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EVALUATING BANKERS' EXPECTATIONS OF INTEREST RATES ON SHORT-TERM FARM LOANS

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Bankers make investment decisions reflecting their expectations of future interest rate trends. For example, if the federal funds rate is anticipated to fall the next day, bank reserve managers can gain by lending federal funds today and borrowing the same amount tomorrow (Hein and Spudeck). Farmers considering refinancing a current loan or deciding whether to lock-in an interest rate with a fixed rate loan are concerned with whether the current interest rate is higher or lower than near term future trends (Robison et al.; Leatham and Baker). The size of the interest rate spread bankers offer farmers on their fixed and variable rate loans depend on interest rate expectations. Generally, an expectation of rising rates results in a larger discount on the variable rate loan. Lenders report increased interest on the part of farmers regarding refinancing of loans when interest rates appear likely to rise (Robison et al.). Such farmers who rely on their banker's advice concerning future loan rate trends would be particularly interested in the reliability of that advice. In addition, profit-maximizing bankers will adjust the relative durations of their assets and liabilities according to their expectations of interest rate trends (Rose).

Bankers' decisions are heavily influenced by the confidence they have in their predictions as well as the predictions themselves. A prediction issued with a 90-percent degree of confidence can elicit a considerably different response by decision makers than the same prediction issued with a 10-percent degree of belief. For example, bankers with little confidence in their ability to anticipate future interest rate trends may respond by adopting costly interest rate hedging techniques. Bankers with excessive confidence might likely assume excessively risky duration gaps in their portfolios. Ellinger and Barry showed that a portion of agricultural banks had significant high or low duration gap measures, leaving them vulnerable to unexpected changes in market interest rates. Belognia and Gilbert showed that the greater this gap, the greater the bank's likelihood of bankruptcy due to interest rate forecast error.

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A deterministic statement is a categorical assertion that a particular event will or will not occur (Yates 1984). A probability forecast is a forecast accompanied by a numeric expression of the forecaster's degree of belief or confidence in the forecast's realization. For example, a banker's probability forecast of next quarter's average loan rate in contrast to the current quarter's average loan rate might be issued as: "25 percent probability of being lower, 35 percent probability of no change, and 40 percent probability of being higher."

The Federal Reserve Bank of Minneapolis collected and reported quarterly farm loan rates and bankers' expectations of one-quarter ahead future loan rates from 1969 through 1993. The time series of 100 quarterly agricultural loan rates was characterized by two trends, an early upward trend (1969:1 - 1981:3) and a later downward trend (1983:4 - 1993:4).

O'Connor et al. showed that human forecast error is greater in a downward-trending series than in an upward-sloping series. Furthermore, there is a greater tendency to anticipate that the downward series will reverse itself while there is a significantly less tendency to do so for an upward series. This suggests that bankers might incur greater forecast error when loan rates are trending downwards than upwards. It also suggests bankers may assign too high a likelihood to higher rates when rates are declining and too high a likelihood to lower rates when rates are trending upward. If so, this might interfere with their ability to properly set premiums on fixed over variable rate loans as well as their role as advisers to farmers on loan refinancings.

Given that agricultural loan rates are characterized by long trends and that research has shown that trends affect human forecast performance, this paper bisected the loan rate series into its upward-sloping and downward-sloping periods. The paper then tested whether agricultural bankers' probability forecast behavior and accuracy differ across the two loan rate trends.

In addition, bankers' ability to forecast future loan rates is contrasted with a naive, no-change model. Stekler notes that a forecaster can make a genuine contribution to decision makers if the forecaster can issue superior forecasts regarding the direction of change to those issued by a naive, no-change model of the same series. Most research has found that both human and econometric forecasters fail to outperform a no-change forecast model in forecasts evaluated with the usual conventional statistical measures (Allen; Leitch and Tanner).

Evaluating Probability Forecasts: The Brier Score

Suppose that an event can occur in only one of r possible outcomes, where the probabilities assigned to each possible outcome j are $f_1, f_2, \ldots f_r$, that the actual event will occur in outcome $j = 1, 2, \ldots, r$ respectively and $0 \leq f_j \leq 1.0$. The greater the forecaster's confidence in j's outcome, the higher f_j. The r classes are chosen to be mutually exclusive and exhaustive so that:

$$\sum_{1}^{r} f_j = 1$$

In order to evaluate the ability of weather forecasters, who issue their predictions in probability form (e.g., there is a 10 percent chance of rain tomorrow), Brier defined a verification or probability score P as:

$$P = \sum_{1}^{r} (f_j - E_j)^2$$

where f_j is the probability assigned to outcome j which expresses the forecaster's confidence in his prediction; E_j takes the value '1' if the event occurred in class j and '0' if it did not; and $0 \leq P \leq 2.0$. The verification score P is often referred to as the Brier Score or Probability Score. While the probability score was originally developed by Brier to evaluate the probability forecasts of weather forecasters, it has recently been used to evaluate probability forecasts in an economic context (Graham; Ruffley and Bessler).

For example, suppose a banker issues a probability forecast for the three possible quarterly directions or trends (hence r = 3) which loan rates may take next quarter in contrast to the current quarter. The banker assigns a probability of one in four to express his degree of belief that rates will decline ($f_1 = 0.25$), is fairly confident they will remain stable and so assigns a probability of 70 percent to that outcome ($f_2 = 0.7$), and is highly confident that rates will not increase and thus assigns a very low probability (5 percent) to the likelihood of higher rates ($f_3 = 0.05$).

Three months later, loan rates were observed to have been stable. Our banker's P score for that particular forecast is:

$$P = (0.25 - 0)^2 + (0.7 - 1)^2 + (0.05 - 0)^2 = 0.1550$$

The higher the probability assigned to that outcome j which occurred ($E_j = 1$), the lower the probability score P. The optimal probability score, $P = 0$, results from assigning a probability of 1.0 ($f = 1.0$) to the event which did occur. Forecast error results from failing to assign complete certainty to the realized outcome. The worst possible probability score, $P = 2.0$, results from assigning complete certainty ($f = 1.0$) to a non-occurring outcome ($E_j = 0$).

Individual probability scores P can be aggregated and averaged for an entire collection of probability forecasts, resulting in what Brier called the mean probability or verification score $\underline{P}$:

$$\underline{P} = (1/n) \sum_{j=1}^{r} \sum_{i=1}^{n} (f_{ij} - E_{ij})^2$$

Following Yates, a total probability score P can be partitioned into probability scores for each of its r possible outcomes. These outcome-probability scores for the r possible outcomes will range from an optimal score of 0 to a worse-case score of 1.0. From the above example, the total probability score can be decomposed into three outcome-probability scores:

$$P_{TOTAL} = P_{LOWER} + P_{STABLE} + P_{HIGHER} = 0.0625 + 0.09 + 0.0025$$

Partitioning the mean total probability score calculated for a series of forecasts allows determining whether forecast error disproportionately arises in a systematic manner over time from one of the r possible outcomes. Such information might prove useful in any recalibration (de-biasing) of future issued probabilities in an attempt to improve future probability forecasts.

Data

The data, interest rates on short-term nonreal estate agricultural loans and bankers' quarterly expectations of them, are from surveys of Upper Midwestern agricultural bankers conducted by the 9th District (Minneapolis) Federal Reserve Bank and reported in the Agricultural Finance Databook (Board of Governors). The quarterly survey usually represents about 150 respondents.

The data, representing 100 quarterly observations, is divided into two periods: 1969:1-1981:3 in which loan rates trended upwards (51 observations) and 1981:4-1993:4 in which loan rates trended downward (49 observations).

The respondents were surveyed each quarter as to whether they believe interest rates on new short-term nonreal estate loans (maturities less than one year) made at their bank over the next quarter would be lower, about the same, or higher than the previous quarter. The Minneapolis Fed does not define these three categories. Bankers base their choice of the three outcomes on their own individual and unreported definitions, then issue their forecasts in a deterministic rather than probabilistic form. These individual lender responses are aggregated and reported quarterly in the Agricultural Finance Databook as the percentages of all bankers anticipating lower, stable, or higher loan rates.

In order to compare bankers' forecasts or expected outcomes (classified as lower, stable, or higher) with the realized or actual outcomes, the time series of quarterly average loan rates is differenced and then categorized as "lower, stable, or higher." However, the Fed's failure to clearly define its classes (lower, stable, higher) introduces the empirical problem as to how broad a range of change in quarterly loan rates should be used when classifying the actual changes in quarterly loan rates as "lower, stable, or higher."

For this study, if the percentage change in quarterly loan rates was greater than the moving average of the past four quarterly percentage changes, then it was classified as either "higher" or "lower." However, it was noted that use of this definition in the highly volatile 1979-1981 period would have classified as "stable" three of the outcomes where the quarterly changes were 80, 110, and 130 basis points. Since quarterly basis point changes this large were deemed unlikely to be perceived as "stable" by bankers, a further condition was added that if the percentage change in quarterly loan rates was at least 5 percent, then it was classified as "higher" or "lower" even if it was less than its related four-quarter moving average.

If the quarterly percentage change was less than the previous four-quarter moving average of percentage changes, it was categorized as "stable." However, strict use of this definition meant several single-digit basis point changes in the early to mid-1970's would be classified as "higher or lower." It is highly unlikely that changes this small would be viewed as significant by bankers; in fact, the Federal Reserve's Agricultural Finance Databook began reporting quarterly interest rate changes rounded to the nearest tenth of a percent in the early 1980's, suggesting the Fed viewed changes less than 10 basis points as economically insignificant. Thus, a further condition was added that any quarterly change of less than 10 basis points was to be classified as "stable."

The Loan Rate Environment: Outcome Uncertainty and Loan Rate Trends

The degree of uncertainty in loan rate outcomes was measured and contrasted for the two periods using two different approaches: the number of changes in sequential quarterly actual outcomes within each period and a measure of uncertainty developed by Murphy for evaluating probability forecasts (Table 1).

A "change in a sequential outcome" was defined as occurring when two sequential-in-time changes in quarterly loan rates yielded different actual outcome categories. Remember that each quarterly change in loan rates is classified as either higher, stable, or lower. For example, if the outcome "stable" was followed by an outcome considered "higher" or "lower" in time, a change in a sequential outcome is considered to have occurred. A "stable" quarterly change followed immediately by another classified as "stable" would not be considered a change in sequential outcomes. The larger the percentage of serial outcomes which can be described as "changes in sequential outcomes" within a period, the more uncertain the forecast environment for that period.

In the first period, there were 16 changes in sequential outcomes (32 percent of the total number of quarterly changes) while in the second period 20 (41 percent) of the sequential outcomes were found to differ from the previous outcome (Table 1).

The Murphy test of outcome uncertainty is calculated as follows:

$$\text{Uncertainty} = \mathbf{d}(\mathbf{1} - \mathbf{d})'$$

where **d** is a vector of the averages of the actual occurrences for each of the three possible outcomes, **1** the unity vector and **(1- d)**′ the transpose of the unity vector minus the **d** vector. For example, in the first period about 6 percent of the 51 outcomes were judged lower (d_L = 0.06), 59 percent were judged "stable" (d_S = 0.59) and 35 percent were considered "higher" (d_H = 0.35). The uncertainty measure for the first period was:

$$\text{Uncertainty} = (0.06\ \ 0.59\ \ 0.35)\,(0.94\ \ 0.41\ \ \ 0.65)' = 0.53$$

The uncertainty measure for the second period was 0.57, indicating that loan rate outcome uncertainty was slightly greater in the second period. Note that one can partition the above vector into uncertainty measures for the three individual outcomes in each period (Table 1). These outcome uncertainty measures are used to normalize the outcome probability scores in each period in order to contrast bankers forecasts of individual outcomes across time while accounting for differences in uncertainty in each period with regard to those outcomes (Table 4).

Greater outcome uncertainty is construed to mean a more difficult forecast environment. The larger number of changes in sequential outcomes in the second period as well as the larger total Murphy uncertainty coefficient suggests that the second period presented a more challenging forecast test for bankers.

Bankers versus A Naive Forecast Model

In order to contrast the bankers' forecast accuracy to a naive model's, the bankers' expectation or forecast for next quarter's loan rate trend was defined as that expected outcome (lower, stable, higher) receiving the largest percentage vote (i.e., a plurality or majority). The naive model used the most recently observed actual outcome as the forecast for next quarter's outcome (e.g., higher rates since last quarter are projected to mean higher loan rates by next quarter).

Bankers outperform the naive model in both periods, as showed by their respective forecast error rates (Table 2). It is interesting to note that bankers disagreed with the naive model's predictions in only 14 percent of the first period forecasts, but in 39 percent of the second period's forecasted outcomes. This suggests that by the second period bankers relied less on recent past loan rate activity when making their expectations of loan rates one quarter into the future.

A naive model would never successfully predict a change in a sequential outcome, earning an error rate of 1.0 in this evaluation. Bankers earned an error rate of 0.81 in the first period and 0.50 in the second period. These two evaluation tests indicate that bankers' forecasts represent a genuine contribution to decisions relying on future loan rate quarterly trends, in that they are superior to those issued by a no-change, naive model.

Bankers and Long-Term Loan Rate Trends

Past research has indicated that human forecasters perform less well in downward-sloping than upward-sloping time series and that human forecasters believe the trend will reverse itself, especially in the case of a downward trend. Is this true for bankers? The results presented here are mixed regarding bankers' relative forecast performance in upward- versus downward-trending loan rates, but are consistent with past research regarding the "dampening phenomenon."

Some of the results suggest bankers performed worse in the second period's downward-trending loan rates. Their forecast error rate rose from 0.24 to 0.33 and the average probability assigned to the correct outcome fell from 0.61 to 0.53 (Table 2). Bankers' total probability score rose from 0.45 to 0.50 and their normalized total probability score rose from 0.86 to 0.89 (Table 4).

'Bias' is the difference between the average probability assigned to a particular outcome j ($\underline{f}_j$) and its observed after-the-fact relative frequency ($\underline{d}_j$). 'Bias' is used as a measure of long-run overall miscalibration in-the-large (Yates 1988). The ideal bias score is 0, and ranges from 1.0 to -1.0. Bankers' forecast bias rose from 0.02 to 0.04 for forecasts of "higher" and from 0.04 to -0.11 for forecasts of "lower" (Table 3), further indication of a decline in forecast performance.

Further evidence of a decline in forecast ability in a downward-trending time series is provided by the decline in the bankers' resolution ability for "lower" loan rates. "Slope" measures the difference between the average probability assigned to an outcome when it occurred minus the average probability assigned to that outcome when it did not occur. The slope indicates how capable bankers are at analyzing current information in order to distinguish whether loan rates will rise (fall) or not over the course of the next quarter. The larger the slope's value, the greater bankers' resolution ability, and the more reliable their judgements or ability to discern short-run loan rate trends. The ideal slope is 1.0 and ranges from -1.0 to 1.0.

Bankers' ability to distinguish when rates would decline fell in the second period, as indicated by a decrease in the slope score for "lower loan rates" from 0.26 to 0.14. Bankers' ability to assign probabilities to loan rates declining when they did in fact decline $\underline{f}_{LOWER,\,1}$ was essentially unchanged (0.33), but the probabilities they assigned to lower rates when rates did not in fact decline $\underline{f}_{LOWER,\,0}$ rose (0.19).

On the other hand, there is evidence that bankers' forecast performance was superior in the downward-sloping portion of the loan rate time series. Bankers improved their ability to forecast that next quarter's trend will differ from last quarter's trend. Their error rate regarding changes in sequential outcomes dropped from 0.81 to 0.50 and the average probability assigned to the correct "change in sequential outcome" rose from 0.29 to 0.43 (Table 2). While bankers' overall (total) ability to assign probabilities declined over time, their ability to realistically assign probabilities to lower and higher loan rates improved, as indicated by the decline in their normalized outcome (lower and higher) probability scores (Table 4).

The second period results indicate that bankers' ability to successively use information to distinguish when higher rates would occur $\underline{f}_{HIGHER, 1}$ had changed little (0.53), but their ability to distinguish when higher rates would not occur $\underline{f}_{HIGHER, 0}$ had improved considerably (0.10). Their resolution skills in forecasting higher loan rate outcomes improved as indicated by the increase in their "higher" slope score from 0.29 to 0.43.

Bankers did show a tendency to predict that trends would "dampen," especially so in the downward-sloping portion of the time series of loan rates. Their bias towards lower loan rates (0.04) exceeded their bias towards higher loan rates (0.02) in the first upward-sloping period (Table 3). In the second downward-sloping period they had a positive "higher" bias (0.04) indicating they had too high a belief that rates would increase and a negative "lower" bias (-0.11) indicating the bankers were underestimating the likelihood of a continuation of the downward trend in loan rates.

Implications for Bankers and Farmers

The improvement in probability forecasting skills regarding bankers' forecasts of higher rates suggests that bankers are less likely than earlier to be surprised by increases in interest rates. Hence, bankers are now more capable of managing portfolios with a positive gap (duration of assets > duration of liabilities) in that their improved skills in forecasting higher loan rates leaves them less likely to be surprised by increases in interest rates. This could be a legacy of bankers' "learning experience" concerning the dangers of unexpected increases in interest rates in the early 1980's.

Bankers net positive slope score (0.14) indicates some if though relatively lesser skill in predicting lower loan rates over the short term. The fact that the relative difference between the higher and lower slope scores increased considerably from the first to second period may result from bankers' perception that unexpected increases in loan rates are relatively more risky than unexpected declines.

Hence, at least to the degree the size of the bank's portfolio duration gap depends on bankers' relative ability to reduce the unanticipated portion of changes in loan rates, bankers are better able to manage a larger positive than negative duration gap.

For potential refinancers interested in avoiding an upturn in loan rates or missing the benefits from a future decline, these results suggest that bankers are more reliable advising borrowers regarding higher than lower rates. Nevertheless, the positive second period slope value (0.14) for "lower" indicates bankers are still more likely than not to be correct when advising farmers to postpone refinancing in order to capture an even lower loan rate. Farmers relying on bankers' predictions of higher loan rates will on the whole find their decisions to lock-in rates with fixed rate loans more successful than farmers choosing variable rate loans relying on bankers expectations of lower rates.

Summary

The results indicate that bankers have improved their ability to assign realistic probabilities to short-term interest rate trends, especially for increases in agricultural short-term nonreal estate loan rates. Bankers do suffer from the proclivity typical of human forecasters in other contexts, the overly optimistic belief that a trending time series will dampen, especially so for a downward time series. Bankers' opinions of short-term loan rate movements are more reliable than not, especially when making predictive statements concerning higher loan rates, a special concern to farmers considering refinancing a loan or choosing between a fixed or variable rate loan. Bankers' relatively superior ability to forecast higher loan rates suggest they can better manage a relatively larger positive than negative duration gap in their portfolios. Such improved skills suggest bankers would not be as surprised by sudden sharp increases in interest rates to the same degree as they were in the 1980's.

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Table 1. Uncertainty Measures of the Loan Rate Environments

	1969:1 - 1981:3	1981:4 - 1993:4
	Murphy's Uncertainty Coefficients (MUC)	
Outcomes:		
Total	0.5259	0.5656
Lower	0.0553	0.2266
Stable	0.2422	0.2474
Higher	0.2284	0.0916
	Changes in Sequential Outcomes	
Number	16	20
Percent of Total Outcome Changes	32	41

Table 2. Bankers vs. the No-Change Forecast

	1969:1 - 1981:3	1981:4 - 1993:4
Error Rate:		
Bankers	0.24	0.33
Naive Model	0.32	0.41
Bankers-Naive Model's Disagreement Rate	0.14	0.39
Changes in sequential outcomes:		
Banker forecast error rate	0.81	0.50
average forecasted probability given a sequential change's occurrence	0.29	0.43
Average "Correct" Probability Forecast	0.61	0.53

Table 3. Bias Scores: Bankers' Expectations versus Relative Frequencies

	1969:1 - 1981:3	1981:4 - 1993:4
$\underline{f}_{HIGHER}$	0.37	0.14
$\underline{f}_{LOWER}$	0.10	0.24
$\underline{d}_{HIGHER}$	0.35	0.10
$\underline{d}_{LOWER}$	0.06	0.35
Bias = $\underline{f}_{HIGHER}$ - $\underline{d}_{HIGHER}$	0.02	0.04
Bias = $\underline{f}_{LOWER}$ - $\underline{d}_{LOWER}$	0.04	-0.11

$\underline{d}_{HIGHER}$ is the relative frequency of "higher" loan rates.

$\underline{f}_{HIGHER}$ is the average probability assigned by bankers to an increase in the next quarter's average loan rate.

Table 4. Brier Probability Scores P

	1969:1-1981:3	1981:4-1993:4
$\underline{P}_{TOTAL}$	0.4512	0.5023
$\underline{P}_{LOWER}$	0.0619	0.2169
$\underline{P}_{STABLE}$	0.1811	0.2362
$\underline{P}_{HIGHER}$	0.2082	0.0492

Normalized Mean Probability Scores

$\underline{P}_{TOTAL}$ / MUC_{TOTAL}	0.86	0.89
$\underline{P}_{LOWER}$ / MUC_{LOWER}	1.12	0.96
$\underline{P}_{STABLE}$ / MUC_{STABLE}	0.75	0.95
$\underline{P}_{HIGHER}$ / MUC_{HIGHER}	0.91	0.53

MUC: Murphy's Uncertainty Coefficient.

Table 5. Bankers' Resolution Skills: Slope Scores

	1969:1-1981:3	1981:4-1993:4
$\underline{f}_{HIGHER,1}$ - $\underline{f}_{HIGHER,0}$	0.56-0.27=0.29	0.53-0.10=0.43
$\underline{f}_{LOWER,1}$ - $\underline{f}_{LOWER,0}$	0.34-0.08=0.26	0.33-0.19=0.14

(1) $\underline{f}_{HIGHER,1}$: means the average probability that had been assigned to the likelihood that higher loan rates would occur given that loan rates did in fact increase.

(2) $\underline{f}_{HIGHER,0}$: means the average probability that had been assigned to the likelihood that higher loan rates would occur given that higher loan rate did not occur.

(3) $Slope_{HIGHER} = \underline{f}_{HIGHER,1} - \underline{f}_{HIGHER,0}$

(4) $-1 \leq$ slope ≤ 1; the greater the positive value of the slope, the greater bankers' resolution skills.