Incorporating Current Information into Historical-Average-Based Forecasts to Improve Crop Price Basis Forecasts

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Paper presented at the NCR-134 Conference on Applied Commodity Price Analysis, Forecasting, and Market Risk Management
St. Louis, Missouri, April 19-20, 2004

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Being able to accurately predict basis is critical for making marketing and management decisions. Basis forecasts can be used along with futures prices to provide cash price projections. Additionally, basis forecasts are needed to evaluate hedging opportunities. Many studies have examined factors affecting basis but few have explicitly examined the ability to forecast basis. Studies have shown basis forecasts based on simple historical averages compare favorably with more complex forecasting models. However, these studies typically have considered only a 3-year historical average for forecasting basis. This research compares practical methods of forecasting basis for wheat, soybeans, corn, and milo (grain sorghum) in Kansas. Across most of the multiple-year forecast methods considered, absolute basis forecast errors were slightly higher for the harvest forecasts than the post-harvest forecasts. Using an historical 3-year average to forecast basis for wheat and soybeans was optimal as compared to other multiple-year forecasts. For corn and milo, a 2-year average was the optimal multiple-year forecast method. Incorporating current market information, such as current nearby basis deviation from an historical average, into a harvest basis forecast improves accuracy for only the 4 weeks ahead of harvest vantage point, but improves the accuracy of post-harvest basis forecasts (24 weeks after harvest) from nearly all vantage points considered.

Keywords: Basis forecast, crop basis, current information

Introduction

Crop production flexibility today requires producers to make management decisions based on market conditions. Economically sound decisions are critical for producers to manage risk and take advantage of marketing opportunities. An integral factor in production and marketing plans is accurate forecasting of the local crop basis. Typically, crop basis has been predicted using historical averages that do not consider current information. The question that arises is: Can alternative methods of basis forecasting that incorporate current market data improve predictions?

There has been considerable debate as to whether producers can enhance income by using systematic crop marketing strategies involving the futures and options markets. Zulauf and Irwin conclude that marketing strategies offer little hope of increasing returns over simply selling at harvest. They suggest that, because futures are efficient, the futures market should be used as a source of information rather than as a trading medium. Kastens, Jones and Schroeder compared various simple-to-construct forecasting methods for cash prices and concluded that the deferred futures plus historical basis forecast method was the most accurate for most commodities considered. Brorsen and Irwin suggest that, rather than forecasting prices, extension economists should rely on the futures market to provide the price forecasts needed in outlook programs. Kastens and Dhuyvetter looked at incorporating deferred futures prices and historical localized basis to make grain storage decisions. However, positive returns to storage were not generally found, indicating that cash markets appear to be efficient.

Several studies have found that producers' price expectations are consistent with futures prices (Eales, et al. and Kenyon). Further, producers have indicated they use the futures market as one of their primary sources of information in forming price expectations to make production and precise buy/sell timing decisions (Schroeder et al.). However, producers also indicated they used extension outlook meetings for price forecasts. A disadvantage of relying on extension outlook meetings is that the price forecasts may not be timely or location-specific enough to meet the needs of producers. Futures market forecasts, on the other hand, are readily available every day and can be used for any location. Thus, it is appropriate to encourage producers to use futures-market-based price forecasts as this is consistent with much of the published research and because they are readily available at little cost.

When producers use the futures market for price forecasts, they need to localize the futures price by adding an expected basis. For that matter, whether producers use the futures market for cash price forecasts or for hedging, the ability to accurately forecast basis is critical. Basis forecasts can be potentially valuable for marketing decisions as they support hedging decisions (Tomek). Many researchers have pointed out that the ability to predict basis is important when hedging (e.g., Hauser, Garcia, and Tumblin; Kenyon and Kingsley; Naik and Leuthold; Tomek). Despite that, in studies using futures as price forecasts, basis procedures rarely garner more than cursory footnotes. Typically, basis forecasts are based on simple time series or naive models. That is, expected (future) basis is assumed to be historical basis. Nonetheless, especially complex models for forecasting basis are probably not relevant for producers, as producers must be able to constantly and quickly translate futures prices to cash price expectations for such information to be useful. Moreover, structural models requiring ancillary forecasts of explanatory variables are of little value to producers needing to make production decisions based on price forecasts with limited information available. Thus, research designed to improve the efficiency of cash price forecasting with futures prices should focus on simple basis models, especially those that are alternative renditions and extensions of "historical basis is expected basis" models.

The objectives of this research involve comparing the accuracy of practical alternatives for forecasting wheat, soybean, corn, and milo (grain sorghum) basis that exist for Kansas producers. Practical alternatives refer to methods of forecasting basis that producers could use with information and methods that are readily available to them. Specifically, the first objective of this study is to determine the number of years that should be used to obtain an historical average that is a reliable predictor of future basis. For example, is a 3-year or 5-year average historical basis more accurate as a predictor of future basis? A disadvantage of using historical basis to forecast future basis levels is that current market information is not considered (Jiang and Hayenga). It is hypothesized that incorporating current market information into a basis forecast may improve forecasting accuracy. Thus, a second objective is to determine if the accuracy of basis forecasts can be improved by incorporating current market data, where this current information will be measured as the difference between the current nearby basis and its historical average. By answering these questions, recommendations can be made to producers regarding basis models that are based on statistically tested basis forecasting methods. Additionally, helping producers forecast basis so they can use the futures market to obtain price forecasts is consistent with the vast amount of research indicating grain futures are efficient.

Background

A number of studies have examined factors that affect grain basis (e.g., Garcia and Good; Kahl and Curtis; Martin, Groenewegen, and Pidgeon; Tilley and Campbell). These studies generally build on the theory of storage as outlined by Working and include fundamental supply and demand factors. Even though these studies examined factors affecting basis, none of them explicitly examined the ability to forecast basis. While understanding and predicting basis is considered to be important for hedging or using the futures market for cash price forecasts, there are relatively few studies examining methods of forecasting basis (Jiang and Hayenga; Tomek).

Jiang and Hayenga compared ten different basis forecasting models for corn and soybeans at various locations in the United States. Of their ten forecasting models, only one, a simple 3-year historical average, could readily be used by most producers given the informational and statistical requirements of the methods. However, based on root mean squared errors (RMSE), the 3-year average forecast method compared favorably to the more complex forecasting methods for corn basis. For soybean basis, the best forecasting method was the 3-year average plus method which incorporated current supply and demand information into the forecast. A seasonal ARIMA model was the second-best method and the simple 3-year average forecast was the third-best method based on the RMSE criterion. They concluded that forecasting basis using a simple 3-year average method can be outperformed by alternative models, however, they also pointed out that the simple historical average method provided a reasonably good forecast.

Hauser, Garcia, and Tumblin compared five different methods of forecasting soybean basis at ten locations in Illinois. They considered a naive forecast (i.e., expected basis is current basis), forecasts based on a 1-year and a 3-year historical average, and an implied basis using the price spread between futures contracts (they used two renditions of this approach). These methods are attractive from a producer's standpoint as they are relatively easy to compute and use information that is available at low cost. The authors also considered regression models that were more "sophisticated," (see Garcia, Hauser, and Tumblin) but concluded that the simpler models provided the best basis forecasts. They found that forecasting basis using observable futures price spreads worked well for certain time periods, however, the time horizons in their basis forecasts were relatively short (30 to 60 days). Naik and Leuthold concluded that predicting expected maturity basis one month ahead of the maturity period was possible using current information, but that the basis prediction accuracy decreases as the time period increased.

Kenyon and Kingsley compared basis forecasts from a simple 3-year historical average and regression models for corn and soybeans in Virginia. Their regression model predicted a change in basis as a function of the initial basis. They concluded that using regression analysis to predict harvest basis was superior to using an historical average to predict basis. However, their regression equation included variables for delivery point cash price and a measure involving open interest, which may not be readily available to producers. Even if these variables are readily available, the regression approach requires producers to use a statistical technique they may not be familiar with or able to update from year to year.

Dhuyvetter and Kastens built upon previous work by Hauser, Garcia, and Tumblin by comparing practical methods of forecasting basis for wheat, corn, milo, and soybeans in Kansas. They found that a 4-year historical average was the optimal number of years to forecast basis. A longer-term average (5 to 7 years) was optimal for corn, milo, and soybeans. They looked at incorporating current market information into forecasts using futures price spreads and an historical average that is adjusted by current nearby basis information. The basis forecasts were slightly more accurate when incorporating price spreads between futures contracts than using current nearby basis information. However, neither of these methods was better than a simple historical average with time horizons greater than 8 to 12 weeks. This analysis did not recognize that the optimal amount of current information to incorporate, when adjusting an historical average, is likely a function of the time horizon.

Tonsor, Dhuyvetter, and Mintert considered the addition of current information in a more formalized model for predicting feeder and live cattle basis. They defined current information to be the deviation of current basis from historical levels on the date the forecast is made. While accuracy of the basis forecast was improved with the addition of current information, they concluded that the value of the current information declined rapidly as the number of weeks between the forecasting horizon and the date being forecasted increased. Beyond 12 and 8 weeks for feeder cattle and live cattle basis forecasts, respectively, there was little value to incorporating current information into the basis forecast.

This study expands the work in grain basis forecasting previously completed by Dhuyvetter and Kastens by formalizing a basis forecasting model that incorporates current information using a methodology similar to that used by Tonsor, Dhuyvetter, and Mintert. This study will also revisit the process of determining the number of years to use in an historical basis forecast model by updating the data used in the previous study by Dhuyvetter and Kastens. Wheat, soybean, corn, and milo basis are forecasted across various time horizons using models based on: (1) alternative historical averages (different numbers of years) and (2) historical average plus current basis information. All forecasting methods rely on data that are readily available to producers and analysis methods that are easily understood by producers. Because local supply and demand conditions vary by crop and location, multiple locations in Kansas are considered for each crop.

Basis Forecast Models

Eight methods are used to forecast basis for wheat, soybeans, corn, and milo for two points during the crop year: harvest and 24 weeks after harvest. Multiple vantage points are considered to forecast the two points. That is, various pre-harvest forecasts are developed for the basis at harvest (*harvest*), and various post-harvest forecasts are developed for the basis at 24 weeks after harvest (*harvest+24*). This study consistently uses basis to mean nearby basis, where nearby denotes the futures contract closest to delivery, only avoiding the delivery month.[2] For example, although December corn futures trade, the corn basis observed in December is cash price in December less March corn futures price on the same day. The first seven forecast methods are based on historical averages and are given as

$$(1) \qquad \hat{Basis}_{k,j,t,i} = \frac{1}{i}\sum_{m=t-i}^{m=t-1} Basis_{k,j,m} \,,$$

where $\hat{Basis}$ represents the nearby basis forecast, *Basis* is observed basis, *k* refers to location, *j* refers to the time period being forecasted (*harvest* or *harvest+24*), *t* refers to the crop year (1989 through 2002) for which a basis prediction is made, and *i* refers to the number of years included in the historical average (1,2,…,7). There is no subscript indicating the vantage point from which the basis forecast is made (the horizon) since the forecast for a particular week is the same regardless of when the forecast is made. Previous studies considering historical averages as basis forecasts generally used a 3- or 5-year average. Historical averages from 1 to 7 years were used to determine if a shorter- or longer-term average is superior.

The eighth method of forecasting basis uses an historical average and incorporates current information by including an adjustment for how the current nearby basis deviates from *its* historical average. The underlying idea is that especially strong or especially weak current basis would be expected to carry into future time periods within the crop year. The basis forecast for this method is given by

$$(2) \qquad \hat{Basis}_{k,j,t,i,h} = \frac{1}{i}\sum_{m=t-i}^{m=t-1} Basis_{k,j,m} + \lambda\left(Basis_{k,j-h,t} - \frac{1}{i}\sum_{m=t-i}^{m=t-1} Basis_{k,j-h,m}\right),$$

where *h* denotes horizon (number of weeks ahead of period forecasted when forecast is made), λ is the "amount" of current information included in the forecast, and all other terms are as already described. Note that $\lambda = 0$ gives back the simple historical average method of equation 1, and that $\lambda = 1$ implies that the traditional historical average basis prediction is "fully adjusted" by the amount current basis deviates from its historical value. Dhuyvetter and Kastens implicitly use $\lambda = 1$ (full information) in their current information basis forecast.

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[2] This distinction of nearby is consistent with grain elevators that do not price delivery month cash prices off the delivery contract, rather they step out one contract.

Data and Forecasts Developed

Wednesday closing prices for wheat, soybeans, corn, and milo were collected for the first week of the 1982 crop year through the last week of the 2002 crop year. Prices were gathered from six locations in Kansas for wheat, milo, and soybeans, and five locations for corn.[3] If a Wednesday happened to fall on a holiday, the Thursday price was used. Nearby futures price data corresponding to the cash price series were collected from the Kansas City Board of Trade for wheat futures and the Chicago Board of Trade for corn and soybean futures. Milo price was converted to dollars per bushel and milo basis was calculated using the corn futures price. Price data were structured on the basis of four weeks per month. If a month had five Wednesdays, the fourth and fifth weeks' prices were averaged and reported as the fourth week of the month. Missing data were extrapolated to ease the computational burden.[4]

Basis forecasts were developed for each commodity at each location and, because of the large quantity of data, for only two points during the crop year (*harvest* and *harvest+24*).[5] Because the 7-year average method requires seven years of historical data, all out-of-sample forecasts were for weeks in the crop years 1989-2002. For the forecasts using current information, harvest basis was forecasted from vantage points of 4, 8, 12, 16, 20, 24, 28, and 32 weeks prior to harvest (collectively referred to as *harvest* forecasts). The basis 24 weeks after harvest was forecasted from vantage points of 4, 8, 12, 16, and 20 weeks prior to that point (collectively referred to as *harvest+24* forecasts). This process was repeated for each location and crop.

Forecast Evaluation Procedures

A series of forecasts is associated with a series of forecast errors. For evaluation, the information embodied in a forecast error series is routinely condensed into a single test statistic such as the sum of squared errors or mean absolute error (MAE) so that alternative forecasts can be compared in a generalizing way. This approach allows pairwise comparisons among competing forecast methods. Producers forecasting basis likely are interested in how precise their forecasts are expected to be. Thus, the relevant error series is absolute error. The MAE of each forecasting method was used to compare the models, by crop, with a pairwise t-test. Because the number of basis forecasts examined in this study was large, absolute errors were first aggregated over locations using means. More importantly, pairwise tests without consideration of the likely location-to-location dependence in absolute error differences would be inappropriate. Yet, aggregating forecast errors across locations still allows one to determine if basis can

[3] Data were collected from Scott City, Beloit, Hutchinson, Topeka, Emporia and Colby for wheat, soybeans and milo. Insufficient data were available from Beloit for corn.

[4] Missing data were less than 1% over the entire study time period and were filled in using proportional changes in corresponding nearby futures prices before and after the missing points. For example, if a cash price in week 2 were missing, but weeks 1 and 3 were present, then the cash price was the average: [(week 2 fut/week 1 fut * week 1 cash) + (week 2 fut/week 3 fut * week 3 cash)]/2. If contiguous cash prices were absent, the adjustment process was iterated until convergence within $0.000001.

[5] Harvest weeks are the 4th week in June for wheat, the 1st week in October for corn, the 3rd week in October for milo, and the 2nd week in October for soybeans (Kastens and Dhuyvetter).

be forecasted more accurately at certain times of the year. Table 1 lists the MAE for each of the forecasting methods averaged across locations for both the *harvest* and *harvest+24* forecast periods.

To obtain a "best" method of forecasting for each crop, the seven historical-average methods were compared based on statistical significance of pairwise t-tests and the magnitude of the MAE's. The intent was to determine a fixed rule that could be formed for both pre- and post-harvest forecasts for a given crop. This rule would simplify exposition in an extension setting. Nothing obvious emerged from the results of the paired t-tests of accuracy. Consequently, based on a subjective consensus of the authors, and partly because of a predisposition to avoid 1- and 7-year forecasts (which where not statistically different from other methods in most cases), the "best" method was arbitrarily selected as a 3-year average for wheat and soybeans and a 2-year average for corn and milo. These respective methods for each crop were used for the both the *harvest* and *harvest+24* forecasting time periods.

The addition of current information to the historical averages was evaluated over the 1989 to 2002 time period. Once the number of years in the multi-year historical average method were selected for each crop, the optimal percentage of current information (i.e., the λ in equation 2) was solved for by minimizing the MAE associated with the forecast model. A separate MAE-minimizing λ was selected for each forecasting vantage point associated with the two time periods forecasted, but not for each location, nor for each year. Additionally, λ estimates were constrained to be between 0 and 1 to be consistent with the underlying theory.

Results

Multi-Year Historical Average Evaluation

The t-test matrices for the *harvest* and *harvest+24* time periods are listed in tables 2 to 5 for wheat, soybeans, corn, and milo, respectively. The "best" forecasting method for wheat was determined to be the 3-year average (based on paired t-tests of associated basis MAE's and p-value ≤ 0.10). Using this method, the MAE was approximately 17.1 cents per bushel for *harvest* forecasts and 16.4 cents per bushel for *harvest+24* forecasts. This compares to a MAE of 10.1 cents per bushel across all weeks of the year for wheat, as determined by Dhuyvetter and Kastens using a 4-year average. A 3-year average method was selected for soybeans. The MAE using this method for soybeans was 16.3 cents per bushel for *harvest* forecasts and 15.7 cents per bushel for *harvest+24* forecasts. Dhuyvetter and Kastens found a MAE of 9.5 cents per bushel across all weeks of the year for soybeans using a 7-year average. A 2-year average was selected for both corn and milo. The MAE for corn was 12.1 cents per bushel for *harvest* forecasts and 10.8 cents per bushel for *harvest+24* forecasts. The MAE for milo was 12.4 cents per bushel for *harvest* forecasts and 12.0 cents per bushel for *harvest+24* forecasts. These compare to Dhuyvetter and Kastens' results indicating a MAE of 10.8 cents per bushel across all weeks of the year for milo, using a 5-year average and 10.6 cents per bushel for all weeks of the year for corn, using a 7-year average.

Current Information Evaluation

Figure 1 shows the optimal values of λ for each crop over the forecast horizons for a *harvest* forecast. Paired t-tests were used to identify the statistical significance of the addition of current information into the forecasting model at various weights (λ = 0, λ = "optimal value", λ = 1). These t-test results and MAE's are provided in tables 6 to 9 for wheat, soybeans, corn, and milo, respectively. Note that λ = 0 gives back the simple historical average method of equation 1, and that λ = 1 denotes the simplistic selection of λ that adjusts the traditional historical average basis prediction fully for the amount current basis deviates from its historical value.

For *harvest* wheat, the only horizon with a λ value statistically different from 0 (based on paired t-tests of associated basis MAE's and p-value ≤ 0.10) was 4 weeks before *harvest*. The optimal weight for this forecast horizon was λ = 0.58. For soybeans, optimal λ's were significantly different from 0 for 4, 12, and 32 weeks prior to *harvest* and were equal to 0.33, 0.34, and 0.58, respectively. The magnitudes of the MAE's of the optimal λ models did not differ significantly from the MAE's of the λ = 0 models for wheat or soybeans.

The optimal values for corn λ's were significantly different from zero at 4, 16, 20, 24, 28, and 32 weeks prior to *harvest*. The values are 0.57, 0.51, 0.67, 0.76, 0.82, and 0.78, respectively. The magnitude of the MAE's of the optimal λ models were significantly different from the λ = 0 models. On average, the MAE of the optimal λ forecasts for *harvest* corn was 9.9 cents per bushel, as compared to an MAE of 12.1 cents per bushel for the λ = 0 models. For milo, optimal λ's different from zero were for 4, 8, 12, 16, 20, and 24 weeks prior to *harvest*. The optimal values of λ are 0.81, 0.56, 0.35, 0.41, 0.31, and 0.43, respectively. There was a significant difference in the magnitude of the MAE's of the optimal λ models versus the λ = 0 models for milo. The average MAE of the optimal λ models was approximately 2 cents per bushel lower than the MAE of the λ = 0 models for *harvest* milo basis. All crops followed a similar pattern of λ being significant and positive four weeks prior to harvest. Other time horizons varied noticeably, depending on the crop.

Figure 2 shows the optimal values of λ for each crop over the forecast horizons for a *harvest+24* forecast. The optimal percentage of current information to include in a *harvest+24* basis forecast increased as the forecast horizons approached the forecast date (24 weeks after harvest) for wheat, corn, and milo. The model for soybeans did not follow a noticeable pattern.

The paired t-test results and MAE's of the different λ weights for the *harvest+24* forecasts are provided in tables 6 to 9 for wheat, soybeans, corn, and milo, respectively. When the optimal weights for each forecast horizon were compared for wheat, all the values of λ were significantly different from zero. The optimal values of λ are 0.51, 0.66, 0.89, 0.74, and 0.87 for the time horizons of 4, 8, 12, 16, and 20 weeks past harvest, respectively. The magnitude of the average MAE of the optimal λ models for *harvest+24* wheat was 10.7 cents per bushel, as compared to an MAE of 16.4 cents per bushel for the λ = 0 models. For soybeans, none of the optimal values of λ was significantly different from zero. Each of the optimal λ's was significant for corn and milo. The optimal values for corn were 0.76, 0.76, 0.90, 0.99, and 0.91 for the time horizons of 4, 8, 12, 16, and 20 weeks past harvest, respectively. On average, the MAE of the optimal λ models for corn was 6.2 center per bushel and the MAE of the λ = 0 model was 10.8 cents per bushel. The optimal values of λ for milo were 0.62, 0.77, 0.79, 0.88, and 0.97 for the time horizons of 4, 8, 12, 16, and 20 weeks past harvest, respectively. The average MAE of the optimal λ models was approximately 4.8 cents per bushel lower than the MAE of the λ = 0 models.

It is noteworthy in figure 2 that, for wheat, corn, and milo, λ's increased as the forecasted period was neared. This should be expected in that current basis should be a more reliable indicator of future basis when the "future" is closer to the present. However, despite discovery efforts, the anomaly associated with soybeans is left unexplained.

In the case of wheat, corn, and milo *harvest+24* forecasts, and corn and milo *harvest* forecasts, most of the MAE's of the λ = 1 (full current information) were lower than the MAE's of λ = 0 (no current information), as listed in tables 6 to 9. This implies that, even if λ were not optimized, the arbitrary full information (λ = 1) selection still would improve the forecasting accuracy over no current information. Recall that the optimal λ was selected *ex post* and, if this value was used in real-time forecasting, it may not be more accurate than the λ = 1 selection.

Summary and Implications

Many studies have shown basis forecasts based on simple historical averages compare favorably with more complex forecasting models. However, these studies typically have considered only a 3-year historical average for forecasting basis. This study attempted to determine an optimal multi-year historical average for each crop considered. However, no obvious rule emerged from the results. As such, optimal methods were determined somewhat subjectively for each crop. However, the optimal methods that were determined by this study differed from results of a previous study by Dhuyvetter and Kastens that looked at very similar data. Their previous research, using data from several Kansas locations over the 1989 to 1997 time period, suggested a 4-year model for wheat and 5- to 7-year models for corn, milo, and soybeans. This study looked at a longer time period (1989 to 2002) with fewer locations and determined that shorter historical averages likely should be used for all crops.

The results of this study indicate that the addition of current information to an historical-average basis model can improve forecasting accuracy for some crops over both the *harvest* and *harvest+24* forecasts of basis. Specifically, current information improves forecasting accuracy of corn and milo for *harvest* forecasts as well as wheat, corn, and milo forecasts for *harvest+24* time horizons. For wheat and soybeans, current information only improved accuracy of *harvest* forecasts for the horizon closest to harvest (4 weeks prior to harvest). For soybeans, the results indicated that current information did not improve accuracy for any *harvest+24* horizons.

In all, it was frustrating in this research to find no particularly meaningful rules-of-thumb for practical real-time basis forecasting – either in terms of the number of years to use in historical averages, or in terms of whether and how best to incorporate current information. This is especially an issue for *harvest* basis forecasts. Of course, more crop and time-of-year specific models can always be developed *ex-post*. However, will more finely-tuned models actually be better in real-time forecasting? Might it be that grain basis simply has become more difficult to forecast in recent years, due perhaps to more variable weather or to less predictable grain stocks from increased freedom-to-farm? If so, will futures become even less relevant to farmers as supply and demand factors become even more localized with, say, increased identity preservation in the grains over time?

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Table 1. Mean Absolute Errors of Crop Basis Forecast Methods (cents/bu)

	Forecast Method[a]						
	1 YR	2 YR	3 YR	4 YR	5 YR	6 YR	7 YR
Wheat:							
Harvest	24.70	21.43	17.08	17.57	18.02	17.38	16.78
Harvest+24	12.82	14.07	16.43	17.04	17.00	16.80	16.76
Soybeans:							
Harvest	19.55	16.07	16.29	16.73	16.79	16.47	15.93
Harvest+24	20.43	16.44	15.73	16.77	16.75	16.47	15.61
Corn:							
Harvest	10.57	12.11	13.31	14.16	13.72	13.29	13.04
Harvest+24	10.57	10.82	11.65	12.54	12.22	11.59	10.92
Milo:							
Harvest	11.84	12.44	13.65	14.69	14.72	14.80	14.69
Harvest+24	11.34	11.96	12.55	12.94	12.76	12.00	12.22

[a] Refers to number of years used in historical average.

Table 2. Paired t-test Matrices for Wheat Basis Forecasts

	Basis Forecast Models						
	1 YR	2 YR	3 YR	4 YR	5 YR	6 YR	7 YR
Harvest							
1 YR	------	0.3780	0.0570	0.0764	0.1169	0.1023	0.0687
2 YR		------	0.0195	0.0555	0.1102	0.0855	0.0515
3 YR			------	0.7277	0.4426	0.8375	0.8561
4 YR				------	0.5427	0.8531	0.4270
5 YR					------	0.3840	0.1625
6 YR						------	0.4551
7 YR							------
MAE (¢/bushel):	24.70	21.43	17.08	17.57	18.02	17.38	16.78
Harvest+24							
1 YR	------	0.5394	0.2214	0.2263	0.2625	0.2903	0.2942
2 YR		------	0.1368	0.2000	0.2829	0.3537	0.3724
3 YR			------	0.5443	0.7002	0.8420	0.8729
4 YR				------	0.9667	0.8726	0.8750
5 YR					------	0.8071	0.8466
6 YR						------	0.9341
7 YR							------
MAE (¢/bushel):	12.82	14.07	16.43	17.04	17.00	16.80	16.76

Note: p-values associated with the null hypothesis that there is no difference in MAE of two different forecast models.

Table 3. Paired t-test Matrices for Soybean Basis Forecasts

	Basis Forecast Models						
	1 YR	2 YR	3 YR	4 YR	5 YR	6 YR	7 YR
Harvest							
1 YR	------	0.2291	0.2407	0.3592	0.3786	0.3286	0.2731
2 YR		------	0.8871	0.7135	0.7416	0.8779	0.9558
3 YR			------	0.6583	0.7217	0.9245	0.8761
4 YR				------	0.9450	0.8513	0.6662
5 YR					------	0.7128	0.5407
6 YR						------	0.5161
7 YR							------
MAE (¢/bushel):	19.55	16.07	16.29	16.73	16.79	16.47	15.93
Harvest+24							
1 YR	------	0.1244	0.0291	0.1051	0.1591	0.1607	0.0683
2 YR		------	0.6788	0.8694	0.8859	0.9884	0.7191
3 YR			------	0.3286	0.4220	0.6107	0.9324
4 YR				------	0.9835	0.8065	0.3411
5 YR					------	0.7559	0.1866
6 YR						------	0.1605
7 YR							------
MAE (¢/bushel)	20.43	16.44	15.73	16.77	16.75	16.47	15.61

Note: p-values associated with the null hypothesis that there is no difference in MAE of two different forecast models.

Table 4. Paired t-test Matrices for Corn Basis Forecasts

	Basis Forecast Models						
	1 YR	2 YR	3 YR	4 YR	5 YR	6 YR	7 YR
Harvest							
1 YR	------	0.0996	0.0836	0.0607	0.1271	0.1904	0.2224
2 YR		------	0.0919	0.0778	0.2654	0.4580	0.5604
3 YR			------	0.1820	0.7043	0.9924	0.8634
4 YR				------	0.4041	0.3677	0.3519
5 YR					------	0.4016	0.4221
6 YR						------	0.5871
7 YR							------
MAE (¢/bushel):	10.57	12.11	13.31	14.16	13.72	13.29	13.04
Harvest+24							
1 YR	------	0.8126	0.4460	0.2514	0.3630	0.5845	0.8574
2 YR		------	0.2614	0.1176	0.2502	0.5908	0.9475
3 YR			------	0.1819	0.4921	0.9566	0.5729
4 YR				------	0.2103	0.1660	0.0673
5 YR					------	0.2320	0.0698
6 YR						------	0.0708
7 YR							------
MAE (¢/bushel):	10.57	10.82	11.65	12.54	12.22	11.59	10.92

Note: p-values associated with the null hypothesis that there is no difference in MAE of two different forecast models.

Table 5. Paired t-test Matrices for Milo Basis Forecasts

	Basis Forecast Models						
	1 YR	2 YR	3 YR	4 YR	5 YR	6 YR	7 YR
Harvest							
1 YR	------	0.6781	0.3869	0.2384	0.2767	0.2616	0.2869
2 YR		------	0.2098	0.1191	0.2043	0.2291	0.2858
3 YR			------	0.1146	0.3248	0.3954	0.4940
4 YR				------	0.9665	0.9134	0.9963
5 YR					------	0.8795	0.9661
6 YR						------	0.8134
7 YR							------
MAE (¢/bushel):	11.84	12.44	13.65	14.69	14.72	14.80	14.69
Harvest+24							
1 YR	------	0.5844	0.5177	0.4993	0.5653	0.7739	0.6912
2 YR		------	0.6094	0.5799	0.6790	0.9810	0.8924
3 YR			------	0.6220	0.8362	0.6657	0.7883
4 YR				------	0.7181	0.3915	0.4907
5 YR					------	0.3125	0.4807
6 YR						------	0.5715
7 YR							------
MAE (¢/bushel):	11.34	11.96	12.55	12.94	12.76	12.00	12.22

Note: p-values associated with the null hypothesis that there is no difference in MAE of two different forecast models.

Table 6. Evaluation of Using Current Information in 3-Year Model for Wheat

		MAE			p-value[b]	
Weeks ahead: [a]	optimal λ	λ = 0	λ = optimal	λ = 1	λ = 0	λ = 1
***Harvest* basis forecasts**						
32	0.05	17.08	17.03	22.17	0.523	0.000
28	0.32	17.08	16.31	20.16	0.150	0.000
24	0.02	17.08	17.07	25.39	0.805	0.000
20	0.08	17.08	17.03	26.59	0.803	0.000
16	0.30	17.08	16.31	20.42	0.172	0.001
12	0.07	17.08	16.99	30.89	0.727	0.000
8	0.00	17.08	17.08	38.74	------	0.000
4	0.58	17.08	14.98	16.49	0.092	0.094
***Harvest+24* basis forecasts**						
20	0.87	16.43	8.03	8.44	0.000	0.075
16	0.74	16.43	10.60	11.03	0.000	0.289
12	0.89	16.43	9.38	9.57	0.000	0.394
8	0.66	16.43	11.29	12.96	0.000	0.031
4	0.51	16.43	14.34	17.52	0.081	0.004

[a] Weeks prior to time period being forecasted.
[b] p-value of paired t-test with optimal λ.

Table 7. Evaluation of Using Current Information in 3-Year Model for Soybeans

		MAE			p-value[b]	
Weeks ahead: [a]	optimal λ	λ = 0	λ = optimal	λ = 1	λ = 0	λ = 1
Harvest basis forecasts						
32	0.58	16.29	13.72	14.88	0.006	0.110
28	0.24	16.29	15.98	17.99	0.427	0.081
24	0.00	16.29	16.29	25.97	------	0.000
20	0.00	16.29	16.29	24.15	------	0.000
16	0.00	16.29	16.29	22.08	------	0.000
12	0.34	16.29	10.95	25.99	0.000	0.000
8	0.00	16.29	16.29	31.91	------	0.000
4	0.33	16.29	14.35	22.00	0.029	0.000
Harvest+24 basis forecasts						
20	0.02	15.73	15.73	19.68	0.978	0.004
16	0.22	15.73	15.17	19.84	0.169	0.000
12	0.00	15.73	15.73	27.94	------	0.000
8	0.89	15.73	13.35	13.50	0.131	0.431
4	0.03	15.73	15.71	21.96	0.677	0.000

[a] Weeks prior to time period being forecasted.
[b] p-value of paired t-test with optimal λ.

Table 8. Evaluation of Using Current Information in 3-Year Model for Corn

		MAE			p-value[b]	
Weeks ahead: [a]	optimal λ	λ = 0	λ = optimal	λ = 1	λ = 0	λ = 1
Harvest basis forecasts						
32	0.78	12.11	9.77	9.86	0.006	0.730
28	0.82	12.11	9.73	9.86	0.025	0.608
24	0.76	12.11	9.71	10.06	0.013	0.311
20	0.67	12.11	9.96	10.98	0.036	0.040
16	0.51	12.11	10.39	10.87	0.012	0.514
12	0.31	12.11	10.83	20.22	0.276	0.000
8	0.32	12.11	10.11	19.68	------	0.000
4	0.57	12.11	8.35	10.41	0.002	0.036
Harvest+24 basis forecasts						
20	0.91	10.82	4.91	5.05	0.000	0.330
16	0.99	10.82	5.33	5.34	0.000	0.656
12	0.90	10.82	6.56	6.70	0.000	0.277
8	0.76	10.82	7.29	7.88	0.000	0.081
4	0.76	10.82	6.65	7.18	0.000	0.145

[a] Weeks prior to time period being forecasted.
[b] p-value of paired t-test with optimal λ.

Table 9. Evaluation of Using Current Information in 3-Year Model for Milo

		MAE			p-value[b]	
Weeks ahead: [a]	optimal λ	λ = 0	λ = optimal	λ = 1	λ = 0	λ = 1
Harvest basis forecasts						
32	0.48	12.44	11.48	13.39	0.170	0.004
28	0.46	12.44	11.67	13.73	0.289	0.005
24	0.43	12.44	11.31	13.21	0.081	0.011
20	0.31	12.44	10.98	13.77	0.002	0.003
16	0.41	12.44	10.71	13.07	0.004	0.004
12	0.35	12.44	10.80	14.15	0.008	0.005
8	0.56	12.44	9.81	10.76	------	0.242
4	0.81	12.44	6.82	7.36	0.000	0.130
Harvest+24 basis forecasts						
20	0.97	11.96	4.62	4.70	0.000	0.146
16	0.88	11.96	6.78	6.92	0.000	0.430
12	0.79	11.96	7.48	8.00	0.000	0.119
8	0.77	11.96	8.78	9.32	0.003	0.150
4	0.62	11.96	8.48	9.49	0.000	0.113

[a] Weeks prior to time period being forecasted.
[b] p-value of paired t-test with optimal λ.

Figure 1. Optimal *Harvest* Forecast Using Current Information

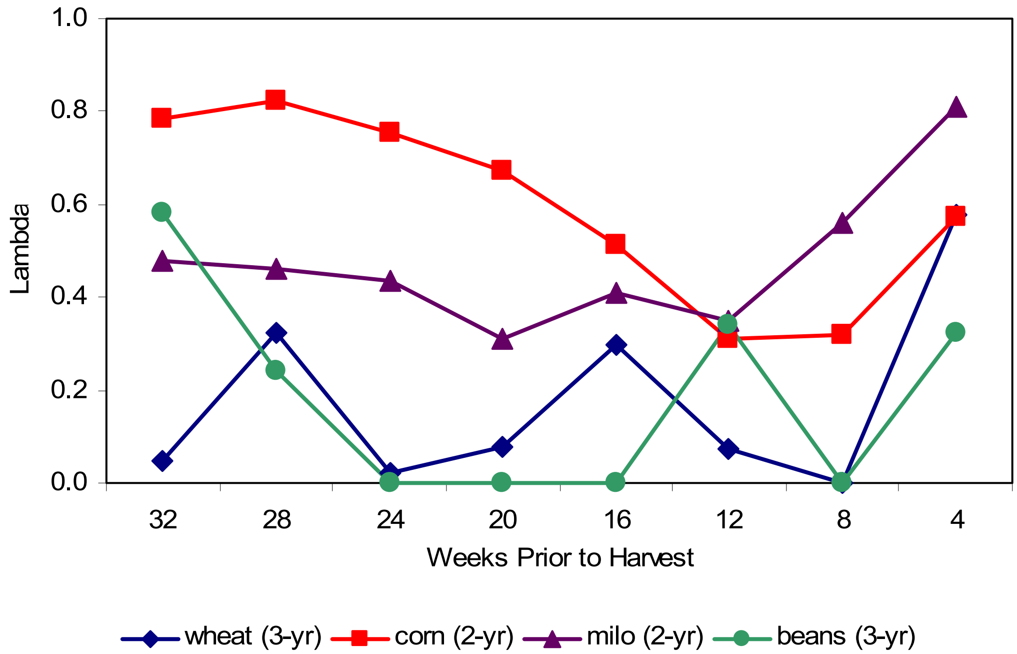

Figure 2. Optimal *Harvest+24* Forecast Using Current Information