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Anticipatory Hedging with Treasury Bills: The Case of a Bank for Cooperatives

Alan K. Severn

Agricultural cooperatives find it difficult to forecast their interest costs and net income. If input and output prices are fixed, anticipatory hedging of future interest costs is appropriate. Banks for Cooperatives obtain funds in maturities longer than the three months of Treasury bills. Hence, anticipatory hedging of interest rates may require selling a "strip" of more than one Treasury bill futures contract. Adapting Peck's model of hedges against forecast error, hedge ratios generally exceed one-for-one, "naive" hedging, with effectiveness generally above 95 percent. Hedges closed out just before a delivery date have the highest effectiveness.

Volatile interest rates of recent years have prompted many agricultural cooperatives to hedge their interest costs, by fixed-rate borrowing or by using financial futures. Banks for Cooperatives (BCs) have helped their member coops to do so. This paper presents a model for a BC's hedges of the cost of funds to be borrowed at a later date, i.e., "anticipatory" hedges.[1] The results show that the Treasury bill futures market is effective for hedging the interest costs of a BC and its member coops.

Introduction

Agricultural coops have long used futures and forward contracts to reduce the impact of variable commodity prices [see Buccola and French]. In the 1980s, volatile interest rates made interest-rate hedging attractive as well. Most coops borrow, mainly from the BCs and commercial banks. A BC is itself a cooperative, owned by its member coops. BCs obtain funds for seasonal lending mainly by issuing six-month Farm Credit bonds in national money markets.[2] Because of a BC's financial expertise, ability to hedge rates on loans to more than one coop, and incentive to reduce risk, it is assumed that interest-rate hedging is done by the BC itself, on behalf of its member coops.[3]

Coops are price takers in financial markets; they cannot affect interest rates in

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[1] There are many studies of the hedging effectiveness of financial futures. Ederington applied Johnson's portfolio model to a dealer's inventory. But the maturity of an inventory of cash bills falls day by day, while the maturity of the bills underlying a futures contract remains 91 days. In other words, bills are analogous to a semi-storable agricultural commodity because of their short maturity. As a result, hedge ratios for an inventory of cash bills decrease continuously [see Franckle], and Ederington's paper is irrelevant to anticipatory hedges.

In an anticipatory hedge, by contrast, the maturity of the securities to be sold later is constant, making the T-bill contract more appropriate to anticipatory hedges than to hedges of bills already purchased. Franckle and Senchack (p. 107) define an anticipatory hedge as a hedge "where a cash position has not been taken but is expected to be taken in the future." They assume naive (one-for-one) hedging and calculate effectiveness as a function of imperfect-time hedging.

[2] A BC has several loan pools, including seasonal and term. Within each pool, each borrower pays an interest rate based on the average interest cost of the debt used to fund that pool.

[3] A necessary condition is a penalty (refund) for prepayment [Batlin, 1983b].

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national financial markets. For a given level of their expected income, it is assumed that coops attempt to minimize the variability of interest costs if doing so helps to minimize the variability of net income. Reducing the variability of income is important for coops, because coop members do not have "the opportunity to diversify risk by holding the claims of many organizations. . . ." [Vitaliano, p. 1082].

A BC can hedge its interest cost by using financial futures or by borowing at a fixed rate. If the loan to be hedged is to be taken down later, a BC would invest the proceeds of fixed-rate borrowing in a short-term security that matures on that date. The net cost of funds for the period in which they are needed is the forward rate, which depends on the rates paid and received. Interest-rate futures are better than fixed-rate borrowing for hedging the cost of funds to be needed later, for two reasons. First, the futures market is more efficient than the forward market.[4] Second, a BC cannot readily borrow for more than nine months at a fixed rate, while interest-rate futures can be used for longer periods.[5]

The next section contains some observations about hedging in the context of coops, and the third section presents the model. Data, estimation, and results appear in sections four and five. Conslusions are in the last section.

Appropriate Use of Interest-Rate Hedging by a BC

Peck [1975] argues that with fixed costs, the task of the hedger is to reduce unanticipated variability, rather than total variability, of income. If all costs other than interest are fixed in advance, the task of reducing the unanticipated variability of income becomes one of reducing the unanticipated variability of interest cost. Unanticipated variability of interest rates causes "forecast error," due to unknown future events (as opposed to anticipated changes in interest rates). For example, suppose that the yield curve is rising. Forward rates exceed cash-market rates. Successively more distant bill futures contracts trade at successively higher rates. In this instance, a BC can only lock in (more properly, "target") the expected increase in interest rates, and thus protect itself against rates even higher than it had expected. If an expected rise in interest rates causes a coop to expect its income to fall, hedging cannot mitigate this decline. Hedging can reduce only the unanticipated variability of interest cost (and thus of net income, if an interest rate hedge is indeed appropriate). The issue, then, is the extent to which hedging can reduce the variance of the difference between actual interest rates and those that were expected earlier. If interest-rate hedging is appropriate, it will also reduce the variance of income around expected income.

Interest-rate hedging is thus appropriate only if interest cost is the coop's largest stochastic element. This is likely to be the case if other sources of variability have been minimized by inventory holding, forward and futures contracts, wage contracts, and other fixed-dollar commitments. In practice, of course, no coop can fix all input and output prices other than

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[4] Daily marking to market causes little bias in futures rates [Cornell and Reinganum]. The effect of taxation on futures rates is small, even before the 1982 Tax Act [Cornell]. For details of taxation, see Arak. For these reasons, Cornell concludes that futures rates are an efficient forecast of cash-market rates. The differences between forward and futures rates [Rendleman and Carabini] result from the difficulty of shorting the cash market [Cornell]. Hence, forward rates are not a good forecast of subsequent cash-market rates. As Startz (p. 327) concludes, "a planner interested in future short rates would be well advised not to take today's implied forward rate as an estimator."

[5] An exception would be a BC's participation in a sale of Farm Credit "term" (more than one year) bonds of the maturity needed, sold at exactly the right time. But term bonds are offered only a few times a year, and the maturity is unlikely to match that of the desired fixed-rate funding.

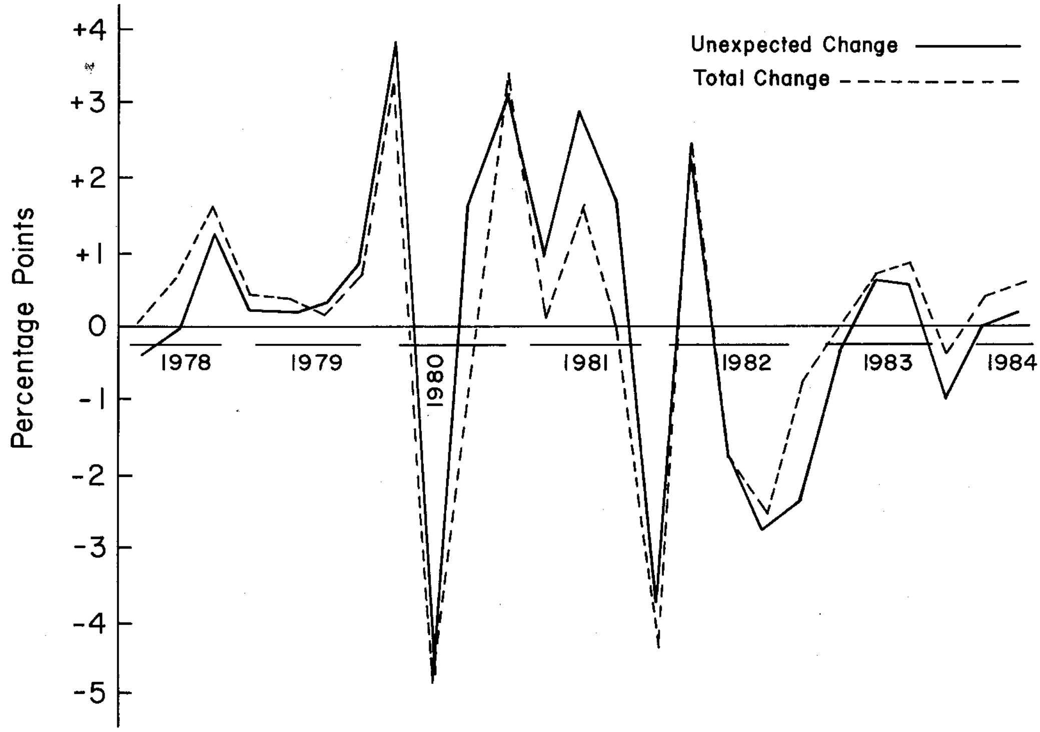

Figure 1. Changes in Three-Month Bill Rates.

interest cost. Hence, interest-rate hedging is likely to be appropriate only for part of a coop's operations, i.e., that part for which interest cost is the largest unknown element.

More generally, hedging of interest costs is appropriate if the correlation between interest rates and output (or input) prices is low. In the long-run, this correlation may exist, resulting from macroeconomic forces such as money supply, exchange rates, and foreign income, as well as from market-specific considerations. For example, unexpected increases in interest rates may cause a coop's competitors to raise their prices, allowing the coop to raise its own prices and recoup its higher interest cost. In such situations, hedging of interest costs may actually destabilize income [Morris; Herr *et al.*]. If, on the other hand, a processing coop has already fixed the prices of its inputs and outputs (e.g., by forward contracting), then interest-rate hedging will stabilize its net income.

If the market expects interest rates to rise, hedging can remove only part of the total variability of interest costs of a BC. Therefore this paper deals with that part of the variability of a cooperative's interest costs that can be hedged, namely the difference between expected interest rates and the rates subsequently paid. Thus, the focus is short-run (limited to one year). The coop is assumed to have determined its output as a function of its members' desires and the market consensus about expected interest rates.[6]

To illustrate the volatility of interest rates, Figure 1 shows the unanticipated and total changes in the three-month Treasury bill rate. The unanticipated change in rates is the quarterly change in the rate on the near contract in the Treasury bill futures market. For example, in June it is the rate on the June contract in June, minus the rate on the June contract observed the preceding March. The total change is the change in the rate on the near contract (a proxy for the rate in the cash market). For example, in June the total change is the difference between the rate on the June contract (in June) and the rate on the March contract (in March). The unanticipated change is highly correlated with the total change, suggesting that changes in interest rates were generally unexpected. The size and frequency of these changes emphasizes the importance for farm coops of hedging activities.

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[6] Batlin [1983a] considers the output and hedging decisions of a for-profit firm when the delivery date of the futures contract differs from the intended marketing date. He shows that this circumstance affects both the output and the amount hedged. The effect on output and on the amount borrowed is ignored here because a coop's utility function differs from that of a for-profit firm. In the case of a supply coop, for example, a reduction in its scale of operations (due to the lack of perfect-time hedging) could increase the cost and/or risk of its mem-

The Model

This model derives minimum-risk hedge ratios as a function of variances and covariances of past forecast errors. A minimum-risk hedge minimizes the variance of interest cost. Expected income is not in the model because the bill futures market is assumed to be efficient [Rendleman and Carabini], and the coop or BC cannot outperform the market. The present futures rate then equals the cash-market rate expected to prevail at the termination of the hedge. Minimum-risk hedge ratios are calculated because of the utility function of the coop and BC [Vitaliano] and because of the efficiency of the bill futures market.

Recall that the BCs fund most of their seasonal lending with six-month, fixed-rate bonds.[7] By contrast, only three-month bills are deliverable for the bill futures contract. If (by chance) a coop planned to borrow on the delivery date of a futures contract, it would need to go short two different contracts: one whose delivery date coincided with the start of the loan, and one three months later.[8] The reason is that interest rates in one period are imperfectly correlated with rates in the following period. In the parlance of futures markets, a combination of two or more successive contracts is a "strip."[9]

In practice, an appropriate termination date for a hedge is the day on which the BC will fix the rate on its issue of six-month bonds. Such dates occur approximately 3, 8, and 12 weeks before the delivery date of any given bill contract.[10] A strip of bill contracts may still be the most effective hedge. For example, a BC might use a short position in June and September

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bers, contrary to its obligation to maximize their utility. Note, however, that the hedge ratios estimated here incorporate the effect of imperfect-time hedging through its effect on variances and covariances, and therefore on the hedge ratios.

[7] The results in this paper apply directly to the part of the seasonal pool that a BC plans to fund with six-month bonds. BCs occasionally participate in offerings of nine-month Farm Credit bonds; the methodology of this paper applies to such bonds also. See Tauer and Boehlje for a model of the maturity selection of Farm Credit debt.

[8] If there were a futures contract for six-month bills, hedging the interest cost of a BC would require only one contract. But there is no futures contract for six-month bills. One was developed by the Chicago Mercantile Exchange and approved by the Commodity Futures Trading Commission, but trading was never opened. A contract on one-year bills was introduced in 1978, but was delisted due to lack of trading volume.

[9] The borrowing anticipated is generally for a period of less than six months. The amount actually hedged is determined by multiplying the number of dollars to be borrowed by the ratio of the length of loan to six months. Suppose, for example, that the BC wishes to hedge a $6 million loan for the month of June, and that the appropriate hedge ratios are one June and one September contract per $1 million of loan. If so, the appropriate hedge would be six June and six September contracts for a six-month loan, or one June and one September contract for a one-month loan.

[10] Terminating a hedge some time before a delivery date may be desirable, because open interest (and hence liquidity) tend to decline shortly before the delivery date of a contract.

bills to hedge its cost of funds for the six months, June through November, inclusive. The reason is that the cost of six-month funds for June through November should approximate the average of the cost of three-month funds for mid-June through mid-September and for mid-September through mid-December.

At the opposite extreme, the most effective single (as opposed to roll-over) hedge of the cost of funds for six months starting in April may use the June contract alone. In this example, the rate prevailing in the middle three months (of a six-month period) may be the best proxy for the rate expected to prevail for the six months as a whole.

Between these extremes, it is impossible to state whether the most effective hedge will use one bill contract or a strip of two contracts. Hence, a general model is derived. Two hedge ratios are estimated simultaneously; b_1 is the hedge ratio for the contract with the first delivery date after the funds will be needed, and b_2 is the hedge ratio for the following contract.

The model focuses on C, the annualized interest rate paid by the BC. The basis, B_t, at time t, the termination of the hedge, is:[11]

$$B_1 = R_t^{BC} - .5(R_t^1 + R_t^2), \tag{1}$$

where R_t^1 and R_t^2 are the rates on the nearest two contracts at time t, and R_t^{BC} is the rate on the six-month Farm Credit bond. This relationship is definitional. It states that the rate for six months equals one-half of the sum of the two three-month rates. It does not force the two hedge ratios to equality.

Without hedging, the expected cost is:

$$E(C^U) = E[.5(R_t^1 + R_t^2) + B_t]. \tag{2}$$

At time $t - i$, the start of the hedge, the futures rates at time t are unknown. Define E_t^1 and E_t^2 as the rates expected (at time $t - i$) to prevail at time t:

$$E_{t-i}^1 = E(R_t^1) \text{ and } E_{t-i}^2 = E(R_t^2). \tag{3}$$

Define the respective hedge ratios as:

$$b_1 = -X_f^1/X_s^1$$

and

$$b_2 = -X_f^2/X_s^2,$$

where X_s and X_f are the respective dollar amounts of spot and futures positions. While these definitions of the hedge ratios are typical, note their rationale in the context of an anticipatory hedge. The BC intends to sell bonds at time t, as does a dealer who holds bills (of appropriate maturity) and also intends to sell at time t. In either case, the prospective seller takes a short position in futures.

The expected net cost resulting from a hedged position is:

$$\begin{aligned} E(C^H) &= [E(C^U) + .5b_1(R_t^1 - E_{t-1}^1) \\ &\quad + .5b_2(R_t^2 - E_{t-i}^2)] \\ E(C^H) &= E[.5(R_t^1 + R_t^2) + B_t \\ &\quad + .5b_1(R_t^1 - E_{t-i}^1) \\ &\quad + .5b_2(R_t^2 - E_{t-i}^2)] \end{aligned} \tag{4}$$

Measuring forecast error as mean squared error, rather than standard error, we have:

$$MSE(C^H) = E\{[C^H - E(C^H)]^2\} \tag{5}$$

$$\begin{aligned} &= E\{.5(R_t^1 + R_t^2) + B_t \\ &\quad - E[.5(R_t^1 + R_t^2) + B_t \\ &\quad + .5b_1(R_t^1 - E_{t-i}^1) \\ &\quad + .5b_2(R_t^2 - E_{t-i}^2)]^2\} \end{aligned} \tag{6}$$

$$\begin{aligned} &= E\{[B_t - E(B_{t-i})] \\ &\quad + .5(1 - b_1)(R_t^1 - E_{t-i}^1) \\ &\quad + .5(1 - b_2)(R_t^2 - E_{t-i}^2)^2\} \end{aligned} \tag{7}$$

$$\begin{aligned} &= \mathrm{Var}(B) + .25(1 - b_1)^2\mathrm{Var}(1) \\ &\quad + .25(1 - b_2)^2\mathrm{Var}(2) \\ &\quad + (1 - b_1)\mathrm{Cov}(B, 1) \\ &\quad + (1 - b_2)\mathrm{Cov}(B, 2) \\ &\quad + .5(1 - b_1)(1 - b_2)\mathrm{Cov}(1, 2) \end{aligned} \tag{8}$$

Partially differentiate (8) with respect to the hedge ratios, set the resulting equations equal to zero, and solve the resulting system of two equations and two unknowns to get:

$$b_1 = \frac{\begin{array}{c}\mathrm{Var}(1)\mathrm{Var}(2) + 2\mathrm{Var}(2)\mathrm{Cov}(B, 1) \\ - 2\mathrm{Cov}(B, 2)\mathrm{Cov}(1, 2) - \mathrm{Cov}(1, 2)^2\end{array}}{\mathrm{Var}(1)\mathrm{Var}(2) - \mathrm{Cov}(1, 2)^2} \tag{9}$$

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[11] Basis is defined in this way for financial futures, because rates move inversely to prices.

$$b_2 = \frac{\mathrm{Var}(1)\mathrm{Var}(2) + 2\mathrm{Var}(1)\mathrm{Cov}(B, 2) - 2\mathrm{Cov}(B, 1)\mathrm{Cov}(1, 2) - \mathrm{Cov}(1, 2)^2}{\mathrm{Var}(1)\mathrm{Var}(2) - \mathrm{Cov}(1, 2)^2} \qquad (10)$$

Again, recall that the variances and covariances are calculated from deviations around the predicted values, not around means. Thus, they are mean squared errors (MSE), not standard errors.

Data and Estimation

Interest cost to the BC is the rate on the six-month bond issued on the first working day of each month.[12] Note that the cash-market rate at the time when the hedge is established is not in this model, because in the bill market there is no link between cash-market and futures rates via storage [Franckle].

Possible proxies for the expected rates, E^1_{t-i} and E^2_{t-2}, include prevailing futures rates, forward rates, judgmental forecasts and econometric forecasts. Howard finds that futures rates and forward rates are about equal as forecasters for horizons up to 25 weeks. Both are far superior to a naive "no-change" model or time series forecasts. From previous studies, Howard concludes that judgmental and econometric forecasts are still less accurate. Thus, the choice is one of futures versus forward rates as a proxy for spot rates expected at a later time. This paper uses futures rates.[13]

Note that the futures rate has two roles in this paper. First, it is a proxy for the expected spot rate. Second, it is the rate implicit in the futures contract itself.

The Farm Credit bond whose rate is being hedged is issued on the first working day of the month, but is priced several days earlier. Once priced, its rate is known and constant. Hence, each hedge ends on a pricing date, and is placed i months earlier, where $i = 1 \ldots 9$.

As Franckle points out, it is important to use futures prices observed at a well-defined point in time. The futures rates E^1_{t-i} and E^2_{t-i} are as of the night before pricing. While the pricing conference does not occur until 1:30 PM, the Funding Corporation for the 37 Farm Credit Banks (the issuer of the Federal Farm Consolidated Bonds) prepares its recommendation prior to this conference; see Puglisi and Vignola for details. Thus, the previous day's close is a reasonable approximation of the information available when the pricing recommendation is prepared.

Hedges can be placed in any month, to be lifted in any subsequent month. But only four bill contracts are available on the IMM for any one year. Futures rates are a forecast of cash-market rates; today's futures rate on, for example, the June contract is a forecast of the cash-market rate on delivery day next June. But it is not necessarily a forecast of the cash-market rate of any other day. This absence of perfect-time hedges [Batlin, 1983a] means that minimum-risk hedge ratios may differ for hedges to be lifted in the March, April, and May cycles. Results are thus presented separately for each of the three cycles, as well as for hedges of different lengths.[14]

Minimum-risk hedge ratios are calculated directly from (9) and (10), using data for the period December 14, 1977, through May 30, 1984.[15] They are ex ante, in that they are calculated from data available at the inception of each hedge.

The standard measure of the effectiveness of a hedge compares hedged to unhedged variability [Johnson; Ederington]. Here, both are defined as the MSE of forecast error:

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[12] Bill rates are quoted on a discount basis. Farm Credit bonds pay a single coupon at maturity. For comparison, all rates were converted to a coupon basis, continuously compounded, using Fielitz's formula.

[13] See footnote 4.

[14] A cycle includes all hedges terminated at a given interval before the delivery date of a futures contract. The March cycle, for example, consists of hedges terminated in March, June, September, and December.

[15] The hedge ratios are not estimated by regression, but the model is analogous to linear regression with the constant term suppressed.

$$\text{EFFECT} = 1 - \frac{\text{MSE}(C^H)}{\text{MSE}(C^U)} \qquad (11)$$

The steps used to calculate effectiveness are as follows. First, variances, covariances, and the mean value of the basis are calculated from the first seven observations.[16] Then hedged and unhedged forecast errors are calculated for the following period.[17] The variances, covariances, and hedge ratios are recalculated, using all data available at the end of the next period; forecast errors are calculated for that period, and so on. When all data have been used, mean square errors are calculated. In addition, a Durbin-Watson ratio is calculated from the forecast errors for the hedged position.[18]

Results

Table 1 shows the hedge ratios estimated for the last hedge period. For the March and April cycles, a high and positive value of b_1 is reflected in a negative value for b_2. The negative values of b_2 reflect the fact that the Treasury bills underlying the second contract mature long after the Farm Credit bond whose rate is being hedged (about 8 and 12 weeks, respectively, for the April and March cycles). Thus, the contract that will be second nearest at the termination of the hedge is a less efficient hedging vehicle than is the nearest contract. Also, the Durbin-Watson statistics are low and negative hedge ratios imply partially-offsetting positions in two contracts that would raise transactions costs.[19]

For these reasons, the hedge ratios have been recalculated with a non-negativity constraint (Table 2).[20] Effectiveness remains high. In the constrained estimates, only the nearest contract is used in the March and April cycles. This is not surprising, because the nearest contract is for bills in the middle of the period being hedged. If forecast errors are small [Startz, p. 328], the expected three-month rate should be highly correlated with the expected rates for the one- or two-month periods before and after the three-month life of the bills underlying the near contract.

In most cases, the two hedge ratios sum

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[16] The use of seven periods to calculate the first hedge ratios is arbitrary.

[17] The forecast error of the unhedged position is the realized interest cost of the BC less the expected interest cost, from (2). The forecast error of the hedged position is the realized cost (from (4), but with realized values substituted for expected values), less the expected cost (calculated directly from (4)).

[18] The numerator is the mean of squared differences between successive realized forecast errors, and the denominator is the variance of realized errors.

[19] McCabe and Franckle estimate the transaction cost for a hedge involving one of each of the two nearest contracts as approximately $200, consisting of $70 for round-trip commissions and $125 for bid–ask spread; initial margin can generally be in the form of interest-earning securities. In addition to these explicit costs, there are implicit costs in the form of management time. By comparison, the futures positions generated gains or losses as high as $25,000. For example, consider six-month hedges ending in the May cycle. Interest rates rose unexpectedly in 7 of 15 observations, and fell unexpectedly in the other eight. The mean of the increases was 247 basis points, for a mean loss of $12,335 to an unhedged borrower. The hedged borrower, by contrast, lost $857. In the eight observations with unanticipated declines in rates, the hedged borrower lost an average of $11,945. Thus, the benefit of hedging was a reduction in the variability of outcomes, with little change in expected returns. Of course, short positions in futures generate losses when rates are falling, and gains when rates are rising. But the size of the ex post gains (losses) is irrelevant, because unexpected changes in interest rates are (by definition) impossible to forecast.

[20] To do so, the expected bill futures rate is set equal to the prevailing rate on the near contract, and basis is redefined as the difference between the Farm Credit bond rate and the rate on the near contract. Hence, estimates of effectiveness for constrained and unconstrained hedges are not comparable.

TABLE 1. Unconstrained Hedges of Six-Month Farm Credit Bond, Using Treasury Bill Futures.

Length of Hedge	March Cycle					April Cycle					May Cycle				
(Months)	b_1	b_2	Effect	DW	MSE	b_1	b_2	Effect	DW	MSE	b_1	b_2	Effect	DW	MSE
1	4.399	−2.772	.588	.708	.561	2.835	−.879	.503	.978	1.231	2.218	−.013	.794	1.194	.619
2	3.816	−1.976	.844	.541	.643	3.873	−1.901	.637	1.571	.683	1.607	.661	.965	2.109	.301
3	3.362	−1.394	.924	1.444	.723	3.721	−1.587	.914	.913	.359	1.853	.399	.964	2.334	.229
4	3.736	−1.827	.901	.809	.392	3.118	−1.025	.963	1.236	.272	1.905	.348	.955	1.287	.351
5	3.329	−1.236	.951	.666	.296	3.366	−1.241	.972	.943	.161	1.921	.254	.966	1.099	.366
6	3.254	−1.228	.958	1.002	.392	3.064	−.928	.975	1.224	.205	2.031	.131	.951	1.063	.419
7	3.451	−1.475	.921	.911	.411	2.959	−.869	.965	1.601	.314	1.984	.152	.972	1.692	.245
8	3.329	−1.131	.959	.851	.331	3.046	−.914	.946	1.667	.352	2.085	−.044	.959	1.933	.424
9	3.908	−1.979	.966	.647	.343	2.873	−.749	.977	2.235	.241	2.091	−.039	.944	1.604	.449

TABLE 2. Constrained Hedges of Six-Month Farm Credit Bond, Using Treasury Bill Futures.

Length of Hedge	March Cycle					April Cycle					May Cycle				
(Months)	b_1	b_2	Effect	DW	MSE	b_1	b_2	Effect	DW	MSE	b_1	b_2	Effect	DW	MSE
1	2.001	—	.594	.824	.464	2.073	—	.569	1.101	.924	2.363	—	.781	1.194	.564
2	2.219	—	.839	.992	.617	2.149	—	.712	1.299	.486	1.607	.661	.976	1.895	.215
3	2.283	—	.951	1.599	.476	2.467	—	.918	1.941	.321	1.853	.399	.962	2.326	.245
4	2.251	—	.884	.684	.445	2.358	—	.964	1.673	.254	1.607	.348	.955	1.287	.351
5	2.457	—	.942	.951	.347	2.496	—	.958	1.591	.227	1.854	.254	.979	1.274	.227
6	2.369	—	.965	1.058	.332	2.244	—	.972	1.364	.226	1.905	.131	.983	1.574	.144
7	2.401	—	.923	.981	.399	2.391	—	.959	1.878	.349	1.984	.152	.982	1.554	.159
8	2.355	—	.958	1.048	.342	2.491	—	.926	2.156	.481	2.187	—	.983	2.365	.175
9	2.282	—	.968	.851	.332	2.408	—	.957	1.841	.441	2.234	—	.973	2.108	.215

Source: Calculated directly from (11) and (12), using data available at the inception of the hedge.

Note: Minimum-risk hedge ratios (b_1 for near contract, b_2 for next contract) are calculated from 24 obs. (1–3 month hedges), 22 obs. (4–6 month hedges), and 20 obs. (7–9 month hedges). Mean square error, Durbin-Watson, and effectiveness are calculated from seven fewer observations in each case.

to more than the value of 2.0 that would imply naive hedging. Cicchetti *et al.* and Ferri *et al.* report similar results for inventory hedges based on standard errors (rather than MSE). High-hedge ratios occur because more-distant contracts are less volatile than are near contracts. Hence, the value of contracts sold must exceed the amount of Farm Credit bonds to be sold.[21]

Except for one- or two-month hedges, effectiveness generally exceeds 95 percent. This result accords with those of McCabe and Franckle, and of Cicchetti *et al.* It suggests that fixed-rate borrowing may be a more effective way to reduce unanticipated volatility of interest rates for short planning horizons. For longer horizons, the bill futures market is an effective alternative to fixed-rate borrowing, especially if the BC cannot readily obtain fixed-rate funds of the maturity needed.

Despite the lower liquidity of the more-distant contracts, there is little loss of effectiveness as the length of hedge increases to nine months. The high effectiveness of long-term hedges, combined with the low values of b_2, suggests that the low values of b_2 reflect a varying term-structure (liquidity) premium, rather than from the thinner markets typical of distant contracts.[22]

Conclusions

This paper has presented a model of a BC's anticipatory hedge against unanticipated changes in interest rates. The model is appropriate where an unhedged rise in rates would reduce the net income of the borrowing coop, and thereby increase its default risk. The model allows the use of a strip of two bill contracts, because the maturity of two successive bills equals that of the bonds to be issued to fund the loan.

The results show that the Treasury Bill futures market is a reliable way for a BC to hedge against unanticipated rises in interest rates. This is especially true when the funds will be needed at least two months later, and just before the delivery date of a bill futures contract. In this case, the risk-minimizing hedge generally involves two different bill contracts.

If the funds will be needed within two months, at a time long before the delivery date of the relevant bill contract, then fixed-rate borrowing and temporary investment of proceeds may be a better alternative to hedging in bill futures. If hedging is to be used when the anticipated need for funds will occur long before the delivery date of a bill contract, then only the nearest contract (at the termination of the hedge) need be used.

Low product prices have made farm coops vulnerable to an increase in interest rates. Hedging of interest costs cannot protect them against expected increases in interest rates. It can, however, defend them against unanticipated increases in interest rates, just as commodity futures and forward contracting help to protect them from unforeseen events in product markets.

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[21] In addition, rates on Farm Credit bonds tend to rise faster than rates on bills of the same maturity. Garbade and Hunt show that yields on Farm Credit bonds exceed those on Treasuries because issues of Farm Credit bonds are smaller; liquidity is of greater concern when all rates are rising.

[22] Actual effectiveness may be lower, if a hedger cannot close out a position because rates have fallen by the daily limit on a pricing day.