouth is. He is not rich. It follows that he is not so smart.

An obvious implication of this argument is that resources should be re-allocated away from public outlook programs towards program areas with positive economic benefits.[1]

There are three substantive reasons for treating existing evidence about the performance of outlook forecasts relative to future prices with some degree of caution. First, statistical tests in previous studies generally have low power to reject a null of no difference in accuracy because of small sample sizes. Ashley (2003) shows that at least 100 observations are typically needed in order for a 20% reduction in mean square error (MSE) to be statistically significant at the 5% level. Second, it is possible for futures prices to have a smaller MSE than outlook forecasts but still not entirely "encompass" the information contained in outlook forecasts (Sanders and Manfredo 2005). Encompassing tests determine whether alternative forecasts add incremental information to a given forecast. Only two previous studies have applied encompassing tests to outlook and futures forecasts, finding mixed results (Sanders and Manfredo 2004 2005). Third, previous studies have not formally tested whether the informational content of outlook forecasts relative to futures prices has changed over time.

The purpose of this paper is to provide a comprehensive evaluation of the accuracy of outlook forecasts relative to futures prices in hog and cattle markets. Published forecasts from four prominent livestock outlook programs are available for analysis: University of Illinois/Purdue University, Iowa State University, University of Missouri, and the Economic Research Service of the U.S. Department of Agriculture (USDA). One-, two- and up to three-quarter-ahead finished hog and one- and up to two-quarter-ahead fed cattle price forecasts are available for each program over the last three decades. Most of the series begin in the mid- to late-1970s and end in 2007. Two-thirds of the forecast series have 100 or more observations, providing by far the largest sample of outlook forecasts examined to date. Following the model developed by Hoffman (2005), live/lean hog and live cattle futures forecasts are constructed based on futures prices available on the day before and the day of release for outlook forecasts. Statistical significance of differences in root mean squared error (RMSE) is tested using the modified Diebold-Mariano test developed by Harvey, Leybourne, and Newbold (1997). The encompassing test of Harvey, Leybourne, and Newbold (1998) is used to determine whether outlook forecasts contain incremental information not found in futures forecasts.

Outlook Forecasts

Table 1 describes sample periods, missing observations, timing of release, cash prices, and publication sources for each outlook forecast series. With three exceptions, all of the forecasts are released on a quarterly basis.[2]

In hogs, the forecast series start in 1974, 1975, or 1979 and end in 2007. One-, two-, and three-quarter-ahead forecasts are available for all programs except the USDA, which is limited to one- and two-quarter ahead forecasts. Note that the number of quarters reported in table 1 reflects the full number of quarters within a given sample period.[3] The number of missing observations is quite small in hogs, with the exception of three-quarter-ahead forecasts for Missouri and two-quarter-ahead forecasts for the USDA. In both cases, about 20% of the observations are missing. Even with the missing observations, every forecast series in hogs contains at least 100 observations.

In cattle, the forecast series start in 1974, 1975, or 1979 and end in 1996 or 2007.[4] One- and two-quarter ahead forecasts are available for Illinois/Purdue, Iowa, and the USDA. Only one-quarter-ahead forecasts are available for Missouri.[5] The number of missing observations is small for one-quarter ahead cattle forecasts, but two-quarter ahead forecasts are missing about 20% or more of the observations in the cases where such forecasts are available (Illinois/Purdue, Iowa, and USDA). Sample sizes in cattle range much more widely than in hogs. The smallest sample size is 48 (Iowa: two-quarters ahead) and the largest is 132 (USDA: one-quarter ahead). Six of the seven cattle price forecast series contain at least 50 observations and two contain over 100 observations.

Data on timing of release is critical in order to correctly match the release date of outlook forecasts to futures forecasts. A mismatch could create an informational advantage for either outlook or futures forecasts. Iowa, Missouri, and USDA outlook publications provide the exact release date. Illinois/Purdue outlook publications only report the month and year of publication. Additional information on timing of release is obtained from Chris Hurt of Purdue University, the current livestock outlook analyst responsible for the forecasts, and Darrel Good of the University of Illinois, the long-time editor of Illinois/Purdue outlook publications. These two individuals indicate that reports containing hog price forecasts generally are released five business days after the release of USDA Hogs and Pigs Reports, while cattle price forecasts are released five business days after the USDA January and July Cattle Reports. These rules are used to specify release dates for Illinois/Purdue outlook forecasts in hogs and cattle.

Some noticeable differences in the timing of release are observed for the different outlook programs. USDA hog price forecasts are released, on average, 43 days before the start of each quarter. In contrast, Illinois/Purdue, Iowa, and Missouri hog price forecasts are issued during the first two business weeks of each calendar quarter, usually following release of the USDA's quarterly Hogs and Pigs Report. Illinois/Purdue and Missouri cattle price forecasts are released on average 57 days before the start of each quarter. Iowa and USDA cattle price forecasts are released on average 59 and 43 days respectively, before the start of each quarter. These differences in timing of release do not affect outlook and futures forecast comparisons because release dates of outlook forecasts are matched to the dates of futures forecasts (see the next section). However, it is not strictly appropriate to compare forecast accuracy measures across outlook programs because the different release dates reflect different information sets. This is true even when the average release dates are the same or similar because release schedules are not constant through time.

Since each outlook program generally releases forecasts on different dates, a flexible definition of forecast horizons is needed to categorize forecasts into one-, two- and three-quarter ahead horizons. Predictions issued up to the first two business weeks of a quarter are considered one-quarter-ahead price forecasts. A similar criterion is used to define two- and three-quarter ahead forecasts.

It is important to compare outlook forecasts to the proper cash price. As shown in table 1, the target cash price for each outlook program has not remained constant. The marketing structure of the U.S. livestock industry has evolved over time, and as consequence, the target cash price used by outlook forecasters has changed. In all cases, outlook price forecast errors are computed using the target cash price given in the outlook publication at the time the forecast is made.

Several additional points regarding the outlook forecast data should be noted. First, forecasts often are reported as ranges, typically $4-5/cwt. Following previous researchers (e.g., Irwin, Gerlow, and Liu 1994; Sanders and Manfredo 2003), point forecasts are generated as the mid-point of the reported forecast price range, which assumes that forecast prices within the reported range follow a symmetric distribution. Second, outlook price forecasts are not reported as a range or point forecast in a limited number of cases; instead they are given as qualitative statements like 'upper $40s' or ‘low $70s.’ A consistent set of rules is applied to map these statements into point forecasts (e.g., upper 40s = $47.50/cwt.) Third, missing outlook forecast observations correspond to gaps in outlook publications rather than gaps in the collection of data. Fourth, missing observations generally are randomly distributed in the outlook forecast series, and thus, are not expected to bias performance comparisons.

Futures Model Forecasts

Live/lean hog and live cattle futures contracts reflect a particular set of delivery markets (whether the contracts specify physical delivery or cash settlement). Consequently, a set of assumptions must be applied to convert the available array of live/lean hog and live cattle futures prices to a quarterly average cash price forecast comparable to outlook program forecasts. This linkage between the cash price being forecast and futures price quotations is an important component of the evaluations.

Futures-based forecasts for this analysis are constructed following the model developed by Hoffman (2005). Hoffman’s model is well-documented, has been in use at the USDA for over a decade, and avoids the mismatching problem inherent in an earlier approach to basis adjustment for livestock outlook forecasts (Irwin, Gerlow, and Liu 1994). Table 2 provides two examples of the construction of one-quarter-ahead price forecasts from lean hog futures. The examples are keyed to the release of USDA hog price forecasts on November 18, 2004 and February 15, 2005. Nearest-to-maturity contracts that do not expire in the target calendar month are first matched to each of the forecast months in a quarter. For example, the February 2005 contract is matched to

January 2005 and the April 2005 contract is matched to February and March 2005 for the futures forecast computed on November 18, 2004. Next, a simple average of the three futures prices is taken to represent the average price forecast by the futures market for the quarter. The quarterly average futures price in these examples also must be converted from lean to live hog units in order to be comparable to outlook forecasts, which are reported in live weight terms.[6] The final step is to add a basis forecast to the quarterly average futures price to obtain the futures model forecast. Following Garcia and Sanders (1996), univariate ARMA models with seasonal (quarterly) dummy variables are used to forecast lean/live hog and live cattle basis.[7] Historical basis levels are computed by averaging daily futures prices for each quarter and subtracting the quarterly target cash price specified by the outlook forecast. Similar calculations are used to compute futures model forecasts for the second, third and fourth calendar quarters.[8]

Two different futures forecasts are created for each outlook forecast release date. As outlined above, the first is based on settlement prices for the day each outlook forecast is released. The second is based on settlement prices from the day before release for each outlook forecast. Both futures forecasts are computed because the exact time that outlook reports are released on each announcement date generally is not known. In addition, the two futures forecasts allow for the possibility of an outlook announcement effect between the day before and the day of release (Isengildina, Irwin, and Good 2006). Test results are similar for both sets of futures forecasts, and hence, only results based on settlement prices from the day of release are presented in the following sections.[9]

Forecast Errors

Descriptive statistics on outlook and futures forecast errors for hogs and cattle are presented in table 3. At a given forecast horizon (one-, two-, or three-quarters ahead), forecast errors are computed as follows:

(1) $$e_{it} = p_t - f_{it} \quad t = 1,...,n \quad i = 1\text{(futures)}, 2\text{(outlook)}$$

where e_{1t} is the error of the futures model forecast for quarter *t*, e_{2t} is the error of the outlook forecast for quarter *t*, p_t is the actual cash price in quarter *t*, f_{1t} is the futures model forecast for quarter *t*, f_{2t} is the outlook forecast for quarter *t*, and *n* is the number of forecast observations.[10]

Mean errors in hogs generally are positive, which indicates that both outlook and futures forecasts tend to be lower than actual prices. However, none of the mean errors is large in economic terms. The largest and only statistically significant bias is associated with the futures model when evaluated against two-quarter-ahead USDA forecasts and it represents just three percent of the average cash price for the sample period. Mean errors in cattle generally are negative for outlook forecasts and positive for futures forecasts. In comparison to the results for hogs, mean errors are larger but still relatively small. The largest bias is associated with two-quarter-ahead Illinois/Purdue forecasts and it represents about four percent of the average cash price for cattle during the respective sample period. Six of the mean estimates are statistically significant. Two are associated with Illinois/Purdue forecast errors and the other four are associated with futures forecasts.

Standard deviations and minimums and maximums indicate a large range in forecast errors for both commodities. For example, one-quarter-ahead hog price forecast errors for Illinois/Purdue range from -$13.45/cwt. to $18.24/cwt. As predicted by optimal forecasting theory (Diebold 2004, pp. 294-295), variability of forecast errors is non-decreasing across forecast horizons with one exception (one-quarter ahead vs. two-quarter ahead cattle price forecasts for Illinois/Purdue). Large differences in variability generally are not evident when comparing outlook and futures forecast errors in both hogs and cattle. This is not surprising in light of the high correlation observed in most cases between outlook and futures forecast errors. Pair-wise correlation coefficients between outlook and futures forecast errors average 0.75 in hogs and 0.82 in cattle.

The Jarque-Bera test is used to analyze the normality of each forecast error series. In hogs, the null hypothesis of normality is rejected only in the case of one-quarter ahead forecast errors for Missouri. Results are less consistent in cattle, as normality is rejected in 6 of 14 cases. Evidence of non-normally distributed errors is found in all USDA cattle forecast errors and the respective futures-based forecast errors, in the two-quarter-ahead Illinois/Purdue forecast errors as well as in the respective one-quarter ahead futures forecast errors for Illinois/Purdue. Overall, forecast errors in hogs show almost no evidence of departures from normality, while forecast errors in cattle show moderate evidence of such departures.

Finally, augmented Dickey-Fuller (ADF) unit root tests are performed for each forecast error series. Results show that all forecast error series in hogs and cattle are stationary, or I(0), except for three-quarter ahead Illinois/Purdue hog forecast errors and one- and two-quarter ahead Illinois/Purdue cattle forecast errors. Lag lengths are selected based on the AIC criterion. In addition, test results are insensitive to the inclusion of a constant or time-trend term in the ADF regressions.

RMSE Tests

Following previous studies (e.g., Sanders and Manfredo 2004 2005), the first step of the formal analysis is a comparison of root mean squared errors (RMSEs) for outlook and futures forecasts. RMSEs for futures and outlook forecasts at a given horizon are computed as follows:

(2) $$RMSE_i = \left[\frac{1}{n} \sum_{t=1}^{n} \left(p_t - f_{it} \right)^2 \right]^{1/2} \quad t = 1,\ldots n \quad i = 1\text{(futures), 2(outlook).}$$

Statistical significance of differences in RMSE between outlook and futures forecasts is assessed using the modified Diebold-Mariano (MDM) test proposed by Harvey, Leybourne, and Newbold (1997). The MDM statistic tests the null hypothesis of equality of forecast performance based on a specified loss function, $E[g(e_{1t}) - g(e_{2t})] = 0$. Assuming a quadratic loss function, the test is based on the difference in squared errors for futures and outlook forecasts at a given horizon:

(3) $$d_t = g(e_{1t}) - g(e_{2t}) = e_{1t}^2 - e_{2t}^2.$$

The MDM test is then specified as follows:

(4) $$MDM = \left[\frac{n + 1 - 2h + n^{-1}h(h-1)}{n} \right]^{1/2} \left[V\left(\bar{d}\right) \right]^{-1/2} \left[\bar{d} \right]$$

(5)
$$V\left(\bar{d}\right)=\left[n^{-1}\left(\gamma_0+2\sum_{k=1}^{h-1}\gamma_k\right)\right]$$

where $\bar{d}$ is the sample mean of d_t, $h=1,2,3$ is the forecast horizon (e.g., 1 = one-quarter ahead forecast), $\gamma_0=n^{-1}\sum_{t=1}^{n}\left(d_t-\bar{d}\right)^2$ is the variance of d_t, and $\gamma_k=n^{-1}\sum_{t=k+1}^{n}(d_t-\bar{d})(d_{t-k}-\bar{d})$ is the k^{th} autocovariance of d_t, $\left(k=1,...,h-1\right)$. Autocovariance terms are included to account for the overlap in two- and three-quarter ahead forecasts. The MDM test statistic follows a *t*-distribution with *n-1* degrees of freedom. As discussed in the previous section, normality is rejected in some forecast error series, particularly for cattle. Harvey, Leybourne, and Newbold (1997) show that the MDM test is robust to departures from normality; hence, the departures from normality in forecast errors are not expected to lead to size or power problems.

RMSE values for hog and cattle forecast series are presented in table 4. Consistent with previous studies of outlook forecasts and futures prices in livestock markets (e.g., Irwin, Gerlow, and Liu 1994; Sanders and Manfredo 2004), the difference between outlook and futures RMSE is relatively small in most cases.[11] The most notable exceptions are Illinois/Purdue hog and cattle price forecasts, where the difference in RMSE averages $1.79/cwt. and $2.05/cwt. in favor of futures across all three forecast horizons for hogs and cattle, respectively. Without Illinois/Purdue, differences in hogs range from -$0.36/cwt. to $1.02/cwt. and average $0.43/cwt. in favor of futures. The average difference represents about 7% of the average (outlook and futures) RMSE value.

Without Illinois/Purdue, differences in cattle range from -\$0.38/cwt. to \$0.73/cwt., with an average difference of \$0.20/cwt. in favor of futures. The average difference in this case represents about 3% of the average (outlook and futures) RMSE value.

Despite the generally small magnitude of RMSE differences, statistical significance is evident for all cases in hogs except two- and three-quarter ahead forecasts for Iowa and three-quarter-ahead forecasts for Missouri. By comparison, statistical significance is found for only three cases in cattle (one- and two-quarter ahead Illinois/Purdue and one-quarter ahead USDA forecasts). In directional terms, outlook forecasts beat futures prices only 2 out of 11 times in hogs and 1 out of 7 times in cattle. In terms of individual outlook programs, Iowa, Missouri, and the USDA perform better relative to futures than Illinois/Purdue in both hogs and cattle.[12]

The RMSE comparisons raise the intriguing question of why Illinois/Purdue performs so much worse than the other outlook programs. Time-series plots of the difference between futures and outlook squared forecast errors (d_t) provide important clues. Figure 1 shows that relative forecast performance in hogs improves noticeably starting in 1990. This is confirmed by the observation that the difference in RMSE between Illinois/Purdue one-quarter ahead hog price forecasts and futures is \$3.06/cwt. before 1990 and \$1.09/cwt. after 1990. Figure 2 shows that an even more dramatic improvement occurs in cattle starting in 1986. The difference in RMSE between Illinois/Purdue one-quarter ahead cattle price forecasts and futures is \$4.16/cwt. before 1986 and only \$0.60/cwt. after 1986. It is interesting to note that the breakpoints in relative forecast accuracy correspond to changes in the analyst responsible for the forecasts. Three different analysts are responsible for Illinois/Purdue hog price forecasts before 1990 and a single analyst thereafter. One analyst is responsible for Illinois/Purdue cattle price forecasts before 1986 and two since then. A clear implication is that the last analyst in hogs and the last two in cattle perform considerably better than their predecessors. This also shows that the poor RMSE performance of Illinois/Purdue forecasts over the entire sample period is largely due to poor performance of analysts before 1990 in hogs and before 1986 in cattle.[13]

Encompassing Tests

The second step of the formal analysis is to test whether outlook forecasts contain incremental information not found in futures forecasts. As first pointed out by Granger and Newbold (1973), it is possible for a forecast to have a larger MSE than another forecast but still provide useful information.[14] Harvey, Leybourne, and Newbold (1998) develop a test of forecast encompassing based on the principle that one forecast encompasses another if the optimal weight of the inferior forecast in a composite forecast is zero. This can be formalized in the following regression equation:

(6) $$e_{1t} = \lambda(e_{1t} - e_{2t}) + \xi_t \qquad t = 1, \dots, n$$

where e_{1t} is the error of the preferred forecast (futures) and e_{2t} is the error of the alternative forecast (outlook). The null hypothesis for the encompassing test is $\lambda = 0$, which implies zero covariance between e_{1t} and $e_{1t} - e_{2t}$. Rejection of the null hypothesis indicates that a composite forecast can be constructed based on the two forecast series that has a smaller MSE than the preferred forecast. In other words, outlook forecasts provide incremental information not contained in futures prices.

Harvey, Leybourne, and Newbold (1998) recommend testing the null hypothesis of $\lambda = 0$ in equation (6) using a version of the MDM test. This is accomplished by re-defining d_t in equation (3) to equal $e_{1t}(e_{1t} - e_{2t})$ and then computing the MDM test statistic in the usual manner. Simulation results in Harvey, Leybourne, and Newbold (1998) show that the MDM test generally has the best combination of size and power among alternative tests, particularly when forecast error distributions are non-normal and heavy-tailed. Both the MDM and regression versions of the encompassing test are used here as a check on the robustness of test results.

Encompassing test results for hogs and cattle, shown in table 5, provide more favorable evidence about the performance of outlook forecasts than RMSE tests. MDM tests reject the null hypothesis that futures forecasts encompass outlook forecasts $(\lambda = 0)$ in 5 of 11 cases for hogs and 4 of 7 cases for cattle. Regression tests reject one additional case, one-quarter ahead cattle price forecasts for Missouri. Regression estimates of λ indicate that composite weights for outlook forecasts are surprisingly large, with an average weight of 0.25 and 0.32 given to outlook across all programs and horizons in hogs and cattle, respectively. By program, the average weight in hogs is 0.09 for Illinois/Purdue, 0.46 for Iowa, 0.27 for Missouri, and 0.16 for the USDA. The average weight in cattle is 0.04 for Illinois/Purdue, 0.58 for Iowa, 0.34 for Missouri, and 0.34 for the USDA. Overall, the evidence shows that a combination of futures and outlook forecasts generally has a lower RMSE than futures alone, and therefore, outlook forecasts provide incremental information relative to futures prices.

While the encompassing results are positive with respect to the incremental information contained in outlook forecasts, further computations are needed to estimate the magnitude of the reduction in RMSE from combining outlook and futures forecasts. This can be obtained by first applying the λ estimates to form composite forecasts, and then comparing the RMSE of the resulting composite forecasts to the RMSE of futures alone. Results of the composite forecast analysis for hogs and cattle are shown table 6. Reductions in RMSE for composite forecasts in hogs range from a low of -0.1% to a high of -9.2% and average -2.2%. Reductions in RMSE for cattle range from a low of -0.1% to a high of -6.9% and average -2.9%. By program, the largest incremental reductions are provided by Iowa, with RMSE reductions averaging -5.7% and -5.2% for hogs and cattle, respectively.

Whether the RMSE reductions are large enough to justify the cost of the outlook programs is a difficult question to answer. This requires the specification and estimation of an equilibrium model of the hog and/or cattle markets and then simulation of market outcomes with and without the information provided by outlook programs (e.g., Hayami and Peterson 1972); a task beyond the scope of this study. A useful perspective on this question can be derived from expected utility simulations in Adam, Garcia, and Hauser (1996). Their results indicate that a one-percent improvement in mean price forecast accuracy increases the certainty equivalent return of a risk-averse hog producer by \$0.47/cwt., or about \$1.15 per head (\$0.47/cwt. x 2.45 cwt./head). Using this figure, the -

2.2% average RMSE reduction in hogs translates into $2.53 of certainty equivalent return for each hog produced, or $25,300 for a representative hog operation producing 10,000 head per year. These computations suggest that the economic value of the RMSE reductions to individual hog producers is non-trivial in at least some cases.

Finally, it should be emphasized that the composite results do not necessarily imply that live/lean hog or live cattle futures markets are inefficient. Sanders and Manfredo (2005) note that a sufficient condition for violation of market efficiency is the ability to generate futures trading profits based on the composite forecasts. In order to test this sufficient condition a trading rule would have to be specified to translate differences in composite and futures forecasts into futures trading positions. A number of assumptions could be used to do so, and returns may be sensitive to the different assumptions (Garcia et al. 1988). Returns also would have to be adjusted for transactions costs and risk.

Structural Change Tests

The third step of the analysis is to test whether the informational content of outlook forecasts relative to futures prices has changed over time. In other words, is there evidence that λ in encompassing regression (6) changes at some point during the sample? This parameter could change for a variety of reasons, including turnover of outlook analysts, changes in the resources devoted to outlook programs, and changes in market structure and efficiency. The long samples of forecasts available in this study allow such tests to be conducted with reasonable power.

The test of structural change used here is the unknown breakpoint test (QLR) originally proposed by Quandt (1960) and analyzed extensively by Andrews (1993) and Andrews, Lee, and Ploberger (1996). The test assumes there is not enough information *a priori* to specify the timing of a structural break, and thereby avoids the arbitrary specification of breakpoints often found in empirical analysis (Hansen 2001). The QLR statistic is the largest Chow *F*-test of structural change across all possible sample breakpoints, with a percentage of the sample observations trimmed from each end to improve the performance of the test. Andrews (1993) recommends trimming 30% of sample observations (15% on each end of the sample). Formally, the QLR statistic is,

$$QLR = \max_{\tau_1 \leq \tau \leq \tau_2} F\left(\tau\right) \tag{7}$$

where $F\left(\tau\right)$ is the Chow *F*-statistic for sample breakpoint τ and τ_1 and τ_2 are the first and last sample breakpoints, respectively, after symmetrically trimming 15% of observations from each end of the sample.[15] The sampling distribution of the QLR statistic is non-standard. Tables of critical values for the QLR statistic can be found in Andrews (1993).

QLR structural change tests (not shown) provide limited evidence that the informational content of outlook forecasts relative to futures prices has changed over the last three decades.[16] Statistically significant structural change is found in only 3 of 18 cases: two-quarter ahead hog price forecasts for Illinois/Purdue and one- and two-quarter ahead cattle price forecasts for Iowa. No significant evidence of structural change is found for the Missouri or USDA in either hogs or cattle. The estimated break date for two quarter-ahead hog price Illinois/Purdue forecasts is 1984.II. Interestingly, this break date does not align with the change in relative RMSE accuracy discussed previously for Illinois/Purdue. The estimated break dates for one- and two-quarter ahead Iowa cattle price forecasts are 1992.III and 1991.III, respectively. It is also interesting to note that in all three cases with significant structural change, estimated λ coefficients decline after the break date. As an example, the estimated λ coefficient for two-quarter ahead hog price forecasts for Illinois/Purdue declines from 0.38 before 1984.II to -0.18 afterwards.

Summary and Conclusions

The purpose of this paper is to provide a comprehensive evaluation of the accuracy of outlook forecasts relative to futures prices in hog and cattle markets. Published forecasts from four prominent livestock outlook programs are analyzed: University of Illinois/Purdue University, Iowa State University, University of Missouri, and the Economic Research Service of the U.S. Department of Agriculture (USDA). One-, two- and up to three-quarter-ahead finished hog and one-and two-quarter ahead fed cattle price forecasts are available for each program over the last three decades. Most of the series begin in the mid- to late-1970s and end in 2007. Two-thirds of the forecast series have 100 or more observations, providing by far the largest sample of outlook forecasts examined to date. Live/lean hog and live cattle futures forecasts are constructed based on futures prices available on the day before and the day of release for outlook forecasts.

Root mean squared error (RMSE) comparisons indicate the difference between outlook and futures RMSE is relatively small in most cases. Despite the relatively small magnitude of RMSE differences, statistical significance is evident for all cases in hogs except two- and three-quarter ahead forecasts for Iowa and three-quarter-ahead forecasts for Missouri. By comparison, statistical significance is found in only three cases for cattle (one- and two-quarter ahead Illinois/Purdue and one-quarter ahead USDA forecasts). In directional terms, outlook forecasts beat futures prices only 2 out of 11 times in hogs and 1 out of 7 times in cattle.

Encompassing test results provide more favorable evidence on the performance of outlook forecasts than RMSE tests. The null hypothesis that futures forecasts encompass outlook forecasts is rejected in 5 of 11 cases for hogs and 4 of 7 cases for cattle. Regression estimates indicate that composite weights for outlook forecasts are surprisingly large, with an average weight of 0.25 and 0.32 given to outlook across all programs and horizons in hogs and cattle, respectively. There is limited evidence that the informational content of outlook forecasts relative to futures prices has changed over the last three decades.

In sum, the results of this study show that a combination of futures and outlook forecasts generally has a lower RMSE than futures alone, and therefore, outlook forecasts of hog and cattle prices provide incremental information relative to futures prices. Previous studies of livestock outlook forecasts and futures typically reach less favorable conclusions. For example, Sanders and Manfredo (2004, p.129) conclude that, "…a simple futures-based forecast may be the best alternative for agribusiness decision makers." The difference in conclusions is most likely due to the use of small samples of outlook forecasts and/or the omission of encompassing-type tests in previous work.

Additional research is needed to determine whether the findings of this study generalize to other agricultural markets, especially major grain markets such as corn, soybeans, and wheat. Further research also is needed to determine whether the incremental value of outlook forecasts is large enough to justify the cost of the outlook programs.

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Endnotes

[1] This logic ignores educational benefits that may be associated the public outlook programs. Brorsen and Irwin (1996) argue that outlook programs can generate net economic benefits in efficient markets by educating participants about the structure and parameters of the underlying economic model and prospective economic conditions.

[2] The first exception is the USDA, which switched from a quarterly to a monthly release schedule in 1992. Consequently, quarterly average price forecasts are updated once a month after 1991 instead of once a quarter. In order to maintain a consistent timing of USDA release schedules across the entire sample, only quarterly forecasts released during the same months pre- and post-1992 are considered. The second exception is Illinois/Purdue cattle price forecasts, which are released on a quarterly basis over 1979.II-1987.III and a semi-annual basis thereafter. The third exception is Missouri cattle price forecasts, which are released on a quarterly basis over 1974.II-1991.IV and an annual basis thereafter. The number of quarters and number of missing observations for Illinois/Purdue and Missouri in cattle reflect an assumption of two release quarters per year after 1987.IV for Illinois/Purdue and one release quarter per year after 1992.I for Missouri.

[3] The number of missing observations must be subtracted from this figure in order to obtain the actual sample size. For instance, five observations are missing from the series of one-quarter-ahead hog price forecasts from Missouri. Subtracting five from the total number of quarters over 1974.II-2007.IV (135) yields the correct sample size (130 = 135 - 5).

[4] Note that cattle forecasts from Iowa end in 1996, because the forecasts are discontinued after that year.

[5] Missouri cattle price forecasts for longer horizons also are available over 1991- 2007. These are not evaluated because cattle price forecasts for Missouri are released only once a year starting in 1991, which would imply small sample sizes for this later time period.

[6] An estimated ratio of 0.73673 is applied to lean-hog futures prices. This factor is obtained by dividing an average weight for lean hogs (180.5) by an average weight for live hogs (245). The adjustment is necessary because the Chicago Mercantile Exchange shifted delivery terms from a live weight to carcass weight basis beginning with the February 1997 contract.

[7] A three-year moving average basis forecast is also computed. Consistent with Garcia and Sanders' (1996) results, ARMA forecasts with seasonal (quarterly) dummy variables provide superior live/lean hog and cattle basis forecasts compared to a three-year moving average procedure. The reduction in RMSE averages \$0.50/cwt., \$0.26/cwt., and \$0.03/cwt. for one-, two-, and three-quarter ahead basis forecasts, respectively, in live/lean hogs. The reduction in RMSE averages \$0.34/cwt. and \$0.19/cwt. for one- and two-quarter ahead basis forecasts, respectively, in live cattle. See Colino and Irwin (2009) for complete results of the basis comparisons.

[8] For both hogs and cattle, second quarter futures forecasts are based on June and August contracts, third quarter forecasts are based on August and October contracts and fourth quarter forecasts are based on December and February (following calendar year) contracts. Settlement prices for live/lean hog and live cattle futures contracts are obtained from the Chicago Mercantile Exchange (CME).

[9] See Colino and Irwin (2009) for the results based on settlement prices from the day before release for each outlook forecast.

[10] Forecast errors also are computed in percentage form. Test results are qualitatively similar with the exception of normality tests for hog price forecast errors. Due to an exceptionally large drop in hog prices during 1998.IV, most percentage forecast errors for this quarter exceed or are close to 100%. This large outlier results in rejection of normality in most cases in hogs. However, subsequent RMSE and encompassing test results are similar whether forecast errors are stated in $/cwt. or percentage terms. See Colino and Irwin (2009) for these additional results.

[11] As noted by an anonymous reviewer, the comparisons in table 4 are based upon "modified futures prices." That is, futures price quotations are adjusted by a basis forecast before comparisons are made to outlook price forecasts.

[12] As discussed earlier, forecast accuracy measures should not be compared across outlook programs because the forecasts have different release dates that may reflect differing information sets. However, an accuracy ranking relative to futures can be constructed based on the RMSE differences found in table 4. Rankings based on the RMSE differences show that Iowa is ranked first for both hogs and cattle at all horizons

except one-quarter ahead in hogs in which Missouri is ranked first. In all other cases, Missouri is always ranked second for hogs and cattle. The USDA is always ranked third and Illinois/Purdue is always ranked last.

[13] Plots of the difference between futures and outlook squared forecast errors (d_t) for other outlook programs did not reveal any comparable breaks in relative forecast accuracy.

[14] The basic intuition is drawn from portfolio theory. Specifically, a portfolio (combination) of two forecasts with equal forecast error variances will have a lower forecast error variance than either of the two individual forecasts so long as the forecast errors are less than perfectly positively correlated. A portfolio of two forecasts with unequal forecast error variances can be formed that will have a lower forecast error variance than the forecast with the smallest error variance, so long as the correlation between the two forecast errors does not equal the ratio of the forecast error variances (Granger and Newbold 1986, p. 267).

[15] It is impossible to test for every possible breakpoint in the sample due to degrees of freedom limitations in estimating regressions. More specifically, the statistical power of the test is reduced as more alternative break points closer to the sample boundaries are analyzed.

[16] Andrews (1993) and Andrews and Ploberger (1994) propose two related tests that may be more powerful than the QLR test. The alternative tests involve simple or exponentially-weighted averages of the sample values for $F(\tau)$. Hypothesis test results

differ little based on the alternative test statistics. In addition, a 10% trimming percentage (5% on each side) is also considered for QLR tests. Hypothesis test results are similar under the smaller trimming percentage. See Colino and Irwin (2009) for these additional results.

Table 1. Outlook program forecast data in hogs and cattle

Commodity/ Outlook Program	Forecast Sample Period	# of Quarters	# Missing Observations 1-qtr.	2-qtr.	3-qtr.	Average Timing of Release	Forecast Cash Price Series	Source Publication
Hogs								
Illinois/Purdue	1979.II-2007.IV	115	3 (2.6)	4 (3.5)	5 (4.3)	10 days after start of each calendar quarter	1979.II-1985.II: Barrows & Gilts (7mkts) 1985.III-1994.I: Barrows & Gilts (Omaha) 1994.II-2007.IV: Barrows & Gilts (6mkts)	*Livestock Price Outlook*
Iowa	1975.I-2007.IV	132	1 (0.8)	1 (0.8)	15 (11.4)	2 days after start of each calendar quarter	1975.I-2006.IV: Barrows & Gilts (Iowa-S.MN.)	*Iowa Farm Outlook*
Missouri	1974.II-2007.IV	135	5 (3.7)	6 (4.4)	27 (20.0)	2 days after start of each calendar quarter	1974.II-1991.IV: Barrows & Gilts (7mkts) 1992.I-1994.II: Barrows& Gilts (6mkts) 1994.III-2007.IV: Barrows & Gilts (Terminal mkt)	*Livestock Outlook Letter Quarterly Hog Outlook-AgEBB*
USDA	1974.I-2007.IV	136	3 (2.2)	25 (18.4)	NA (NA)	43 days before start of each calendar quarter	1974.I-1991.IV: Barrows & Gilts (7mkts) 1992.I-1992.II: Barrows & Gilts (6mkts) 1992.III-1999.III: Barrows& Gilts (Iowa-S.MN.) 1999.IV-2006.IV: Barrows& Gilts (Nat. Base)	*Livestock Situation & Outlook LDPO*
Cattle								
Illinois/Purdue	1979.II-2007.IV	75	9 (12.0)	19 (25.3)	NA (NA)	57 days before start of each calendar quarter	1987.III-1995.II: Choice Steers (Omaha) 1995.III-2007.IV: Choice Steers (Nebraska)	*Livestock Price Outlook*
Iowa	1975.I-1996.I	85	1 (1.2)	37 (43.5)	NA (NA)	59 days before start of each calendar quarter	1975.I-1996.I: Choice Steers (Iowa-S.MN)	*Iowa Farm Outlook*
Missouri	1974.III-2007.I	86	6 (7.0)	NA (NA)	NA (NA)	57 days before start of each calendar quarter	1974.III-1992.I: Choice Steer (Omaha)	*Livestock Outlook Letter Quarterly Cattle Outlook-AgEBB*
USDA	1974.I-2007.IV	136	4 (2.9)	24 (17.6)	NA (NA)	43 days before start of each calendar quarter	1974.I-1991.I: Choice Steers (Omaha) 1991.II-2007.IV: Choice Steers (Nebraska)	*Livestock Situation & Outlook LDPO*

Notes: Figures in parentheses are the percentage of missing observations. NA denotes not applicable. AgEBB: Agricultural Electronic Bulletin Board. LDPO: Livestock, Dairy, and Poultry Outlook. Illinois/Purdue cattle price forecasts are released on a quarterly basis over 1979.II-1987.III and a semi-annual basis thereafter. Missouri cattle price forecasts are released on a quarterly basis over 1974.II-1991.IV and an annual basis thereafter. The number of quarters and number of missing observations for Illinois/Purdue and Missouri in cattle reflect an assumption of two release quarters per year after 1987.IV for Illinois/Purdue and one release quarter per year after 1992.I for Missouri.

Table 2. Examples of futures model computations for one-quarter-ahead hog forecasts, 2005.I and 2005.II

	Forecast quarter: 2005.I USDA outlook release date: 11/18/2004				**Forecast quarter: 2005.II USDA outlook release date: 2/15/2005**				
	Jan'05	**Feb'05**	**Mar'05**	**Apr'05**	**Apr'05**	**May'05**	**Jun'05**	**Jul'05**	**Aug'05**
Futures prices									
1) Settlement price by contract observed the day of USDA outlook report release		73.17		70.10			77.35		70.47
2) Monthly average price based on futures contract prices	73.17	70.10	70.10		77.35	77.35	70.47		
3) Quarterly futures price (average)		71.12				75.06			
4) Lean-live adjustment [(3)*1/1.35]		52.68				55.60			
5) basis (ARIMA forecast)		-0.31				-2.24			
6) **Quarterly futures-based forecast** [(4)+(5)]		**52.37**				**53.36**			
7) Actual quarterly price		51.92				52.09			

Notes: All figures are reported as $/cwt.

Table 3. Descriptive statistics for outlook and futures forecast errors in hogs and cattle

Forecast Comparison	Horizon	Hogs Mean	Hogs Standard Deviation	Hogs Minimum	Hogs Maximum	Cattle Mean	Cattle Standard Deviation	Cattle Minimum	Cattle Maximum
Illinois/Purdue vs.	1-qtr.-ahead	-0.10	5.60	-13.45	18.24	-1.88 **	7.53	-19.56	22.73
Futures		-0.53	3.63	-9.75	8.72	0.65	5.75	-9.58	21.87
	2-qtr.-ahead	-0.18	7.53	-20.72	19.23	-2.62 **	7.37	-27.21	10.97
		-0.08	5.90	-13.68	19.68	0.68	5.61	-13.47	16.03
	3-qtr.-ahead	0.08	8.45	-22.31	18.54	NA	NA	NA	NA
		0.35	6.62	-17.77	17.08	NA	NA	NA	NA
Iowa vs.	1-qtr.-ahead	0.32	4.42	-9.68	10.80	-0.55	5.44	-14.33	13.07
Futures		0.32	3.61	-11.08	11.56	1.19 **	5.15	-10.65	11.45
	2-qtr.-ahead	0.42	6.30	-19.01	16.98	0.13	6.05	-12.33	16.91
		0.91	6.62	-15.47	22.27	1.91 **	6.14	-12.77	16.27
	3-qtr.-ahead	0.81	7.24	-20.01	17.69	NA	NA	NA	NA
		0.86	7.43	-19.03	21.26	NA	NA	NA	NA
Missouri vs.	1-qtr.-ahead	0.00	4.07	-13.73	8.73	-0.64	5.45	-14.34	13.06
Futures		-0.20	3.45	-11.82	8.73	0.94	5.05	-10.95	12.01
	2-qtr.-ahead	0.32	6.49	-17.01	16.63	NA	NA	NA	NA
		0.63	5.87	-13.66	17.38	NA	NA	NA	NA
	3-qtr.-ahead	0.72	7.04	-16.01	17.22	NA	NA	NA	NA
		0.86	6.95	-17.99	16.70	NA	NA	NA	NA
USDA vs.	1-qtr.-ahead	0.42	6.03	-15.00	16.82	-0.41	5.83	-13.84	22.38
Futures		0.58	4.99	-12.84	15.14	0.74 *	5.05	-9.31	18.81
	2-qtr.-ahead	0.68	7.47	-15.00	17.75	-0.49	6.29	-13.71	22.38
		1.25 **	6.44	-16.31	15.32	1.72 ***	5.95	-11.74	26.11

Notes: All statistics are reported as $/cwt. NA denotes not applicable. The first row in each pair of rows shows results for the indicated outlook program at a given forecast horizon and the second row shows results for the comparable futures forecast. One, two, and three stars indicate statistical significance at the 10% , 5%, and 1% levels, respectively. Sample periods in hogs are: Illinois/Purdue - 1979.II-2007.IV; Iowa - 1975.I-2007.IV; Missouri - 1974.II-2007.IV; USDA - 1974.I-2007.IV. Sample periods in cattle are: Illinois/Purdue - 1979.II-2007.IV; Iowa - 1975.I-1996.I; Missouri - 1974.III-2007.I; USDA - 1974.I-2007.IV

Table 4. Root mean squared errors (RMSEs) of outlook and futures forecasts in hogs and cattle

Forecast Comparison	Hogs 1-qtr.-ahead	Hogs 2-qtr.-ahead	Hogs 3-qtr.-ahead	Cattle 1-qtr.-ahead	Cattle 2-qtr.-ahead	Cattle 3-qtr.-ahead
Illinois/Purdue vs.	5.57	7.50	8.41	7.70	7.76	NA
Futures	3.65	5.88	6.60	5.75	5.60	NA
Difference	1.92 ****	1.62 ***	1.82 ***	1.95 ***	2.15 *	NA
Iowa vs.	4.41	6.29	7.25	5.43	5.99	NA
Futures	3.61	6.65	7.45	5.26	6.37	NA
Difference	0.80 ***	-0.36	-0.20	0.18	-0.38	NA
Missouri vs.	4.06	6.47	7.04	5.46	NA	NA
Futures	3.45	5.89	6.97	5.11	NA	NA
Difference	0.61 **	0.59 **	0.07	0.35	NA	NA
USDA vs.	6.03	7.47	NA	5.82	6.28	NA
Futures prices	5.01	6.53	NA	5.09	6.17	NA
Difference	1.02 ****	0.94 *	NA	0.73 **	0.11	NA

Notes: All figures are reported as $/cwt. NA denotes not applicable. The first row in each pair of rows shows the RMSE for the indicated outlook program and the second row shows the RMSE for the comparable futures forecast. One, two, and three stars indicate statistical significance at the 10%, 5% and 1% level, respectively, based on the Modified Diebold-Mariano (MDM) test. Sample periods in hogs are: Illinois/Purdue - 1979.II-2007.IV; Iowa - 1975.I-2007.IV; Missouri - 1974.II-2007.IV; USDA - 1974.I-2007.IV. Sample periods in cattle are: Illinois/Purdue - 1979.II-2007.IV; Iowa - 1975.I-1996.I; Missouri - 1974.III-2007.I; USDA - 1974.I-2007.IV

Table 5. Forecast encompassing tests between outlook and futures forecasts in hogs and cattle

Forecast	Hogs			Cattle		
Comparison	1-qtr.-ahead	2-qtr.-ahead	3-qtr.-ahead	1-qtr.-ahead	2-qtr.-ahead	3-qtr.-ahead
		---MDM statistic---			---MDM statistic---	
Illinois/Purdue vs. Futures	1.16	0.38	1.08	0.27	0.36	NA
Iowa vs. Futures	1.93 *	4.70 ***	3.91 ***	2.20 **	2.33 **	NA
Missouri vs. Futures	2.07 **	0.70	2.05 **	1.66	NA	NA
USDA vs. Futures	1.30	1.10	NA	1.66 *	2.77 ***	NA
		--- λ estimate---			--- λ estimate---	
Illinois/Purdue vs. Futures	0.09	0.05	0.13	0.04	0.05	NA
Iowa vs. Futures	0.20 **	0.61 ***	0.57 ***	0.41 **	0.74 ***	NA
Missouri vs. Futures	0.23 **	0.11	0.46 **	0.34 *	NA	NA
USDA vs. Futures	0.13	0.19	NA	0.21 *	0.47 ***	NA

Notes: NA denotes not applicable. One, two, and three stars indicate statistical significance at the 10%, 5% and 1% level, respectively. The null hypothesis for the encompassing test is that the "preferred" forecast (futures) encompasses the alternative forecast (outlook). MDM denotes modified Diebold-Mariano test statistic. The λ estimates are based on a regression of the futures forecast error on the difference between the futures and outlook forecast error without an intercept. Sample periods in hogs are: Illinois/Purdue - 1979.II-2007.IV; Iowa - 1975.I-2007.IV; Missouri - 1974.II-2007.IV; USDA - 1974.I-2007.IV. Sample periods in cattle are: Illinois/Purdue - 1979.II-2007.IV; Iowa - 1975.I-1996.I; Missouri - 1974.III-2007.I; USDA - 1974.I-2007.IV.

Table 6. Composite forecast comparisons in hogs and cattle

Outlook Program	Horizon	Hogs Composite RMSE	Hogs Futures RMSE	Hogs RMSE Reduction	Cattle Composite RMSE	Cattle Futures RMSE	Cattle RMSE Reduction
Illinois/Purdue	1-qtr.-ahead	3.63	3.65	-0.6%	5.75	5.75	-0.1%
	2-qtr.-ahead	5.87	5.88	-0.1%	5.60	5.60	-0.1%
	3-qtr.-ahead	6.55	6.60	-0.7%	NA	NA	NA
Iowa	1-qtr.-ahead	3.55	3.61	-1.7%	5.08	5.26	-3.4%
	2-qtr.-ahead	6.04	6.65	-9.2%	5.93	6.37	-6.9%
	3-qtr.-ahead	6.99	7.45	-6.1%	NA	NA	NA
Missouri	1-qtr.-ahead	3.38	3.45	-1.9%	4.97	5.11	-2.6%
	2-qtr.-ahead	5.88	5.89	-0.2%	NA	NA	NA
	3-qtr.-ahead	6.80	6.97	-2.4%	NA	NA	NA
USDA	1-qtr.-ahead	4.98	5.01	-0.5%	5.03	5.09	-1.1%
	2-qtr.-ahead	6.47	6.53	-0.9%	5.81	6.17	-5.9%

Notes: RMSE denotes root mean squared error, which is reported as $/cwt. NA denotes not applicable. Composite forecasts are based on λ estimates from encompassing regressions of futures errors on the difference between futures and outlook forecasts (see table 5). Sample periods in hogs are: Illinois/Purdue - 1979.II-2007.IV; Iowa - 1975.I-2007.IV; Missouri - 1974.II-2007.IV; USDA - 1974.I-2007.IV. Sample periods in cattle are: Illinois/Purdue - 1979.II-2007.IV; Iowa - 1975.I-1996.I; Missouri - 1974.III-2007.I; USDA - 1974.I-2007.IV

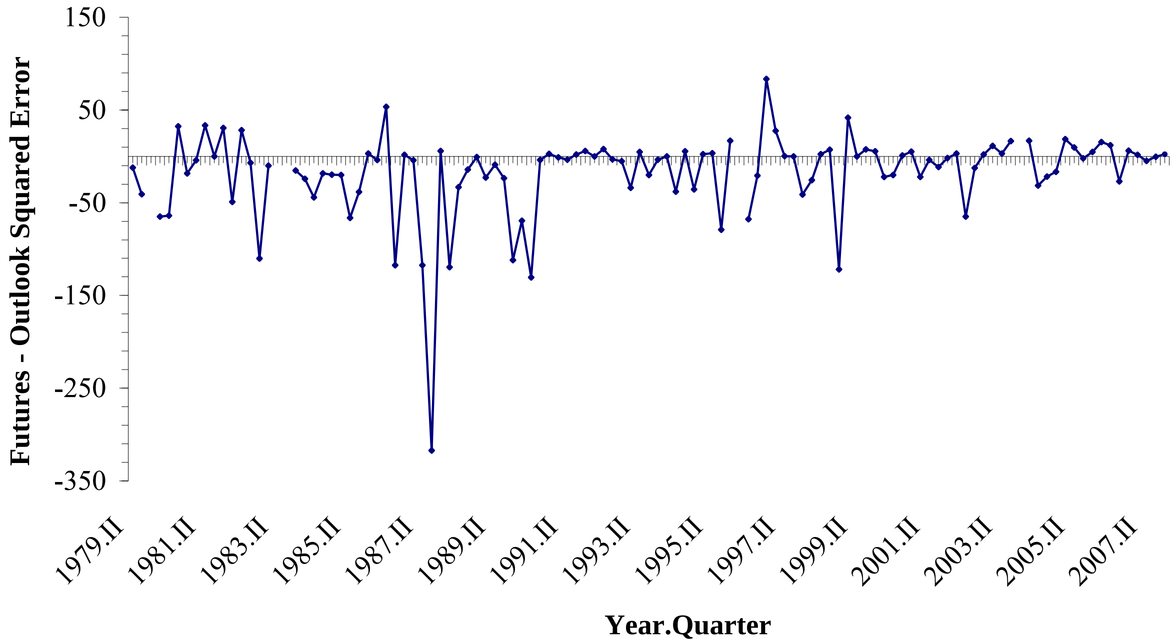

Figure 1. Difference Between Futures and Illinois/Purdue One-Quarter Ahead Squared Forecast Errors ($/cwt.) for Hogs, 1979.II-2007.IV

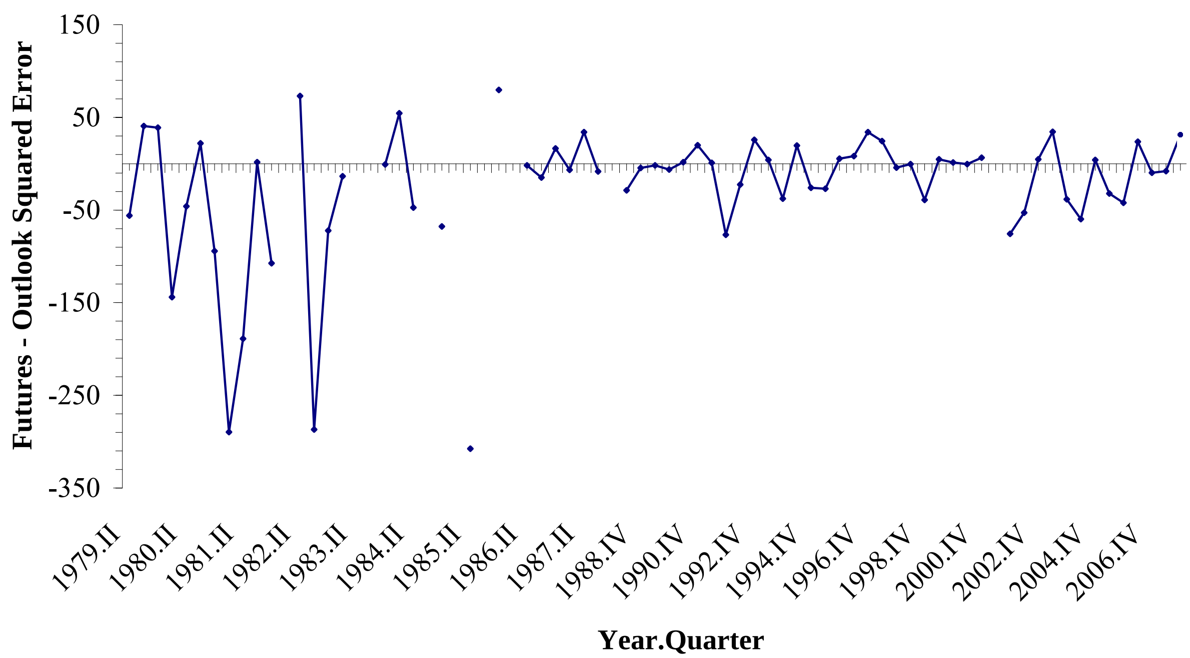

Figure 2. Difference Between Futures and Illinois/Purdue One-Quarter Ahead Squared Forecast Errors ($/cwt.) for Cattle, 1979.II-2007.IV