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VARIABLE-RATE LOAN COMMITMENTS, DEPOSIT WITHDRAWAL RISK, AND ANTICIPATORY HEDGING

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**Variable-Rate Loan Commitments, Deposit
Withdrawal Risk, and Anticipatory Hedging***

by

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Abstract

Currently, variable-rate loan commitments enjoy widespread use at large banks for commercial and industrial loans. This paper shows that financial futures contracts can be used to hedge the risk of uncertain loan revenues from variable-rate loan commitments and simultaneously, the risk of deposit withdrawals. The theoretical model predicts that a long futures market hedge will be greater and a short futures market hedge smaller: i) the greater the expected fall in interest rates, ii) the more inelastic the demand for credit by borrowers, and iii) the smaller the problem of disintermediation. For 1976-82, a T-bill futures market hedge of 90% of the bank's risk exposure decreases the variability of unhedged profits by 10% for a stylized large bank in the Seventh Federal Reserve District.

Variable-Rate Loan Commitments, Deposit Withdrawal Risk, and Anticipatory Hedging

The obvious elements in a bank's balance sheet that can benefit from the risk shifting possibilities of financial futures trading are nonloan assets such as government securities, or variable-rate deposits such as money market accounts (see Ciccehetti et al (1981), Ederington (1979), Franckle (1980), and Parker and Daigler (1981)). Less research exists on the usefulness of financial futures contracts in commercial lending operations (for exceptions, see Batlin (1983), Dew and Martell (1981), and Koppenhaver (1983)). In the only other published theory on loan commitments and financial futures, Ho and Saunders (1983) develop a model to determine a hedge of fixed-rate commitment takedowns when funding costs are subject to interest rate risk. In contrast, this paper shows that financial futures contracts can help manage the interest rate and takedown uncertainty associated with making variable-rate loan commitments when deposits are subject to withdrawal risk. The results of this investigation are that the anticipatory hedge of interest rate and quantity risks will be greater, i) the greater the expected fall in interest rates, ii) the more inelastic the demand for credit by borrowers, and iii) the smaller the problem of disintermediation. Using alternative assumptions about the formation of expectations and the risk aversion of bank management, a simulation of the optimal futures trading strategy using bank data from the Seventh Federal Reserve District indicates that up to 10% of the variability of unhedged profits could be eliminated by T-bill futures hedging.

There are two general types of loan commitments used in practice: fixed-rate and variable-rate. In a fixed-rate loan commitment the lender

provides credit on demand up to some previously determined quantity at a constant, known interest rate. In a variable-rate loan commitment the lender provides future credit on demand up to some maximum quantity at a price determined by a previously specified formula calculated after the realization of a random variable. Borrowers desire loan commitments either because their cash needs are random or because their future credit worthiness is uncertain. A fixed-rate agreement provides the borrower with insurance against random changes in the cost of credit; a variable-rate agreement assures the availability of credit at a favorable rate if the borrower's credit rating changes unfavorably. In general, lenders make loan commitments because they seek to strengthen borrower-lender relationships, gain deposits through compensating balances, or gain fee income.

The importance and implications of both kinds of loan commitments have largely been ignored in models of bank behavior. The usual treatment emphasizes spot market loan decisions (see Baltensperger (1980), O'Hara (1983), and Sealey (1980)). Loan commitments are like forward contracts where the terms of the exchange specify a future delivery of credit. Two articles (Campbell (1977) and Deshmukh et al (1982)) have extended the theory of the banking firm by focusing on the optimal quantity of loan commitments when commitment takedowns are uncertain and the bank faces a funding risk. This extension of the literature seems warranted given the estimate by Boltz and Campbell (1979) that over 55% of the business loans at large money center and regional banks in 1977 were made under loan commitment agreements. Using their estimates, roughly one third of the business loans stipulated variable-rate loan commitment terms.¹ The subject of this study is the management of the risks associated with this element of the bank's balance sheet when combined with deposit withdrawal risk and hence, uncertain funding costs.

Section one models the bank's operating environment. Bank management is assumed to maximize the expected utility of profit (see Edwards (1977), and Ratti (1980)) given uncertainty about the low cost-high cost mix of fixed-rate deposits. Bank loans are made entirely through variable-rate loan commitments; hence, bank management is also uncertain about the return on its assets. By assumption, the bank's balance sheet exhibits a gap between rate-sensitive assets (loan commitments) and rate-sensitive liabilities (deposits). Compounding this decision problem are random loan takedowns on the loan commitments.

The optimal futures position is calculated in section two. The relationships between the futures position and the other elements of the decision problem are then discussed. In section three, the performance of the model and the T-bill futures market are evaluated relative to their effectiveness in reducing combined price and quantity risks. Section five concludes the paper by examining the critical assumptions and by commenting on the results.

I. The Model

The framework used here is related to the model developed by Sealey (1980). Similar to Sealey's model, deposit flows are uncertain--possibly because depositors' tastes and preferences for holding money balances fluctuate randomly, i.e., the velocity of circulation is unstable. Another similarity is the presence of an uncertain return to bank loans determined by market forces.² In the model below, however, loan returns are uncertain because both the interest rate and commitment takedowns are unknown. No distinction between variable-rate forward and spot lending exists, assuming 100% takedowns. Rather than consider spot loans a choice variable, the volume

of loan commitments is assumed predetermined prior to the futures trading decision period. This assumption is made so that the theory is consistent with the empirical application below.

A T-bill futures decision is introduced as a bank decision with an uncertain return depending on the price of the futures contract at the end of the planning period.³ Deposit interest rates are always known with certainty and are given to the bank by Regulation Q restrictions and market forces. It is assumed the bank has access to two different deposit markets: a Regulation Q deposit market and a certificate of deposit market. The rate on the latter is assumed higher than the rate on the former; thus, random changes in deposit mix are the only source of funding risk for the bank. If disintermediation is a problem, the interest rate sensitivity of bank assets is matched to a limited extent by interest rate sensitivity in bank liabilities. In this case, higher interest rates imply greater asset returns and a shift in deposit mix toward relatively expensive certificates of deposit.

The sequence of decision-making is assumed as follows. Suppose bank management has a one period planning horizon. At the beginning of the planning horizon when deposit interest rates are known but before deposit flows are revealed, management must decide on the size of the T-bill futures position given a predetermined level of variable-rate loan commitments. This futures position is an anticipatory hedge; loans have not been made but are expected to be made after one period through loan commitment takedowns. Loan commitment takedowns are uncertain because the credit worthiness of the borrowers can change before the commitments must be exercised, or the quantity of credit demanded is sensitive to the loan rate. An anticipatory hedge of an asset implies bank management should take a long position in the futures market.⁴

The net futures position, however, also considers an anticipatory hedge of deposits. In the presence of disintermediation, deposit outflows are hedged by a short (sell) futures position. In the absence of disintermediation, deposit outflows are hedged by a long (buy) futures position. With uncertain deposits, the futures position acts, in effect, as an alternate source of funds. Deposit inflows imply a positive gap in the bank's balance sheet; deposit outflows greater than loan commitment takedowns imply a negative gap. Given a positive gap, the bank is exposed to the risk that a fall in interest rates on exercised loan commitments are not offset by a fall in deposit rates because the latter are assumed known ex ante. Given a negative gap, the bank is exposed to the risk that deposit withdrawals force it to fund exercised loan commitments from the expensive certificate of deposit market, narrowing the bank's profit margin. Overall, the net futures hedge could be long or short depending on the relative magnitude of effects in the commitment and deposit markets.

After the futures decision is made, the size of deposit inflows or outflows is revealed along with the loan commitment interest rate and takedown. Funds are then purchased or sold in the one period certificate of deposit market to equate assets and liabilities. At this time, the T-bill futures position is offset returning any futures trading profits. The decision process repeats itself at the beginning of the next planning horizon.

Currently, the regulations set out in a joint policy statement issued by the Federal Reserve, Federal Deposit Insurance Corporation, and Comptroller of the Currency require that financial futures positions be a bona fide hedge of overall balance sheet interest rate exposure, leaving the specifics of the hedging program up to the individual bank.⁵ To capture this governmental restriction in the model, the size of the futures market position is limited

in absolute value to a position less than or equal to the absolute value of the maximum loan volume realized through commitments plus deposit changes. This does not preclude the possibility of a partial hedge of the bank's exposure, however.

The principal relationships in the model are as follows. Let h be the per dollar requirement for initial margin needed to establish a futures position.⁶ Therefore, hX is the margin deposit for a long futures position of size X , $-hX$ for short futures position. The bank's balance sheet can be expressed as

$$L + I(X)hX = B + D \quad (1)$$

where L = predetermined loan commitments, with the underlying loans maturing in two periods, $L > 0$,

$I(X)$ = +1 for a long futures position and -1 for a short futures position,

B = purchases ($B < 0$) or sale ($B > 0$) of one period certificates of deposit, and

D = demand and savings deposits.

Bank profits are the sum of revenues from exercised loan commitments and T-bill futures trading minus (plus) the cost (return) of purchasing (selling) funds minus the cost of Regulation Q deposits. For simplicity, assume no fees are earned on unused loan commitments and assume no variation margin calls on the futures position. Bank profits, π , at the start of the planning horizon are given by (tildes indicate future values and random variables)

$$\tilde{\pi} = \tilde{R}_L \tilde{\theta} L + [(1 - \tilde{R}_X) - (1 - R_X)]X + I(X)R_T hX - R_B B - R_D \tilde{D} \quad (2)$$

where \tilde{R}_L = the interest rate earned on used loan commitments

$\tilde{\theta}$ = the loan commitment takedown rate, $0 \leq \tilde{\theta} \leq 1$,

- \tilde{R}_X = the interest rate on a futures contract at the end of the period,
 R_X = the interest rate on a T-bill futures contract at the beginning of
the period,
 R_T = the interest rate on one period Treasury securities posted as
initial margin,
 R_B = the interest rate on one period certificates of deposit, and
 R_D = the interest rate payable on demand and savings deposits, set by
Regulation Q.

If the borrower's credit worthiness improves between the time the loan commitment is made and the time the commitment is exercised, he may obtain credit in the spot loan market. If so, the realized θ will fall along with bank profits. If interest rates rise, movement along the borrower's demand curve for credit causes the realized θ to fall, given unchanged credit worthiness. In this case, the impact on bank revenues depends on the interest elasticity of loan demand.

The objective of bank management is to choose X and B to maximize the expected utility of profit, $EU(\tilde{\pi})$, subject to the balance sheet constraint in equation (1) and expectations about the future. Let these subjective expectations be described by the joint cumulative density $F(\tilde{R}_L, \tilde{R}_X, \tilde{\theta}, \tilde{D})$. It is assumed this joint distribution does not change over the planning horizon. The maximization problem can be stated as

$$\text{Maximize } E[\text{Max}_{|X| \leq |L + \Delta D|} U(\tilde{\pi}) \mid F(\tilde{R}_L, \tilde{R}_X, \tilde{\theta}, \tilde{D})] \quad (3)$$

subject to equation (1), where ΔD is the change in Regulation Q deposits, E is the expectations operator, and $\tilde{\pi}$ is given by equation (2). The model is closed by assuming that bank management is risk averse, such that $U'(\tilde{\pi}) > 0$ and $U''(\tilde{\pi}) < 0$.

II. The Optimal Futures Position

If the random variables are joint normally distributed and bank management exhibits constant absolute risk aversion, then it can be shown (see the appendix below) that the optimal anticipatory hedge, X^* , is

$$\begin{aligned}
 X^* = & \frac{E[(R_X - \tilde{R}_X) + I(X)(R_T - R_B)h]}{\gamma \text{Var}[(R_X - \tilde{R}_X)]} + \frac{-\text{LCov}[(\tilde{R}_L - \tilde{\theta} - R_B), (R_X - \tilde{R}_X)]}{\text{Var}[(R_X - \tilde{R}_X)]} \\
 & + \frac{-(R_B - R_D)\text{Cov}[\Delta \tilde{D}, (R_X - \tilde{R}_X)]}{\text{Var}[(R_X - \tilde{R}_X)]}, \tag{4}
 \end{aligned}$$

where γ is the constant absolute risk aversion index, Var represents variance, and Cov represents covariance.⁷ Equation (4) shows that the optimal T-bill futures position is the sum of three distinct terms: an expectations term, a loan commitment term; and a deposit term.⁸

The first term on the right hand side of (4) captures the influence of interest rate expectations and risk aversion on futures trading. The lower the expected futures contract interest rate at maturity, the more profitable a long futures position; hence, the greater is X^* . Similarly, the greater the current futures interest rate R_X , the greater the futures position given unaltered expected interest rates. An increase in the initial margin requirement, h , makes the futures position less profitable by increasing the opportunity cost of the funds needed to establish the futures position; hence X^* falls. What is more, bank management's aversion to interest rate risk determines the magnitude of the expectations term in deriving the optimal futures position. Greater aversion to risk is indicated as the index γ rises and as γ approaches infinity the role of expectations in the trading strategy diminishes to zero. Conservative bank management would base its

futures position only on the cash market sources of risk: variable rate loan commitments and random deposits.

The loan commitment term in equation (4) is interesting in two respects. First, the greater the loan commitments made prior to the futures decision, the greater the risk exposure of the bank. Therefore, the optimal response is to take a greater long position in the futures market to manage this risk. Second, the sign of $\text{Cov}[(R_L \tilde{\theta} - \tilde{R}_B), (R_X - \tilde{R}_X)] = -\text{Cov}(R_L \tilde{\theta}, \tilde{R}_X)$ merits attention. It seems likely that \tilde{R}_L and \tilde{R}_X are positively correlated. Given this, the interest elasticity of loan demand must then be specified to sign $\text{Cov}(\tilde{R}_L \tilde{\theta}, \tilde{R}_X)$. If borrower credit worthiness is unchanged and loan demand is interest inelastic, high \tilde{R}_X and \tilde{R}_L are associated with an insignificant decrease in θ so $\text{Cov}(\tilde{R}_L \tilde{\theta}, \tilde{R}_X) > 0$. If the borrower's credit rating changes unfavorably, the change in loan demand makes demand more inelastic at all interest rates and again $\text{Cov}(\tilde{R}_L \tilde{\theta}, \tilde{R}_X) > 0$. Only when loan demand is interest elastic or the borrower's credit rating improves will $\text{Cov}(\tilde{R}_L \tilde{\theta}, \tilde{R}_X) < 0$, all other things equal.

Since one cannot rule out that $\text{Cov}(\tilde{R}_L \tilde{\theta}, \tilde{R}_X)$ is negative, the loan commitment term in equation (4) could also be negative. The optimal futures position, X^* , would be depressed by a magnitude of $L\text{Cov}[(\tilde{R}_L \tilde{\theta} - \tilde{R}_B), (R_X - \tilde{R}_X)] / \text{Var}[(R_X - \tilde{R}_X)]$; there is less interest rate exposure to be managed by futures trading. Higher interest rates result in significantly smaller takedowns, and thus, the gap between rate sensitive assets and liabilities is smaller and possibly negative. If loan demand is interest inelastic and the borrower's credit rating is unchanged over the period, then an increase in the variability of $\tilde{R}_L \tilde{\theta}$ causes an increase in X^* , provided the correlation coefficient between $\tilde{R}_L \tilde{\theta}$ and \tilde{R}_X is unchanged. That is, as the marginal revenue earned on total loan commitments, $\tilde{R}_L \tilde{\theta}$, becomes more uncertain the T-bill futures position increases to cover more of the risk exposure.

The deposit term in the right hand side of equation (4) indicates the influence of withdrawal risk on the optimal futures decision. Since $(R_B - R_D) > 0$ by assumption, the sign of this term depends on the sign of $\text{Cov}[(\Delta\tilde{D}, (R_X - \tilde{R}_X))]$. Binding Regulation Q ceilings on deposit interest rates could yield $\text{Cov}[\Delta\tilde{D}, (R_X - \tilde{R}_X)] > 0$ or $\text{Cov}(\Delta\tilde{D}, \tilde{R}_X) < 0$ through disintermediation effects. As interest rates rise, deposit withdrawals cause the bank to borrow more expensive funds in the certificate of deposit market. Interest rate sensitive loan commitments are now partially matched with interest rate sensitive deposit costs. The futures position, X^* , should be reduced to reflect the bank's smaller exposure. Alternatively, Regulation Q deposits might be uncertain because the velocity of circulation and money demand is unstable. Changing tastes and preferences for holding money as a source of deposit uncertainty imply $\text{Cov}(\Delta\tilde{D}, \tilde{R}_X)$ could be positive, negative, or zero.

$\text{Cov}(\Delta\tilde{D}, \tilde{R}_X) > 0$ implies the bank's funding costs decline as interest rates rise. In this case, bank liabilities are again sensitive to interest rates: their cost moves the opposite of the interest rate on assets. The gap between rate sensitive assets and liabilities widens as interest rates rise, and X^* increases to cover the greater interest rate exposure. Equation (4) also has implications for the removal of Regulation Q interest rate ceilings. As R_D increases with the deregulation of deposit markets, $(R_B - R_D)$ gets smaller. Therefore, the deposit term in equation (4) becomes less important in the optimal futures position. Even with uncertain deposit flows, the bank's funding risk is reduced as R_D approaches R_B because the mix of liabilities becomes less important for bank decision-making.

III. A Hedging Evaluation

Unfortunately, an empirical test of the model presented in the last two sections is extremely difficult given the lack of data on actual bank hedging. Indeed, several surveys of bank futures trading indicate that perhaps 10% of all banks currently participate in the financial futures markets (see Drabenstott and McDonley (1982); Koch, et al (1982); Veit and Reiff (1983)). An alternative empirical application of the model is to test the effectiveness of the T-bill futures market in reducing the interest rate and quantity risks discussed above. Such an application is simultaneously a test of the T-bill futures market efficiency and the firm-theoretic model itself. Although not attempted here, the performance of the futures strategy in equation (4) can be compared with the performance of alternative strategies, such as always hedging 100% of the bank's exposure. This section of the paper estimates the performance of the firm-theoretic strategy, using the T-bill futures contract, relative to a nonhedging strategy. If its performance is unacceptable relative to nonhedging, comparisons with other strategies using the same futures market are not needed.

To assess the model's performance, observations for each of the elements in the right hand side of equation (4) must be collected. This requires bank specific data for L , $\text{Cov}[(\tilde{R}_L - \tilde{R}_B), (R_X - \tilde{R}_X)]$, R_D , and $\text{Cov}[\Delta \tilde{D}, (R_X - \tilde{R}_X)]$. It is unlikely that any real world bank faces a situation exactly satisfying the assumptions of the model, but equation (4) can be simulated using survey and Report of Condition data compiled by the Federal Reserve Board and the Federal Reserve Bank of Chicago. In the Seventh Federal Reserve District, fifteen banks have consistently reported their loan commitment positions since July 1973. All reporting banks have assets greater than \$1 billion. Average unused commercial and industrial loan commitments are calculated for the

reporting banks and this value is taken as an approximation for L .⁹ The ratio of outstanding commitments to the total of unused and used commitments is taken as a proxy for θ , the commitment takedown rate. $R_L\theta$ is determined as the product of θ and the monthly average prime rate for business loans. ΔD is taken to be the average change in demand and savings deposits for reporting banks.

The hedging simulation covers the time period from March 1977 to June 1982. Currently, T-bill contracts mature in the following four months: March, June, September, and December. Assuming a three month planning horizon and futures contract maturity at the end of the planning period, T-bill futures interest rates are collected on the first day of contract maturity and on the first day of the month 90 days prior to maturity. The time period contains 22 non-overlapping opportunities for hedging.

To capture the effects of changing interest rate volatility, all variances and covariances are recalculated for each new hedging period using ex post values. This procedure creates a time series measuring interest rate and quantity volatility over the simulation period.¹⁰ The rate at which banks are assumed to sell or purchase funds is the monthly average rate in the secondary market for six month certificates of deposit. The cost of deposits, R_D , is the average interest rate on savings and demand deposits established by Regulation Q, weighted by the size of each deposit category. Margin requirements are set at .3 percent of position face value, approximately the exchange minimum.

Two elements of equation (4) remain to be specified. The first is the index of constant absolute risk aversion, γ . Little if any empirical research has been done on the appropriateness of any particular index value in the banking industry. Rather than make an ad hoc assumption about any particular index value, the simulation results are reported for a range of

index values. It is assumed that the index of constant absolute risk aversion exhibited by bank management ranges between 1×10^{-5} and 1×10^{-7} . Parameter values within this range are reported below to indicate changes in the hedging strategy when risk aversion changes.

The second variable to be specified is $E\tilde{R}_X$, the three month forecast of the 13-week T-bill futures rate. Three alternative forecasts are reported in the simulation results. The first assumes that bank decision-makers make no interest rate forecast other than the rate expected by the T-bill futures market. Banks without economic research or forecasting units may be able to use the T-bill futures market as an expectations generating mechanism; therefore, T-bill futures interest rates merit consideration as forecasts in a futures hedging strategy.

The second kind of forecast used is the forward rate imbedded in the short-term segment of the yield curve.¹¹ Because the purpose is to forecast 90-day T-bill futures rates 90-days in the future, the forward interest rate is calculated as:

$$1 + R_{T,1}^f = (1 + R_{T,2})^2 / (1 + R_{T,1}) \quad (5)$$

where

- $R_{T,1}^f$ = the forward interest rate on a 90-day T-bill beginning 90-day in the future,
- $R_{T,2}$ = the current interest rate on a 180-day T-bill and
- $R_{T,1}$ = the current interest rate on a 90-day T-bill.

From the pure expectations theory of the term structure of interest rates, the implied forward rate in the yield curve is an unbiased expectation of the actual future interest rate when markets are in equilibrium.

The third type of forecast used was the actual T-bill futures interest rate existing at the end of the planning period. The hedging simulation results using a perfect interest rate forecast serve as a performance standard

for evaluating the other forecasts. Furthermore, using a perfect forecast in the simulation serves as a proxy for all other possible regression and time series models capable of predicting three-month T-bill interest rates.

Table 1 shows the simulation results with five alternative values of the risk aversion index. Sample means and their standard deviations are calculated depending upon the type of T-bill futures forecast used and the number of hedging periods in which the optimal position satisfied $|X^*| \leq |L+\Delta D|$. The hedging ratio in column two is defined as $X^*/(L+\Delta D)$ and indicates the percent of bank risk exposure hedged in the T-bill futures market. In the third column, hedging effectiveness is calculated as the percent change in the variance of unhedged profits due to T-bill futures hedging.¹² It takes a value of zero if no futures trading occurs ($X^*=0$). Hedging effectiveness greater than zero indicates that financial futures hedging increases the variability of bank profits relative to non-hedging.

From the results in Table 1, it seems likely that a bank's interest rate and quantity risks can be hedged successfully using the T-bill futures market and the firm theoretic model developed above. Hedging 90% of its risk exposure reduces the variability of unhedged profits by 7-10% at all levels of constant absolute risk aversion. Although the effectiveness of the T-bill futures hedge is small quantitatively, it is statistically significant at all but the lowest values of the risk aversion index using forward and perfect forecasts. In similar instances, the hedging ratios are significantly less than 100% of the bank's net risk exposure. By comparison, the hedging ratios are consistent with those reported in Ederington (1979) and Franckle (1980), while the hedging effectiveness results are much lower. Hedging effectiveness is lower here because the role of expectations are explicitly incorporated, the hedge is a cross-hedge, and quantity risks are involved.

Table 1
Firm-theoretic Simulation Results
1976-82
(22 possible hedge positions)

<u>Risk Aversion Index and T-bill Forecast</u>	<u>Hedging Ratio</u>	<u>Hedging Effectiveness</u>	<u>Futures Return (in 000s)</u>	<u>Initial Margin (in 000s)</u>	<u>N^a</u>
1. $\gamma = 1 \times 10^{-5.2}$					
a. Futures Forecast	.897 ^b (.040)	-.098 (.036)	-916.144* (786.647)	359.439 (49.392)	21
b. Forward Forecast	.878 (.049)	-.097 (.036)	-767.914* (735.299)	342.131 (47.068)	21
c. Perfect Forecast	.885 (.043)	-.098 (.036)	-775.519* (736.004)	347.646 (46.940)	21
2. $\gamma = 1 \times 10^{-5.6}$					
a. Futures Forecast	.897 (.040)	-.098 (.036)	-915.761* (786.504)	359.396 (49.380)	21
b. Forward Forecast	.799 (.067)	-.097 (.035)	-573.059* (710.677)	306.060 (50.763)	20
c. Perfect Forecast	.863 (.050)	-.097 (.036)	-561.154* (675.897)	327.995 (44.743)	21
3. $\gamma = 1 \times 10^{-6.0}$					
a. Futures Forecast	.897 (.040)	-.098 (.036)	-914.801* (786.144)	959.289 (49.351)	21
b. Forward Forecast	.900 (.042)	-.074 (.020)	-333.254* (757.654)	333.617 (50.003)	17
c. Perfect Forecast	.848 (.052)	-.099 (.037)	-250.991* (637.607)	304.301 (42.021)	20
4. $\gamma = 1 \times 10^{-6.4}$					
a. Futures Forecast	.897 (.040)	-.098 (.036)	-912.387* (785.241)	359.020 (49.280)	21
b. Forward Forecast	.896** (.056)	-.076* (.037)	-579.286* (884.355)	369.336 (62.463)	21
c. Perfect Forecast	.753 (.070)	-.071 (.022)	-555.075* (1,032.482)	289.829 (60.712)	18
5. $\gamma = 1 \times 10^{-6.8}$					
a. Futures Forecast	.896 (.041)	-.098 (.036)	-905.962* (782.996)	357.909 (49.080)	21
b. Forward Forecast	.987** (.012)	-.080* (.039)	-1,015.900* (1,019.201)	406.243 (64.954)	20
c. Perfect Forecast	.864** (.075)	-.078* (.043)	-662.419* (1,113.768)	334.285 (71.770)	18

^aNumber of hedge positions satisfying $|X^*| < |L + \Delta D|$.

^bSample mean with standard deviation in parenthesis.

* Not significantly different than zero at the 5% level.

**Not significantly different than one at the 5% level.

Different expectations and levels of risk aversion lead to different results in the hedging strategy solely through the expectations term in equation (4). As argued in section II, the higher the degree of risk aversion, the less important the expectations term in the hedging strategy. This result is also seen in Table 1. For $\gamma = 1 \times 10^{-6.8}$, lines 5b and 5c, the number of hedge positions satisfying the regulatory constraint, $|X^*| \leq |L + \Delta D|$, are fewer than for $\gamma = 1 \times 10^{-5.2}$, lines 1b and 1c, and the regulatory constraint is binding more often for the former than the latter. At low levels of risk aversion there is an incentive to speculate in the futures market and to increase the bank's risk exposure. The regulatory constraint prohibits this; hence, Table 1 reports hedging ratios not significantly different than one and hedging effectiveness not significantly different than zero at the lowest level of risk aversion. Because using a futures market forecast greatly diminishes the role of expectations and risk aversion in the hedging strategy, the results for this forecast approximate the most conservative use of the model and market.

A striking result in Table 1 is that changes in expectations and risk aversion make insignificant differences in hedging performance. This suggests the expectations term in equation (4) is dominated by the loan commitment and deposit terms, at least with respect to determining the hedging ratio and hedging effectiveness. However, the costs of using the T-bill futures market to hedge interest rate and quantity risks do depend on the expectations term. A partial assessment of the costs of each T-bill futures hedging strategy is given in columns four and five of Table 1. Column four computes the gross T-bill futures return on average excluding the repayment of initial margin at the end of the period and excluding any interest earned on margin. Column five calculates the average initial margin required to initiate the hedging strategy. These figures represent partial costs because the model ignores

roundturn brokerage commissions, interest on initial margin, and most important, profits on losses from the daily marking to market of the position.

The average T-bill futures returns are negative, although not significantly so, for all hedging strategies in Table 1. The losses tend to be greatest when hedging with a futures market forecast and smallest when hedging with a perfect forecast. The returns from hedging with a forward forecast are similar to the perfect forecast returns. Of the two ex ante forecasts, futures and forward, the latter results in a more selective anticipatory hedge and therefore, is less costly. Initial margin requirements range from \$300-400 thousand per hedge, indicating the futures positions are quite large. In sum, part of the costs of attaining a 10% reduction in unhedged profits is an insignificant reduction in overall bank profitability and the opportunity cost of the \$300-400 thousand required as initial margin.

IV. Conclusion

The applicability of these results depends on the assumptions of the underlying theory of bank behavior. Bank assets typically include spot market loans and a securities portfolio; for simplicity they have been excluded. Including these assets in the model would create an opportunity for hedging in the T-bill, T-bond, and GNMA futures markets and the implementation of an integrated strategy.¹³ The resulting optimal futures position may be long or short or a spread depending on expectations and the bank's exposure. The volume of loan commitments acquired by the bank need not be predetermined at the time of the futures decision. Similarly, variable-rate liabilities could have been added to the model with perhaps a deposit interest rate as a choice variable. Generalizing the model in these ways would make the futures decision dependent on the cash market decisions and vice versa. Unfortunately, this would obscure the purpose of this paper: to describe the

role of anticipatory hedging in a bank's forward lending operations when its deposit flows are uncertain. Outside of these matters, the model could have incorporated initial fees on making loan commitments, compensating balances, or fees on unused commitment balances without substantially changing the conclusions.

As for the simulation results, it is unlikely that the estimated costs and benefits of using the firm-theoretic hedging strategy with the T-bill futures market are directly applicable to any existing bank. The simulation's purpose is to illustrate the types of bank specific data required to implement the strategy and to assess the outcome quantitatively. The model has the flexibility to incorporate different expectations and risk bearing preferences; the outcomes from a variety of each are estimated. The results suggest that interest rate and quantity risks can be reduced using the T-bill futures market and the firm-theoretic model, although the prospects for decreasing the variability of unhedged profits are less than in pure interest rate risk situations.¹⁴ Dissemination of the mechanics and possible performance of hedging interest rate and quantity risks is therefore valuable because it helps current and potential hedging institutions determine when futures trading decreases rather than increases overall bank risk. Given the simulation results, hedging interest rate and quantity risks has a high probability of increasing bank risk unless the hedging strategy incorporates the elements discussed above.

To date, little theoretical or empirical work addresses the type of financial futures hedge studied here. The bank's futures position is a cross-hedge of an expected loan asset with an uncertain rate of return, funded at an uncertain cost. Unlike the banks discussed by Batlin (1983) and Dew and Martell (1981), the bank described above is a direct rather than an indirect participant in the financial futures market. It is the bank rather than the

borrower that is better able to transfer interest rate risk to the futures market because it has the ability to pool small balances and risks. The futures position is also different because it is an anticipatory hedge of interest rate and quantity risks. Because any futures hedge of an existing cash market position can be duplicated by the purchase and sale of cash market instruments with different maturities, Franckle and Senchak (1981) argue that the most effective use of financial futures markets is to hedge an anticipated cash position. The theoretical model in section one was developed with such a purpose in mind. In reality, bank applications of anticipatory hedging commonly involve a quantity risk such as commitment takedowns, loan prepayments or deposit withdrawals. Financial futures contracts are best suited for managing interest rate risks, and this helps explain why the bank's T-bill futures market hedge results in only a 10% reduction in the variability of unhedged profits. Although this reduction is significant, further research into the usefulness of other anticipatory hedging applications is needed before it can be labeled the most effective type of bank hedging.

V. Appendix

Since the balance sheet constraint, equation (1), can be solved for B in terms of X, the maximization problem in (3) can be expressed as

$$\text{Maximize } EU\{(\tilde{R}_L \tilde{\theta} - R_B)L + [(R_X - \tilde{R}_X) + I(X)(R_T - R_B)h]X + (R_B - R_D)\tilde{D}\} \quad (A1)$$

$$|X| \leq L + \Delta D$$

Differentiating expression (A1) with respect to the futures decision, $X = 0$ gives¹⁵

$$EU'[\tilde{\pi}][(R_X - \tilde{R}_X) + I(X)(R_T - R_B)h] = 0, \text{ or} \quad (A2)$$

$$EU'[\tilde{\pi}]E[(R_X - \tilde{R}_X + I(X)(R_T - R_B)h) + \text{Cov}[U'(\tilde{\pi}), (R_X - \tilde{R}_X)] = 0, \quad (A3)$$

where Cov represents covariance. Next, assume the random variables are joint normally distributed. Using Rubinstein's (1976) result, equation (A3) can be rewritten as

$$EU'[\tilde{\pi}]E[(R_X - \tilde{R}_X) + I(X)(R_T - R_B)h] + EU''[\tilde{\pi}]\text{Cov}[\tilde{\pi}, (R_X - \tilde{R}_X)] = 0. \quad (A4)$$

The final assumption needed for a closed form solution is that bank management exhibit constant absolute risk aversion. The fixed index of risk aversion, γ , equals $-U''[\tilde{\pi}]/U'[\tilde{\pi}] > 0$. Rewriting this relationship and taking expectations yields $EU''[\tilde{\pi}] = -\gamma EU'[\tilde{\pi}]$. Since $\text{Cov}[\tilde{\pi}, (R_X - \tilde{R}_X)] = L \cdot \text{Cov}[(\tilde{R}_L \tilde{\theta} - \tilde{R}_B), (R_X - \tilde{R}_X)] + X \text{Var}[(R_X - \tilde{R}_X)] + (R_B - R_D) \text{Cov}[\Delta \tilde{D}, (R_X - \tilde{R}_X)]$ where Var represents variance and $\tilde{D} = D + \Delta \tilde{D}$, equation (A4) can be solved for the optimal anticipatory hedge, X^* , given by equation (4) in the text.

VI. Footnotes

¹Given that 55-61% of the business loans made were under commitment agreements and that 55-66% of the business loans had floating interest rates, a rough approximation of 30-40% of the business loans made had variable-rate loan commitment terms.

²This model abstracts from the explicit problem of default risk on bank loans.

³In this theory, no special significance should be attached to the T-bill futures contract. Any money market futures contract could be used by the bank and the particular choice of contract depends on the covariance between futures prices and the exposure that is being hedged.

⁴The current futures trading guidelines set out by the three federal banking agencies (see 45 Federal Register 18120-18122 and 18116-18118 (March 20, 1980)) do not proscribe long anticipatory hedging by banks. Long futures positions can be used when funding interest-sensitive assets with fixed rate sources of funds provided this is the net exposure in the bank's overall balance sheet. The anticipated transaction must be probable to occur because the institutions has little discretion to do otherwise.

⁵These guidelines were issued simultaneously by all three regulatory agencies in November 1979 and revised in March 1980. For national banks, see Banking Circulars No. 79 issued by the Comptroller of the Currency. For insured state nonmember banks, see Banking Letter No. 17-80 issued by the Federal Deposit Insurance Corporation.

⁶This model considers only initial margin; margin calls are ignored. Also, any excess margin monies beyond maintenance margin on the open futures position is usually invested in interest earning accounts by the brokerage house. It seems likely that ignoring margin calls biases the estimated costs

of futures trading downward. Finally, fixed roundturn brokerage commissions are also ignored. These commissions are approximately \$100 per contract.

⁷Constant absolute risk aversion implies that favorable odds are required before accepting a risky gamble of fixed absolute size and that those favorable odds do not change as profits change.

⁸If the model has been developed without the quantity risk of uncertain deposit flows, $\text{Cov}[\Delta\tilde{D}, (R_X - \tilde{R}_X)] = 0$. In addition, assuming the expected T-bill futures rate equals the current T-bill futures rate (the futures market is martingale efficient), margin requirements are zero, and loan commitment takedowns are 100%, equation (8) becomes

$$X^*/L = -\text{Cov}[(\tilde{R}_L - R_B), (R_X - \tilde{R}_X)] / \text{Var}[(R_X - \tilde{R}_X)]. \quad (4')$$

The optimal ratio of T-bill futures to risk exposure, X^*/L , is given by $-\beta$ in the regression $(\tilde{R}_L - R_B) = \alpha + \beta(R_X - \tilde{R}_X)$. This is the portfolio-choice method developed for financial futures hedging by Ederington (1979) but applied here to a cross-hedge between the bank's profit margin and the change in T-bill futures rates. The advantage of the firm-theoretic solution, equation (4), is that the role of expectations, margins, and quantity risks can be considered in the bank's risk-bearing decisions.

⁹A better approximation may be Boltz and Campbell's (1979) estimate that 55-66% of the business loans made at money center and regional banks had variable rate terms. The simulation tends to overstate the stylized bank's risk exposure, therefore.

¹⁰Some of the bank-specific items used in the simulation are as follows (means over the simulation period with standard deviations in parentheses).

<u>L</u> <u>(\$000s)</u>	<u>Cov[($\tilde{R}_L - \tilde{R}_B$), ($R_X - \tilde{R}_X$)]</u>	<u>Cov[$\Delta\tilde{D}$, ($R_X - \tilde{R}_X$)]</u>
134,190 (12,117)	-.0000235 (.0000115)	-245,896 (61,157)

¹¹For further discussion on a comparison between forward and futures interest rates as expectations see Lang and Rasche (1978) and Poole (1978).

¹²Therefore, hedging effectiveness was taken as:

$$\begin{aligned} [\text{Var}(\tilde{\pi}) - \text{Var}(\tilde{\pi}_u)] / \text{Var}(\tilde{\pi}_u) = & \{ (X^*)^2 \text{Var}[(R_X - \tilde{R}_X)] + 2LX^* \text{Cov}[(\tilde{R}_L \tilde{\theta} - R_B), (R_X - \tilde{R}_X)] \\ & + 2X^* (R_B - R_D) \text{Cov}[\Delta \tilde{D}, (R_X - \tilde{R}_X)] \} / \text{Var}(\tilde{\pi}_u) \end{aligned}$$

where $\text{Var}(\pi_u)$ = the variance of bank profits without futures hedging.

¹³Including a variety of assets in the bank's portfolio also complicates the calculation of net risk exposure. An important factor inhibiting the use of financial futures by banks may very well be their inability to calculate the gap between rate sensitive assets and liabilities at different maturities.

¹⁴Another possible explanation for the low estimates of hedging effectiveness is that the simulation used monthly average prime rates in calculating $\tilde{R}_L \tilde{\theta}$. It is well known that the prime rate is a poor reflection of the terms of bank lending, especially at larger institutions. Unfortunately, other proxies for \tilde{R}_L are not easily obtained.

¹⁵A sufficient condition for a maximum in expression (4) requires that the utility function demonstrate risk aversion.

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