An Empirical Analysis of Bank Hedging in Futures Markets

G. D. Koppenhaver

Much has been written about the use of futures contracts to manage the interest rate and quantity risks associated with bank operations. The majority of the research has been empirically oriented.[1] The empirical applications have either simulated solutions for optimal bank futures positions (see Koppenhaver (1985(a)) and Morgan, Shome, and Smith (1988)) or more commonly, focused on a specific item held by banks and then used market prices to estimate an item-specific hedge ratio.[2] Although it can incorporate overall risk exposure, the usefulness of a simulation as a practical guide to bank management depends on the assumptions used in the simulation. Item-specific hedge positions are economically useful only if the item being hedged is the sole source of risk for the bank. Otherwise, an offsetting risk may be ignored and the futures position might increase rather than decrease the overall risk exposure of the bank.

A few articles have used surveys to investigate the actual futures market participation by banks (see Booth, Smith and Stolz (1984), Drabenstott and McDonley (1982), Koch, Steinhauser and Whigham (1982), Parkinson and Spindt (1986), and Veit and Reiff (1983)). A consistent conclusion of these studies is that banks are not utilizing futures contracts to any significant extent, except for the largest institutions. The reasons given for limited bank utilization include: the existence of cash market alternatives for managing risk, such as maturity matching; the unfavorable accounting treatment of futures market positions; the lack of qualified personnel to implement hedging policies; and resistance by top management in authorizing a futures market hedging program.

To date, no formal analysis of actual bank positions in futures markets exists. Since 1983, the Federal Reserve has collected quarterly data on futures and forward market positions of U.S. commercial banks (Schedule L, Report of Condition and Income).[3]

The author gratefully acknowledges the helpful comments of Roger Stover, Iowa State University, seminar participants at Iowa State University, and the Federal Reserve Bank of Philadelphia, and two anonymous referees. The author alone is responsible for any remaining errors. The Federal Reserve Bank of Chicago provided the data used in this study.

G. D. Koppenhaver is an Associate Professor of Finance at Iowa State University.

[1]For theoretical contributions, see Hilliard (1984), Ho and Saunders (1983), Kolb and Chiang (1982), and Koppenhaver (1985(a)). On a more practical level, Booth and Koveos (1986) develop a two-stage linear programming model of optimal cash and futures decisions made by a bank concerned with liquidity risk management.

[2]The latter empirical approach is more popular because the data requirements are less. For example, see the pioneering work of Ederington (1979) and the recent articles by Howard and D'Antonio (1986) and Overdahl and Starleaf (1986).

[3]The data in Table I overstates bank participitation in futures markets because over-the-counter forward contracts are included. On the other hand, the data in Table I excludes bank positions in foreign currency futures and so understates futures participation.

The Journal of Futures Markets, Vol. 10, No. 1, 1–12 (1990)
© 1990 by John Wiley & Sons, Inc.
CCC 0270-7314/90/010001-12$04.00

The size and type of the positions, as well as the frequency of use, is reported in Table I for all banks and two subsets of large institutions. Table I shows that total industry out-

Table I
FUTURES AND FORWARD CONTRACT POSITIONS OF U.S. COMMERCIAL BANKS[a]

	1983	1984	1985	1986	1987
A. Total Outstanding (in billions)					
Long contracts	$24.4	$50.4	$43.5	$64.3	$121.2
Short contracts	26.1	41.8	44.1	59.8	108.9
B. All Banks					
Percent reporting					
Long positions[b]	2.1	1.5	1.4	1.2	1.6
	(313)	(223)	(199)	(175)	(228)
Short positions	1.5	1.4	1.4	1.4	1.3
	(219)	(200)	(208)	(194)	(181)
Average ratio to equity[c] (%)					
Long positions	45.1	40.7	52.4	74.0	62.4
Short positions	74.8	61.5	77.6	63.2	65.0
Net positions[d]	−5.6	−10.2	−19.7	2.7	8.5
C. Banks with Total Assets > $500 million					
Percent reporting					
Long positions	24.9	22.1	21.9	18.8	20.7
	(106)	(99)	(104)	(96)	(110)
Short positions	28.5	25.9	24.7	24.0	21.2
	(121)	(116)	(117)	(123)	(113)
Average ratio to equity (%)					
Long positions	45.9	50.3	49.6	96.0	72.9
Short positions	49.8	52.1	39.2	67.6	61.5
Net positions	−9.0	−8.5	4.5	7.0	8.5
Share of total outstanding (%)					
Long positions	97.1	99.4	99.5	99.5	99.4
Short positions	96.9	99.0	98.6	99.5	99.4
D. Top 10 Banks by Total Assets[e]					
Average ratio to equity (%)					
Long positions	41.4	100.4	76.0	100.5	199.7
Short positions	54.6	79.8	84.8	109.3	156.6
Net positions	−13.2	20.9	−8.7	−8.9	43.1
Share of total outstanding (%)					
Long positions	65.2	77.4	68.3	67.0	81.8
Short positions	66.7	69.6	76.8	73.1	80.9

[a]All dates correspond to the March report of Condition and Income except 1983; the 1983 data is from the June Report.
[b]Number of Reporting banks in parentheses.
[c]For those banks reporting nonzero levels.
[d]Negative (positive) values indicate an excess of short (long) contracts.
[e]All banks reported both long and short futures and forward positions.

standings have grown substantially, especially from 1986 to 1987 while market participation rates have stayed constant or fallen. Over time, banks are taking larger positions and in total have changed from a net short (sell) position in all contracts to a net long (buy) position. Table I also shows that banks with total assets in excess of $500 million reported virtually all of the contracts outstanding. Finally, the ten largest banks have increased both long and short positions over the data period, relative to bank equity, and reported between 65 and 80 percent of all contracts outstanding in the banking industry.

A testable hypothesis is whether reported bank futures positions offset the overall interest rate risk of operations (macro hedging), as spelled out by federal bank regulators in policy guidelines, or whether bank futures positions are used to offset the risk of specific banking activities (micro hedging).[4] To test this hypothesis, the determinants of actual bank futures positions are investigated below, based on a theory of how banks might selectively manage their balance sheet interest rate risk with futures contracts. Actual futures positions from bank Call Reports are analyzed, going beyond simulations and surveys to directly test the relationship between interest rate risk and futures positions for a large cross-section of banks.

The empirical analysis indicates that positions obligating the bank to sell securities are related to the balance sheet risk of the bank, on average, but the relationship is not quantitatively large. The empirical hedge ratio for the average short hedging bank in the sample is estimated at less than 10% of its balance sheet interest rate risk. Positions obligating the bank to purchase securities are also related to the balance sheet risk of the bank, on average, although the risk being hedged is different than for short hedging banks and the empirical hedge ratio is only 4%. The results also imply that bank futures and forward positions are more strongly related to micro hedging considerations of off balance sheet risk than macro hedging considerations of balance sheet risk.

I. THEORETICAL FOUNDATION[5]

To motivate the specification of the empirical model, this section develops a simple model of selective bank hedging decisions. At the beginning of a one-period planning horizon before all interest rates are revealed, assume bank management must decide on the size and type of futures position to take, given predetermined levels of loans, the sole earning asset, and retail deposits.[6] Assume the term to maturity of bank loans extends beyond the end of the period and loans are held to maturity. Therefore, the loan rate is known with certainty. The retail deposit rate is also assumed to be certain. At the end of the period, funds are either competitively purchased or sold at revealed market

[4]See Koppenhaver (1987) for a discussion of the current regulations on bank and thrift use of derivative market contracts. Commercial banking and organizations have been approved to trade futures contracts based on U.S. Treasury and agency securities, negotiable money market instruments, foreign currencies, and indices of municipal bonds and stocks.

[5]See the appendix for a complete expression of the mathematical model of optimal bank futures trading.

[6]The model assumes away the problems created by random loan defaults, loan prepayments, and deposit withdrawals on the optimal bank futures position. If stochastic loan demands and deposit withdrawals are incorporated in the theory, the net effect is to change the bank's fundamental exposure to interest rate risk, the GAP variable in eq. (1). In addition to the uncertain cost or revenue of the marginal source or use of funds, the bank would also be uncertain about the quantity of borrowing or lending that occurs at the end of the period. The interaction of price and quantity risk must then be considered in calculating the bank's fundamental balance sheet risk. See Batlin (1983), Ho and Saunders (1983), and Koppenhaver (1985(b)), for models that treat these extensions. Note that the estimation, below, does implicitly incorporate these extensions in the results for the optimal empirical hedge ratios.

rates to equate assets and liabilities. Depending on the amount of lending relative to retail deposits, the bank may have either a positive, zero, or negative maturity gap in its overall balance sheet. If predetermined loans are greater (smaller) than predetermined deposits, the bank is exposed to the risk of a rise (fall) in interest rates. The futures position is also offset at the end of the planning period, returning any futures trading profits or losses. The process repeats itself at the beginning of the next planning period.

Assume a bank's hedging policy is directly determined by bank management and not by the bank's owners. If banks are widely-held corporations, then stockholders can hold diversified portfolios and hedge the residual risk on their own. Banking corporations may have less incentive to hedge in seeking value maximization than owner-operated banks. But this relationship between hedging and bank organization would seem to be contrary to the actual position-taking by banks reported in Table I; the larger institutions hold virtually all of the outstanding contracts in the industry yet are the most likely to be organized as corporations with publicly traded stock.

Smith and Stulz (1985), however, argue that hedging enhances the value of widely-held corporations if it reduces expected tax liabilities or bankruptcy costs. Hedging is also value enhancing if bank managers own a nontradeable, uncertain claim on the firm, are risk averse, and hedge away the risk so that expected compensation costs are lower. This article adopts the managerial risk argument for hedging and assumes that managers choose the bank's hedging policy to maximize the expected utility of wealth given a nontradable risk, a predetermined compensation scheme, and subjective expectations about the future.

To induce management to act in the best interest of shareholders, the owners specify the managerial compensation scheme. The managers, in maximizing end-of-period wealth, may pursue an active hedging policy to reduce risk even though shareholders only care about the maximization of the value of the bank. Since the bank's loan portfolio is predetermined, lending policies are not affected by hedging. The shareholders will be indifferent about the financial decision embodied in the futures position if trading is costless or firm value is maximized. The particular form of the compensation scheme assumed here (linear in profits) simplifies the analysis yet still reveals the relationship between managerial compensation and the hedging policies of corporations.[7]

Let management's end-of-period wealth be the sum of an amount of riskless income and a salary which is tied to the uncertain profitability of the bank. If management is constant absolute risk averse, management's salary is a direct linear function of firm profitability, and the random variables are joint normally distributed, the solution to the futures hedging problem yields

$$X^* = \frac{-E\tilde{v}}{\lambda\theta' R_X \sigma_v^2} + \delta\,\mathrm{GAP}, \tag{1}$$

where: X^* = the optimal futures position,
$E\tilde{v}$ = the expected percentage change in futures interest rates,
λ = the index of constant absolute risk aversion, >0,
θ' = the proportion of bank profits paid to management, with $0 < \theta' \leq 1$,
R_X = the current futures interest rate,
σ_v^2 = the variance of $\tilde{v}$,

[7]See Campbell and Kracaw (1987) and Stulz (1984) for other theoretical applications of hedging to maximize managerial expected utility. The focus of Stultz, however, is on the management of unsystemaic foreign exchange risk. Campbell and Kracaw also study managerial hedging of unsystematic risk and model the compensation scheme as endogenous to labor market equilibrium.

δ = the minimum variance hedge ratio for the futures contract relative to the cash risk exposure, and

GAP = the fundamental interest rate risk of the bank.[8]

The first term on the right-hand side of eq. (1) captures the effect of expectations, risk aversion, and compensation on the optimal hedging policy. Higher (lower) expected rates push the optimal position to the short (long) side of the futures market. Note that if interest rates are expected to fall substantially, management may choose a long futures position in maximizing their expected utility in spite of balance sheet interest rate risk that exposes the bank to a rise in rates. That is, management may choose to speculate in interest rate changes through the futures position, adding to the risk of a mismatched balance sheet, if it helps attain the preferred level of risk-bearing.

As either managerial risk aversion falls or managerial compensation decreases as a proportion of profits, the expectations term gains importance in the hedging decision. For example, as management's compensation becomes less sensitive to the profit performance of the bank, management in effect becomes more willing to bet on the expected change in interest rates in choosing the futures position. By taking a bigger bet, compensation is greater should expectations be realized. The bet may be taken by either futures speculation or a smaller partial hedge of balance sheet risk. The expectations term therefore drives the selectivity of the hedging program undertaken by bank management.

The second term in the right-hand side of eq. (1) captures the effect of the fundamental risk exposure of the bank on the hedging decision. Assume cash and futures interest rates move sympathetically, or that $\delta > 0$. If the bank must purchase liabilities (assets) at the end of the period or the GAP is negative (positive), the optimal futures hedge for the fundamental risk of the bank is a sell (buy) futures position.[9] The fundamental risk exposure of the bank is the primary determinant of an optimal futures hedge if either interest rates are not expected to change or bank management is infinitely risk averse.

II. EMPIRICAL MODEL

Eq. (1) is the starting point for the empirical analysis. Given data on bank futures positions, interest rate risk, and expectations, the linear relation in eq. (1) can be estimated and the hedge ratio, δ, determined empirically. In studying the determinants of futures positions, the focus is on banks with total assets in excess of $500 million. Little data is lost in explaining the total value of contracts outstanding by restricting the focus to these banks. June and December Call Report data from 1983–1987 are pooled over the ten report dates and banks that did not fall in the asset size category in all ten Reports are omitted. The resulting sample includes 356 banks with 3560 total observations.

The dependent variables are assumed to be futures and forward contracts that obligate the bank to either purchase or sell securities. The data separates buy and sell positions, but because information about the actual contracts that make up the positions are not reported, a bank's net position is not used as the dependent variable. Using gross instead of net futures and forward contracts avoids any bias that might be introduced by netting

[8] As shown in the appendix, -GAP in the model is the difference between bank loans net of equity funding at a binding capital constraint k and retail deposits net of reserve requirements r. If the difference is positive (negative), the bank is exposed to a rise (fall) in interest rates since the bank must purchase (sell) funds to equate assets and liabilities.

[9] As the required ratio of capital to earning assets increases or the required reserves against retail deposits falls, the fundamental risk of the bank tends toward a positive maturity gap and the purchase of futures contracts becomes optimal. See the appendix.

different contracts that may require different hedge ratios.[10] Since the frequency of use for futures and forward contracts is only 20–25 percent in the bank asset size category, a tobit estimation procedure is used to incorporate information on both bank hedgers and nonhedgers.[11]

The basic form of the empirical model for bank j, given that they report a futures and forward position, is:

$$
\begin{aligned}
i\text{FUTRS}_t = \alpha_0 &+ \alpha_1\text{GAP6}_t + \alpha_2\text{GAP12}_t \\
&+ \alpha_3\text{TDGACTT}_t + \alpha_4\text{YLDCRV}_t + \varepsilon_t,
\end{aligned} \tag{2}
$$

where $i = S$ or L, and the variables are defined in Table II. All balance sheet variables are normalized by total bank assets. Nontransaction savings deposits are included in the

Table II
SAMPLE STATISTICS AND DEFINITIONS FOR DATA SERIES USED IN TOBIT ESTIMATION (3560 OBSERVATIONS)

Variable	Mean	Std. Dev.	Definition
SFUTRS	0.008	0.030	Short (sell) futures and forward position/total assets
LFUTRS	0.008	0.033	Long (buy) futures and forward position/total assets
GAP6	−0.079	0.115	Six month maturity gap/total assets
GAP12	0.017	0.038	Twelve to six month maturity gap/total assets
TDGACCT	0.004	0.011	Trading account/total assets
YLDCRV	0.128	0.050	Logarithm (6–mo. forward rate/ 6–mo. cash rate on Treasury bills)
SIZE	7.671	1.032	Logarithm (total assets/1,000,000)
CR3	0.756	0.186	Three firm concentration ratio for county-wide deposits
FOREX	0.485	0.500	Equals one if foreign currency position, zero otherwise
LNCOM	0.159	0.146	Loan commitments/total assets
SWAPS	0.260	0.438	Equals one if interest rate swap position, zero otherwise

Source: Report of Condition and Income, June and December, 1983–1987, Federal Reserve Bulletin, various issues.

[10]For example, a 100 basis point rise in interest rates always causes the Eurodollar or Treasury Bill futures contracts to fall by \$2,500 while the Treasury Bond futures contract will fall by \$7,958 if rates were initally at 9%. To hedge the risk of a two-year, \$1 million cash exposure priced at par and yielding 9%, either 7.5 Eurodollar futures contracts with face value of \$7.5 million or 2.3 Treasury Bond futures contracts with face value of \$230,000 could be used. If the bank faced this cash exposure on both the short and the long sides and hedged each separately (with Eurodollar futures on the long side and Treasury Bond futures on the short side), then netting the reported positions would show the bank to be a net buyer of \$7.23 in futures contracts. The reported balance sheet position of the bank would reflect the existing mismatch between assets and liabilities, not the offsetting anticipated cash transaction. Therefore the net futures position may or may not appear to offset an existing cash exposure. Without information on the contracts being used, gross positions involve fewer data problems than net positions.

[11]See Maddala (1983, Ch. 6) for a discussion of the tobit estimation procedure.

liabilities maturing in the six month maturity interval; trading account assets are not categorized in any of the maturity gap variables and so are included separately.

The common set of independent variables implies that the GAP variables, measured as assets minus liabilities maturing or repricing during the relevant period (Schedule *J*, Report of Condition and Income), should have negative signs in explaining sell positions and positive signs in explaining buy positions. Apriori, the greater (smaller) the amount of assets relative to liabilities repricing or maturing over a given time period, the greater the loss in bank profitability from a fall (rise) in interest rates. If futures and forward market positions are related to a bank's balance sheet interest rate risk, then the size of the buy (sell) positions should be directly (indirectly) related to the GAP variables. Two different gap variables are included as explanatory variables to capture the specific interest rate risk that determines hedging decisions. Because futures and forward contracts could be used to hedge anticipated trading account purchases, as well as the risk of the existing portfolio, no apriori sign for the TDGACCT variable can be determined.

Although bank-specific rate expectations are important in the implementation of a hedging program, they are not available for the banks in the sample. The direction of fundamental expectations for all banks at each report date, however, is measured by the interest rate spread between the six-month forward and cash Treasury bill rates, YLDCRV. If the yield curve steepens, YLDCRV increases and interest rates are expected to rise in the future. In eq. (2), short (long) futures and forward positions should then increase (decrease) because of the greater (smaller) expected profitability of the bank's futures and forward position.

III. ESTIMATION RESULTS

The regression from estimating the tobit model of hedging determinants (eq. (2)) are presented in the first and third columns of Table III.[12] For short futures and forward positions, only the GAP12 variable has the expected negative sign; the coefficient for GAP6 implies that as the average bank's balance sheet exposure to a fall in interest rates grows, short contract positions also grow. The result is not consistent with overall balance sheet hedging because sell positions show profits if interest rates rise, not fall. The size of short contract positions are also significantly related to the size of bank trading accounts. Expectations of higher interest rates, captured in a steeper yield curve, are directly related to short futures and forward contract positions. In total, the empirical results in the first column are generally consistent with the theory of optimal managerial hedging.

In the third column of Table III, the results for long futures and forward positions look very much the same as the results in the first column, except that the effect of rate expectations as measured by YLDCRV are statistically insignificant. But now GAP12 is estimated with a sign contrary to expectation, while the coeficient for GAP6 is as expected. Clearly, the empirical models are missing important aspects of the hedging decision. Even though a low R^2 is to be expected with cross-sectional estimation, both models explain only a small fraction of the variation in bank futures and forward positions.

The second and fourth columns in Table III report the results of adding six variables (described in Table II) to the basic empirical model. Two variables (SIZE and CR3) relate to characteristics of the bank's decision-making environment and the remainder measure various off balance sheet activities not captured in the basic empirical model.

[12]It is not possible to directly interpret the estimated tobit coefficients as the marginal effects of the independent variables on the futures position. To find marginal effects, multiply the coefficients by the cumulative standard normal distribution function evaluated at a given level for the independent variables.

Table III
THE DETERMINANTS OF FORWARD AND FUTURES POSITIONS: TOBIT ESTIMATES (N = 3560)

Independent Variables	Dependent Variables			
	SFUTRS		LFUTRS	
GAP6	0.055**	−0.003	0.086**	0.041**
	(0.014)	(0.012)	(0.016)	(0.013)
GAP12	−0.191**	−0.072**	−0.176**	0.039
	(0.044)	(0.036)	(0.051)	(0.039)
TDGACCT	1.788**	0.391**	1.961**	0.146
	(0.104)	(0.093)	(0.118)	(0.097)
YLDCRV	0.055*	0.082**	0.024	0.040
	(0.029)	(0.024)	(0.033)	(0.025)
SIZE		0.017**		0.015**
		(0.001)		(0.001)
CR3		−0.000		0.027**
		(0.006)		(0.007)
FOREX		0.014**		0.023**
		(0.003)		(0.003)
LFUTRS		0.630**		
		(0.030)		
SFUTRS				0.942**
				(0.038)
LNCOM		0.004		0.023**
		(0.009)		(0.009)
SWAPS		0.005*		0.011**
		(0.003)		(0.003)
CONSTANT	−0.055**	−0.200**	−0.059**	−0.215**
	(0.004)	(0.012)	(0.005)	(0.013)
R^2	0.046	0.349	0.040	0.401

**(*) Significantly different from zero at the 5% (10%) level.
Note: Standard error of the estimate in parentheses.

SIZE measures any nonlinearities in the relationship between bank asset size and the dependent variables, perhaps due to economies of scale in the futures trading operation. The ability to set rates and transfer balance sheet risk through the exercise of market power, as measured by CR3, may supplant the need for derivative market hedging. On the other hand, limited competition may provide bank management with the slack needed to undertake a derivative market trading strategy.

The remainder of the variables attempt to account for bank experience with related derivative market risk management techniques or the interest rate risk created by bank off balance sheet activities. Balance sheet mismatches are not the only source of interest rate exposure for banks. The variable FOREX tests for complementarities between the management of foreign exchange risk and the management of interest rate risk with derivative market contracts. LFUTRS (SFUTRS) is included in the model explaining short (long) futures and forward positions because the interest rate risk of bank over-the-counter forward contracts can be managed with offsetting futures contracts. Given the significant results in the first and third columns of Table III, however, inclusion of this variable is likely to cause multicollinearity in the estimates. The result is unbiased estimators for the multicollinear variables but inflated standard errors to that hypothesis tests of individual variables may not be valid. If banks use futures contracts to hedge the risk of over-the-counter forward contracts, the estimated coefficient on LFUTRS (SFUTRS) in the short (long) position model should be positive.

Outstanding loan commitments, LNCOM, are added to the models because both Ho and Saunders (1983) and Koppenhaver (1985(b)) maintain that loan commitment risk can be hedged with futures. The existence of an interest rate swap position, SWAPS, is included because interest rate swaps are an alternative method for managing interest rate risk, although those banks dealing in swaps may run a book of temporarily open positions whose risk can be laid off in the futures market.

The estimated results in the second and fourth columns of Table III show a dramatic improvement in the explanatory power of each model. The GAP variables now have the expected sign in each model and are consistent with a hedge of balance sheet risk. Note that short bank positions are only significantly related to GAP12, while long bank positions are only significantly related to GAP6. That is, short positions hedge a different maturity mismatch than long positions, although the multicollinearity problem mentioned above makes a definitive conclusion impossible. It also appears that short futures and forward positions are more strongly related to the size of the trading account than long futures and forward positions. Futures and forward positions are used to hedge existing trading account securities rather than anticipated purchases for the trading account, on average. The only (insignificant) variable that still carries a sign contrary to expectation is YLDCRV in the long position model (the fourth column). The variable may be too rough a proxy for individual bank rate expectations to be used as a determinant of long futures and forward positions.

Table III also shows a significant nonlinear effect of bank asset size on short and long futures and forward positions, which supports the published survey findings. Banks in more highly concentrated markets also take larger long forward and futures positions. Futhermore, the existence of forward positions in foreign currencies and the use of interest rate swaps are significantly associated with greater positions in both types of forward and futures contracts. Familiarity with related risk management instruments seems to contribute to the size of forward and futures positions, especially on the long side. Loan commitments have a significant, positive effect on buy positions. The hedging of variable-rate loan commitments is the likely reason for the estimated effect. Finally, the results in Table III show that one of the most important reasons for banks taking futures and forward positions is to offset the risk of existing delayed delivery security positions. Given the relative differences in liquidity and execution costs in forward and futures markets, it seems reasonable that banks would offset unwanted interest rate risk due to forward contract positions with futures contracts; the estimated coefficients for LFUTRS and SFUTRS capture such hedging behavior.

As a last point, note that the marginal effects of the maturity gap and trading account variables on the futures and forward positions can be interpreted as the banks' perception of the risk minimizing hedge ratio for each balance sheet exposure (see eq. (1)). Evaluated at sample means, the marginal effects of the independent variables on SFUTRS (LFUTRS) are 0.194 (0.168) times the estimated tobit coefficients. The empirical short hedge ratios for the maturity gap variables sum to less than 1.5 percent for two maturity gaps. The empirical hedge ratio for the trading account is about 7.5%. Altogether, the average short hedging bank in the sample covered less than 10% of its balance sheet risk with derivative market positions. By similar calculations, the average long hedging bank in the sample covered less than 4% of its balance sheet risk with derivative market positions. On the other hand, the empirical hedge ratios for the two continuous, off balance sheet variables imply that average bank short and long positions covered 12% and 16% of the exposure due to off balance sheet activities. The estimated balance sheet hedge ratios are less than is generally found in studies that estimate item-specific hedge ratios, perhaps due to their failure to consider the overall risk in balance sheet and off balance sheet activities.

IV. CONCLUSIONS

Actual futures positions from bank Call Reports are analyzed, going beyond published simulations and surveys to directly test the relationship between interest rate risk and futures positions for a large cross-section of banks. An empirical model is developed based on a theory of how bank management should use futures contracts to maximize their expected utility. Theoretical futures positions are shown to be comprised of two terms, an expectations term and a term reflecting the interest rate risk in the bank's operations. The importance of the expectations term relative to the risk exposure term depends on the risk attitude of management and the proportion of bank profits paid to management as salary, as well as management's subjective rate expectations.

Empirically, both long and short futures and forward positions are shown to hedge the balance sheet interest rate risk faced by banks, although the estimated hedge ratios are small. Buy and sell positions are also related to bank asset size and experience with foreign currency forward markets and interest rate swaps. A more important finding suggests that bank futures and forward positions, which are off balance sheet activities themselves, are being used to hedge the interest rate risk in other off balance sheet activities, such as forward contracts and loan commitments.

The stated goal of this research is to investigate whether bank futures positions reduce the overall interest rate risk of operations (macro hedging), as spelled out by federal bank regulators in policy guidelines, or whether bank futures positions are used to offset the risk of specific banking activities (micro hedging). But without information on how the interest rate risk of bank balance sheet and off balance sheet activities interact, it is difficult to tell whether micro hedges of off balance sheet risk reduce the earnings variability of hedging relative to nonhedging banks. At this juncture, it seems likely that bank futures market participation will grow with increased off balance sheet banking rather than through the expansion of more traditional bank operations.

V. Appendix

The purpose of the appendix is to formally present a simple mathematical model of the bank's selective hedging decision. The model underlies the solution in eq. (1).

Let the bank's *ex post* balance sheet be

$$(1 - k)L = B + (1 - r)D, \tag{A1}$$

where L = predetermined loans, B = federal funds purchased (>0) or sold (<0), D = demand and savings deposits, k = a binding ratio of equity to loans, and r = the reserve requirement on retail deposits. Bank profits at the end of the planning period before the payment of managerial salaries are the sum of revenues from the loan and futures position minus the cost of purchased funds and retail deposits. Bank profits, $\tilde{\pi}$, are given by (a tilde indicates a random variable and future value)

$$\tilde{\pi} = R_L L = [(1 - \tilde{R}_X) - (1 - R_X)]X - \tilde{R}_B B - R_D D, \tag{A2}$$

where R_L = the interest rate earned on loans, $\tilde{R}_X$ = the futures contract interest rate at the end of the period = $R_X(1 + \tilde{v})$, R_X = the futures contract interest rate at the beginning of the period, X = the size of the futures position, $\tilde{R}_B$ = the market interest rate at the end of the period = $R_B(1 + \tilde{e})$, and R_D = the interest rate on retail deposits.

Since eq. (1) can be solved for B in terms of L and D, the profit function in eq. (2) can be rewritten as

$$\tilde{\pi} = [R_L - (1 - k)\tilde{R}_B]L + [R_X - \tilde{R}_X]X + [\tilde{R}_B(1 - r) - R_D]D. \tag{A2$'$}$$

The objective of bank management is to choose X in eq. (A2′) to maximize the expected utility of their end-of-period wealth, given subjective expectations about the future. Let management's end-of-period wealth be the sum of riskless income, I, and a salary which is tied to the uncertain profitability of the bank. The maximization problem can be expressed as

$$\underset{X}{\text{maximize}}\ EU[\tilde{W}|F(\tilde{R}_B, \tilde{R}_X)], \tag{A3}$$

where U is management's risk averse utility function ($U' = \partial U/\partial W > 0$ and $U'' = \partial^2 U/\partial W^2 \leq 0$), $\tilde{W} = I + \theta(\tilde{\pi})$ is management's end-of-period wealth, θ is management's salary as a known function of firm profits, $F(\tilde{R}_B, \tilde{R}_X)$ is the joint cumulative density describing expectations, and E is the expectations operator. Furthermore let $\theta' = \partial\theta/\partial\pi > 0$ and $\theta'' = \partial^2\theta/\partial\pi^2 = 0$; that is, management's salary is a direct proportion of firm profitability with $0 < \theta' \leq 1$.

Assuming the random variables are joint normally distributed and bank management is constant absolute risk averse, the solution to the maximization problem yields

$$X^* = \frac{-E\tilde{v}}{\lambda\theta' R_X \sigma_v^2} - \frac{[(1 - k)L - (1 - r)D]R_B\sigma_{e,v}}{R_X\sigma_v^2}, \tag{A4}$$

where $\lambda = -EU''/EU'$ = the index of risk aversion, $\sigma_{e,v}$ = the covariance between $\tilde{e}$ and $\tilde{v}$, and σ_v^2 = the variance of $\tilde{v}$. If GAP is defined as $-[(1 - k)L - (1 - r)D]$ and δ is defined as $R_B\sigma_{e,v}/R_X\sigma_v^2$ then eq. (1) results.

Bibliography

Batlin, C. (1983, Fall): "Interest Rate Risk, Prepayment Risk, and Futures Market Hedging Strategies of Financial Intermediaries," *Journal of Futures Markets,* 3:177–184.

Booth, J., Smith, R., and Stolz, R. (1984, Spring): "Use of Interest Rate Futures by Financial Institutions," *Journal of Bank Research,* 15–20.

Booth, G., and Koveos, P. (1986, Fall): "A Programming Model for Bank Hedging Decisions," *Journal of Financial Research,* 9:271–279.

Campbell, T., and Kracaw, W. (1987, September): "Optimal Managerial Incentive Contracts and the Value of Corporate Insurance," *Journal of Financial and Quantitative Analysis,* 22:315–328.

Drabenstott, M., and McDonley, A. (1982, May): "The Impact of Financial Futures on Agricultural Banks," *Economic Review,* Federal Reserve Bank of Kansas City, 19–30.

Ederington, L. (1979, March): "The Hedging Performance of the New Futures Markets," *Journal of Finance,* 34:157–170.

Hilliard, J. (1984, December): "Hedging Interest Rate Risk with Futures Portfolios under Term Structure Effects," *Journal of Finance,* 39:1547–1569.

Ho, T., and Saunders, A. (1983, December): "Fixed Rate Loan Commitments, Take-Down Risk, and the Dynamics of Hedging with Futures," *Journal of Financial and Quantitative Analysis,* 18:499–516.

Howard, C., and D'Antonio, L. (1986, Spring): "Treasury Bill Futures as a Hedging Tool: A Risk-Return Approach," *Journal of Financial Research,* 9: 25–39.

Koch, D., Steinhauser, D., and Whigham, P. (1982, September): "Financial Futures as a Risk Management Tool for Banks and S&Ls," *Economic Review,* Federal Reserve Bank of Atlanta, 4–14.

Kolb, R., and Chiang, R. (1982, Summer): "Duration, Immunization, and Hedging with Interest Rate Futures," *Journal of Financial Research,* 5:161–170.

Koppenhaver, G. D. (1985(a), March): "Bank Funding Risks, Risk Aversion, and the Choice of Futures Hedging Instrument," *Journal of Finance,* 40: 241–268.

Koppenhaver, G. D. (1985(b), Fall): "Variable-Rate Loan Commitments, Deposit Withdrawal Risk, and Anticipatory Hedging," *Journal of Futures Markets,* 5:317–330.

Koppenhaver, G. D. (1987, May): "Regulating Financial Intermediary Use of Futures and Options Contracts: Policies and Issues," *Review of Futures Markets,* 6:144–164.

Maddala, G. (1983): *Limited Dependent and Qualitative Variables in Econometrics,* Cambridge University Press, New Rochelle.

Morgan, G., Shome, D., and Smith, S. (1988, March): "Optimal Futures Positions for Large Banking Firms," *Journal of Finance,* 43:175–195.

Overdahl, J., and Starleaf, D. (1986, Spring): "The Hedging Performance of the CD Futures Market," *Journal of Futures Markets,* 6: 71–81.

Parkinson, P., and Spindt, P. (1986): "The Use of Interest Rate Futures by Commercial Banks," in M. Kwast, Ed., *Financial Futures and Options in the U.S. Economy,* Board of Governors of the Federal Reserve System, pp. 221–248.

Smith, C., and Stulz, R. (1985, December): "The Determinants of Firms' Hedging Policies," *Journal of Financial and Quantitative Analysis,* 20:391–405.

Stulz, R. (1984, June): "Optimal Hedging Policies," *Journal of Financial and Quantitative Analysis,* 19:127–140.

Veit, E., and Reiff, W. (1983, Fall): "Commercial Banks and Interest Rate Futures: A Hedging Survey," *Journal of Futures Markets,* 3:283–293.

Copyright of Journal of Futures Markets is the property of John Wiley & Sons, Inc. / Business and its content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use.