Use of Derivatives and Bank Holding Companies' Interest-Rate Risk

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This study finds that bank holding companies reduced stock return sensitivity to interest-rate changes during the 1998-2003 sampling period using a combination of on- and off-balance sheet methods. Employing controls for balance sheet composition and asset size, the extent to which derivatives lessen interest-rate risk exposure is explored. The evidence from this study indicates that bank holding companies separate their efforts to control exposure to interest-rate risk, using gap-management approaches to control exposure to changes in short-term rates and using interest-rate derivatives to control residual rate exposures such as those from changes in the slope of the term structure. The results of this study are consistent with Diamond's (1984) insight that banks using interest-rate derivatives can make better use of diversification to lessen their overall risk levels.
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1. Introduction

One of the most important forms of risk that banks face as financial intermediaries is interest-rate risk. Interest-rate risk arises from mismatches in the rate sensitivity of the bank's inflows and outflows. A special function of a financial institution is asset transformation, which involves buying primary securities or assets (such as mortgages, loans, and securities) and issuing secondary securities or liabilities (such as certificates of deposit and federal funds borrowing) to fund asset purchases. Inflows from assets often have maturity and liquidity characteristics that differ from those for the outflows from liabilities. Consequently, financial institutions often face the need to manage interest-rate risk.

Interest-rate risk is the risk from changes in interest rates that adversely affect a bank's income and/or market values. In addition to potential refinancing or reinvestment problems that occur when interest rates change, a bank faces market-value risk as well. For example, when asset durations exceed those for liabilities, an increase in interest rates causes the market value of the bank's assets to fall by a greater amount than for its liabilities.

Commercial banks manage interest-rate risk using two major techniques. One technique is to match the rate sensitivities of their assets and liabilities as closely as possible (on-balance-sheet technique); the other technique is to use interest-rate derivatives (off-balance-sheet technique).

Traditionally, banks use maturity gaps to predict how their net interest margin, or accounting earnings, would be affected by changes in market interest rates. This method posited that given equal rate sensitivity, a rise or fall in interest rates will have an equal and offsetting effect on both sides of the balance sheet; that is, that changes in revenue from assets will perfectly match changes in expense from liabilities. Hence, in principle, perfect matching leaves a bank's market value unaffected by changes in interest rates. Flannery and James (1984) provide evidence on the importance of the maturity gap by examining the relationship between the interest-rate sensitivity of common stock returns and the maturity gap between interest-rate-sensitive assets and liabilities. In the financial institution industry, a commonly used measure of on-balance-sheet maturity

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composition is an institution's one-year maturity gap. Schrand (1997) points out that this measure reflects the short-term maturity mismatch of the institution's assets and liabilities.

Since the 1980s, derivative instruments have become an increasingly important product used by banking institutions to manage their interest-rate risk exposure. The rise in derivative usage arises from the fact that derivatives may provide a less expensive means for banks to change their interest-rate risk exposure. In theory, the existence of an active derivative market should increase the potential for banking firms to attain their desired level of interest-rate risk exposure. Diamond (1984) develops a theory of financial intermediation in which banks have monitoring advantages in comparison to small depositors. He shows that diversification within a bank lowers the cost of monitoring and generates net benefits of intermediation services. An implication of Diamond's model is that banks should not assume any nondiversifiable risk unless they have special advantages in monitoring them. Thus, in Diamond's model, banks find it optimal to hedge interest-rate risk by using interest-rate derivatives.

This paper investigates two central questions: (1) Do interest-rate derivatives provide banks with better control over their interest-rate risk exposure? (2) To what extent do interest-rate derivatives lessen interest-rate risk exposure? Do managers of bank holding companies' interest-rate risk consider both the derivative hedging and non-derivative hedging (i.e., maturity-gap management)?

A large body of research investigates the relationship between interest-rate risk exposure and banks' derivative usage. This study differs from the existing literature on several aspects and makes three key contributions to the literature. First, it examines data from a period when derivative use was well established. Few previous studies cover the period from 1998 through 2003. During this period, interest-rate derivative usage for individual banks was much more extensive than found in earlier studies. For example, the use of these derivative instruments by banks increased tremendously during the period of this study, rising from notional amounts of $25 trillion at the end of December 1997 to $63 trillion at the end of December 2003. The substantial increase in the use of interest-rate derivatives suggests that the inferences drawn may be clearer than in previous research. Therefore, the sample period of this study sheds more light on the effect of derivative usage on banks' interest-rate risk exposure.

Second, we analyze the simultaneous choice of two alternative means of interest-rate risk management (maturity-gap decision and interest-rate derivative usage). This methodology allows us to investigate whether the managers of bank holding companies' interest-rate risk use these alternative means as complements or as substitutes. Further, beginning with the third quarter of 1997, improvements in the Federal Reserve's Report of Condition and Income increase the detail of banks' assets and liabilities by reporting those that are due to mature or re-price within one year.[2] Therefore, the maturity-gap variable used in this study is more accurate and much more detailed than was available to previous researchers.

Finally, the sample period in this study covers a full business cycle, thereby providing evidence for interest-rate changes experienced during both an economic expansion and a contraction. Schrand (1997) studies a sample of publicly traded savings and loan associations (S&Ls) for the period 1984 through 1988, a period of a downward trend in interest rates. Hirtle (1997), on the other hand, examines a sample of bank holding companies for the sample period of 1991 to 1994, a period during which interest rates were increasing. In contrast, this study offers a more comprehensive picture by including a sample having interest-rate environments associated with both economic expansion and contraction. This dataset therefore affords statistics that are less conditional on differences in the stages of the business cycle.

The primary finding of this study is that bank holding companies combine on- and off-balance sheet methods to reduce stock return sensitivity to interest-rate changes during the 1998-2003 sampling period. Managers of bank holding companies' interest-rate risk separate their efforts to

[2]The increase in derivative usage also increases the importance of establishing how these instruments are being utilized.

control exposure to interest-rate risk, using gap-management approaches to control exposure to changes in short-term rates and using interest-rate derivatives to control residual rate exposures such as those from changes in the slope of the term structure. This study contributes to the existing literature by offering evidence that suggests interest-rate derivatives increase bank holding companies' ability to manage exposure to changes in interest rates during the 1998-2003 period. This finding is consistent with Diamond's (1984) insight that banks using interest-rate derivatives can make better use of diversification to lessen their overall risk levels.

The remainder of the paper is organized as follows. The next section reviews related research that has examined the relationship between derivatives and banks' interest-rate risk exposure. Section 3 describes the sample and data sources. A discussion of the econometric methods used then follows. Next, we present the empirical results. The final section provides the concluding remarks.

2. Related Research

Even though the potential for using derivative instruments in hedging interest-rate risk is widely recognized, the tremendous increase in the use of derivatives by banks has triggered regulators' concerns as to whether banking firms have used derivatives primarily for hedging or for speculation. Much research focuses on the role played by derivatives, but there is no clear answer regarding which of these two alternatives, hedging or speculation, is more likely.

A major concern facing policymakers and bank regulators today is the possibility that the rising use of derivatives has increased the riskiness of individual banks and of the banking system as a whole. A number of studies have examined the relationship between interest-rate risk exposure and banks' derivative usage. The evidence from previous studies is mixed. Sinkey and Carter (1994), Tufano and Headley (1994), and Gunther and Siems (1995) find a significant negative relationship between the balance sheet "gap" measures of interest-rate risk exposure--the difference between assets and liabilities that mature or re-price within a specified time period--and the extent of derivative usage by banks. These research articles have documented evidence that is consistent with the idea that increased use of derivatives by banks tends to result in higher levels of interest-rate risk exposure. Hirtle (1997) studies a sample of 139 bank holding companies and finds that holdings of derivatives are associated with significantly greater interest-rate risk exposure for the sample period of 1991 to 1994. These findings are consistent with the idea that the derivative instruments act as substitutes for on-balance-sheet sources of interest-rate risk exposure rather than as a hedge. Minton, Stulz, and Williamson (2009) examine the use of credit derivatives by U.S. bank holding companies from 1999 to 2005. They conclude that the use of credit derivatives by banks to hedge loans is limited due to adverse selection and moral hazard problems. Earlier research therefore raises important concerns regarding the extent to which derivatives are used for hedging purposes.

In contrast to these studies, Brewer, Jackson, and Moser (1996) find a negative correlation between risk and derivative usage by savings and loan institutions. Ahmed, Beatty, and Takeda (1997) find that for the majority of derivative users, derivative usage reduces interest-rate exposure. Schrand (1997) finds that derivative activities are negatively associated with stock-price interest-rate sensitivity for a sample of publicly traded savings and loan associations (S&Ls). The results also indicate that S&Ls, on average, use derivatives to hedge interest-rate risk rather than to speculate. Brewer, Minton, and Moser (2000) evaluate an equation relating the determinants of Commercial and Industrial (C&I) lending and the impact of derivatives on C&I loan lending activity. They find that engaging in derivative activities helps banks reduce the delegation costs of monitoring contracts issued by their loan customers, thereby enabling banks to increase their lending activities without increasing the total risk level faced by the banks. Brewer, Jackson, and Moser (2001) examine the major differences in the financial characteristics of banking organizations that use derivatives relative to those that do not. They find that banks that use derivatives grow their business loan portfolio faster than banks that do not use derivatives. Zhao and Moser (2009) investigate the relationship between bank participation in derivative contracting and bank lending for the period March 31, 1996, through December 31, 2008. They find that the aggregate use of derivative instruments, in particular interest-rate options, interest-rate futures, and interest-rate forwards, is associated with higher growth rates in C&I loans. This documented positive association is consistent with Diamond's (1984) hypothesis that derivative contracting and lending are complementary activities.

Following the lead of this related research, we explore the following questions: Do interest-rate derivatives provide banks with better control over their interest-rate risk exposure? For instance, is there a significant association between derivative activities and stock return interest-rate sensitivity? To what extent do interest-rate derivatives lessen interest-rate risk exposure? Specifically, we examine the role of derivatives in determining the interest-rate sensitivity of bank holding companies' (BHC) net worth, while controlling for the influence of on-balance-sheet activities and other bank-specific characteristics.

3. Data and Construction of Maturity-Gap Variable

This section describes the data sources and the construction of the one-year maturity-gap variable.

In the financial institution industry, a commonly used measure of on-balance-sheet maturity composition is an institution's one-year maturity gap. Assuming each dollar of maturity-matched assets and liabilities are equally sensitive to changes in the term structure of interest rates, the difference in their amount determines the expected dollar impact from a given-size rate change. Although an incomplete measure of exposure to interest-rate risk in that it captures only the short-term portion of overall rate-sensitivity mismatches, it is a reasonable proxy for rate exposure, provided the extent of the mismatched rate sensitivity for short-term assets is similar to the extent of duration mismatch for all interest-rate sensitive assets and liabilities.[3] Flannery and James (1984) and Purnanandam (2007) construct a 12-month gap measure as their proxy for interest-rate risk.

Beginning with the third quarter of 1997, bank call reports filed with the Federal Reserve System aggregate BHC rate-sensitive assets and liabilities that are either due to mature or to re-price within one year. Figure I depicts the constituents used in this paper's one-year maturity-gap variable. We scale the gap measure by total BHC assets, labeling it ASHORT, to obtain comparability across sampled banks and over time.

The stock return data and interest rate data as well as the balance sheet data and derivative data from 1998 through 2003 are from the following sources:

(1) Market return data (last trading day of each week): Center for Research in Security Prices (CRSP) value-weighted indices covering the period from January 1998 through December 2003.

(2) Bank return data (last trading day of each week): Center for Research in Securities Prices (CRSP).

(3) (3) Interest rate data (yield on constant-maturity one-year Treasury securities): FRED II database posted at the website of the Federal Reserve Bank of St. Louis.

(4) (4) Balance sheet data and derivative data: Reports of Condition and Income (call reports) filed with the Federal Reserve System.

Weekly holding-period returns for one-year U.S. Treasuries are calculated from constant-maturity one-year yields produced by the Federal Reserve using interpolations of the term structure for outstanding Treasury issues. Those returns are percentage differences from unity for dollar bonds with coupon rates set to the constant-maturity rate for the previous week discounted at the current week's constant-maturity rate.

[3] The fact that use of this measure persists suggests that many financial institution practitioners believe the measure to be a useful first approximation.

Figure I
Construction of the One-Year Maturity-Gap Measure

Loans and Leases Due to Mature or Re-Price Within One Year		Term Deposits Due to Mature or Re-Price Within One Year
+		+
Securities Due to Mature or Re-Price Within One Year		Fed Funds Borrowed
+	−	+
Fed Funds Sold		Other Liabilities for Borrowed Funds
+		+
Customers' Liabilities to the Bank for Outstanding Acceptances		Bank's Liabilities on Customers' Outstanding Acceptances

4. Econometric Methods

The foundation of the empirical analysis is the two-factor market model of Flannery and James (1984) who measure interest-rate sensitivities for a sample of actively traded commercial banks and savings and loan associations during the period 1976 to 1981. Their two-factor market model relates bank j's common stock return to the returns on the market and an interest-rate term that captures changes in interest rates. We interpret the coefficient on the interest-rate term (the interest-rate "beta") as a measure for interest-rate exposure. The interest-rate risk measures derived from the first-stage regression are usefully understood as the "output" from banks' attempts to manage their interest-rate risk exposure by using the "inputs" of balance sheet positions and interest-rate derivatives. Hirtle (1997) employs this insight when she decomposes interest-rate betas in a second-stage regression of interest-rate coefficients on a variable that reflects the scope of BHCs' participation in the interest-rate derivative market.

We employ Hirtle's two-stage procedure by first estimating a market-model regression to capture the measures of interest-rate sensitivity (the interest-rate "beta"), then decomposing the interest-rate betas by regressing them on bank balance sheet variables and measures of participation in the interest-rate derivatives market.

Equation (1) is our specification for the first-stage regression for each bank j:

$$\tilde{R}_{jt} = \beta_{0j} + \beta_{mj}\tilde{R}_{mt} + \beta_{Ij}\tilde{R}_{It} + \tilde{\varepsilon}_{jt} \tag{1}$$

where
$\tilde{R}_{jt}$ = return of bank j's stock in week t.
$\tilde{R}_{mt}$ = return on the CRSP value-weighted portfolio of common stock in week t.
$\tilde{R}_{It}$ = weekly holding period return on a constant-maturity one-year Treasury security.
$\tilde{\varepsilon}_{jt}$ = error term

The coefficient on the interest-rate term—β_{Ij}—measures sensitivity of the return on bank holding company (BHC) j's stock to changes in interest rates while controlling for changes in the return on the market. Thus, β_{Ij} usefully measures the interest-rate risk exposure of BHC j. Owing to the inverse relation between bond prices and their yields, a positive interest-rate beta implies that the market value of the BHC's equity increases with interest-rate decreases. Similarly, a negative interest-rate beta implies that BHC market value declines with interest-rate increases. To the extent that interest-rate changes can be construed as an independent return-generating "factor," it follows that a bank successfully structured to obtain immunity to rate changes will have a zero interest-rate beta. However, because equation (1) includes a market-wide portfolio constructed from interest-sensitive assets, the interest-rate beta cannot be considered an independent factor. I.e., changes in the interest-rate environment also affect the return on the market and, through that variable, impact the systematic return on BHCs. Gilberto (1985) raises this point in his comment on Flannery and James (1984). We acknowledge that this affects our results.

Following earlier researchers, we estimate first-stage regressions for each calendar year between 1998 and 2003 for each BHC whose stock traded publicly for at least 30 weeks (57.7% of weeks) in a given calendar year. This estimate obtains an interest-rate beta for each institution during each year that it is in the sample. We note that this approach minimizes the effect of biases from inclusion or survival by limiting those effects to, at most, the portion of the year in which a BHC enters or departs the sample.

In the second-stage equation, interest-rate betas derived from first-stage regressions are regressed on a series of variables that reflect the composition of the BHCs' balance sheet and the scope of their participation in the interest-rate derivatives market. The second-stage estimation equation is the following:

$$\bar{\beta}_{Ij\tau} = \sum_{\tau=1}^{k} \alpha_\tau D_\tau + \alpha_{k+1}\left(\frac{SHORT}{TA}\right)_{j\tau} + \alpha_{k+2}\left(\frac{DERIV}{TA}\right)_{j\tau} + \alpha_{k+3} Log(TA_\tau) + \omega_{Ij\tau} \quad (2)$$

$\bar{\beta}_{Ij\tau}$ are the estimated coefficients from equation (1) for the interest-rate variable for bank j during year τ; that is, the interest-rate beta of bank j's equity during year τ. The D_τ are indicator variables designating, in order, calendar years 1998 through 2003. *SHORT*, bank j's one-year maturity gap, is the j^{th} bank's average net short position; it is computed as the value of assets netted against liabilities where both assets and liabilities either mature or re-price within one calendar year. *TA* is the j^{th} bank's total assets. *DERIV* is the j^{th} bank's notional amount of interest-rate derivative instruments. $\omega_{Ij\tau}$ is an error term. We extract the balance sheet variables SHORT, DERIV, and TA from data provided in the June call reports of their respective years.

Coefficients on the time-indicator variables capture the net effects in the respective years from interest-rate changes on assets and liabilities maturing or re-pricing in more than one year conditional on the effects picked up by the specification's remaining variables. The magnitudes of these coefficients are indicative of the interest-rate mismatch not captured by the SHORT and DERIV variables. The coefficient α_{K+1} measures the contribution of gap management on interest-rate sensitivity, and α_{k+2} measures the contribution of derivatives on interest-rate sensitivity. Finally, α_{k+3} picks up any size-related effects. Inclusion of a size-effect variable follows Demsetz and Strahan (1995, 1997) who point out that size differences may determine risk preferences.[4]

5. Empirical Results

This section presents the empirical results of this study. Table 1 summarizes the descriptive statistics. Table 2 presents the market-model regression results, and Table 3 reports the second-stage regression results.

5.1. Descriptive Statistics

We construct a sample by matching BHC data from the Federal Reserve's *Reports of Condition and Income* (call report) for the years 1998 through 2003 to CRSP returns for BHCs. The sample period was one of significant BHC re-structuring, resulting in a decline in sampled institutions from 215 in 1998 to 171 in 2003. Table 1 reports means and standard deviations for all variables used in the analysis.

Financial market results during the period are weekly holding-period returns computed from closing prices on the last business day of each week. The mean holding-period returns for sampled bank holding companies and value-weighted CRSP are, respectively, 0.37 percent and 0.18 percent.

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[4] Size effects may be induced through diversification across the extent of activities conducted by larger institutions or by implicit too-big-to-fail guarantees.

Returns for the one-year constant maturity Treasury index averaged 0.25 percent. Rankings of the standard deviations for bank holding-period returns and the stock index, respectively at 4.48% and 2.65%, accord with mean-variance theory. Notably, the standard deviation for Treasury returns at 10.02% is well above that for the two stock return measures, suggesting a significant value added from investments in managing interest-rate risk.

Balance sheet variables include the maturity-gap variable and the notional values for derivatives holdings, both scaled by total assets. Total assets averaged $488.4 million. Over the sample period, the mean maturity-gap-to-asset ratio was a negative 23 percent, indicating that these banks faced substantial risk from a steepening of the yield curve for maturities under a year. That risk is even greater to the extent that this maturity mismatch is indicative of overall duration mismatches.

Large financial institutions, known to be significant users of derivatives, reported notional values of interest-rate derivatives at just under 50 percent of their assets. A breakdown of derivatives used by the sample institutions gives the following: 23.08 percent of the sample banks reported using interest-rate swaps; 12.04 percent reported using interest-rate options; 10.68 percent reported using interest-rate forwards; and 3.19 percent of the sample banks reported using interest-rate futures. Finally, derivatives dealers as determined by membership in the International Swaps and Derivatives Association (ISDA) comprise approximately 1 percent of the sample.

Table 1
Summary Statistics for the Full Sample

Variable	Mnemonic	Mean	Standard Deviation
Stock Return and Interest-rate Indices			
BHC's Stock Return	BHCRET	0.0037	0.0448
Market Return	VWRET	0.0018	0.0269
Interest-rate Term	TREAS01	0.0025	0.1002
Balance Sheet Data			
Maturity Gap Scaled by BHC's Total Assets	ASHORT	-0.2326	3.1738
Derivative Scaled by BHC's Total Assets	ADERIV	0.4985	3.1168
Log Total Assets	LNTASST	20.0067	2.1729
Classification Variable			
Swaps (0-Yes, 1-No)	DSWAP	0.2308	0.4686
Futures (0-Yes, 1-No)	DFUTURES	0.0319	0.1843
Forwards (0-Yes, 1-No)	DFORWARD	0.1068	0.3390
Options (0-Yes, 1-No)	DOPTION	0.1204	0.3628
Derivatives Dealer (0-No, 1-Yes)	DEALER	0.0120	0.1082

5.2. Market-Model Regression and Interest-Rate Sensitivity

We estimate market-model regressions annually between 1998 and 2003 for each BHC whose stock traded publicly for at least 30 weeks in a given year. Table 2 presents yearly means and standard deviations for parameter estimates obtained from the market-model regressions. The regression process produces a separate interest-rate sensitivity beta for each bank holding company for each year that the BHC is in the sample. The average of those individual betas is positive (0.4013), suggesting that an increase in interest rates leads to a decrease in BHC equity values. These regressions are representative of the results across the BHCs contained in the sample for a given year. Consistent with the findings of Hirtle (1997), there is considerable variation across years in both the coefficients on the market return and on the interest-rate term.

5.3. Estimation Results of Regression Model

Since banks' use of derivatives increases during the sample period, we employ a pooled cross-sectional time-series regression to incorporate this dynamic effect. Specifically, we run a cross-

Table 2
Two-Factor Market-Model Estimates, 1998 Through 2003

Year	Intercept β_{0j}		Return on Value Weighted Stock Index β_{mj}		Return on Constant Maturity Treasury Index β_{0j}		Number of BHC
	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev	#
1998	-0.0029	0.0038	0.8670	0.4432	0.2363	0.2482	215
1999	-0.0033	0.0042	0.4676	0.4649	0.3170	0.4780	204
2000	0.0033	0.0051	0.3215	0.2388	0.2700	0.4396	201
2001	0.0068	0.0051	0.5242	0.3255	0.4810	0.1467	193
2002	0.0052	0.0036	0.7089	0.4342	-0.0908	0.1428	178
2003	0.0019	0.0028	0.7204	0.3329	0.4750	0.1048	171

Notes:Table 2 reports mean and standard deviations of coefficients obtained from regressions of one week BHC holding-period returns on date-matched returns for the value-weighted CRSP index and the one-year constant-maturity Treasury index($\tilde{R}_{jt} = \beta_{0j} + \beta_{mj}\tilde{R}_{mt} + \beta_{Ij}\tilde{R}_{It} + \tilde{\varepsilon}_{jt}$).Subsequent second-stage regressions decompose the coefficients on the interest-rate term from this first-stage regression.

sectional OLS regression with interest-rate betas as the dependent variable. Using estimates of interest-rate betas from the first-stage regressions as dependent variables, we utilize equation (2) to examine the impact of derivatives on bank holding companies' interest-rate sensitivity. Table 3 reports regression results for the sample period 1998 through 2003. Regression (3) is our base regression (equation 2). Regressions (1) and (2) provide some background to the baseline regression by exploring the time consistency of the ASHORT variable. Regressions (4) and (5) continue the examination of the time-consistency issue using two different specifications for the ADERIV variable.

Regression (1) includes the year-indicator variables and the ASHORT variable with the intercept suppressed. Industry practice that funds long-term assets using short-term liabilities implies that ASHORT should enter negatively. It does, but at lower-than- customary significance levels. Coefficients on the indicator variables appear to be symmetric about zero, ranging from -0.100 to 0.099. Since the ASHORT variable impounds interest-rate sensitivity coming from the short end of the term structure, coefficients on the year-indicator variables approximate the remaining interest-rate sensitivity, owing to net-rate exposures (assets netted against liabilities) at longer maturities. The sum of coefficients on the year-indicator variables is -0.08235. Notably, however, the symmetry about zero is suggestive of efforts by the sampled BHCs to manage their interest-rate exposures.

Regression (2) incorporates interactions between the ASHORT variable and the year-indicator variables to assess the time consistency of possible BHC efforts to manage interest-rate exposures using short-maturity assets and liabilities. Coefficients on these interactions enter negatively, albeit significantly so, in only three years. We also note that coefficients on the stand-alone indicator variables do not differ markedly from those in regression (1). This result suggests that short-term assets and liabilities ineffectively manage overall rate sensitivity.

Regression (3), our base specification in this investigation of the determinants of interest-rate sensitivity, includes the ADERIV and LNASST variables. As before, the sign of the coefficient on the ASHORT variable is negative, but not significantly different from zero. Interestingly, the coefficients on the year-indicator variables have the same signs as in regressions (1) and (2), but none differs significantly from zero. Thus, comparison of the coefficients on ASHORT and the year-indicator variables across regressions (1) to (3) suggests that inclusion of the ADERIV and LNASST variables is capturing the rate sensitivity of BHC equity returns as measured by the rate-sensitivity coefficient in equation (1). Indeed, the ADERIV coefficient does enter negatively and differs significantly from zero, while LNASST does not differ from zero. The sign of the coefficient on ADERIV indicates that the direction of effect from derivatives during the six-year sample period was consistent with that indicated by the ASHORT variable. Thus, coefficients on both the ASHORT and the ADERIV variables indicate that interest-rate increases result in lower asset valuations, specifically asset valuations that were fully offset by re-valuations of liabilities. The result leaves open, however, the extent to which derivatives lessened interest-rate exposures. We explore this question in the next two regressions.

Regression (4) of Table 3 re-introduces the interactions of ASHORT with the time-indicator variables while retaining both ADERIV and LNASST. Comparing coefficients on the stand-alone time-indicator variables as well as their interactions with ASHORT, the results from regressions (2) and (4) are nearly identical. Likewise, the coefficients on ADERIV and LNASST from regressions (3) and (4) are comparable in both their magnitudes and statistical significance. We note, however, an increase in adjusted R square. The increased statistical significance for the coefficient ADERIV appears to be related.

Regression (5) adds to the specification interactions between ADERIV and the time-indicator variables. This specification employs a period-by-period look at the impacts of ASHORT and ADERIV to see whether derivatives usage obtains offsetting effects from interest-rate changes. We note first that coefficients on interactions between ASHORT and the year-indicator variables do not change materially from those obtained in specification (4). On the other hand, interactions between ADERIV and the year-indicator variables are negative for 1998 through 2001, becoming positive in the last two years of the sample. Hence, for 2002 and 2003, it does appear that derivatives usage lessened interest-rate sensitivity. In those years, rate increases at the short end of the term structure affecting the stock returns of banks appear to have been offset by the derivatives positions held by the sampled banks.

Two additional tests investigate the possibility of coordinated management of interest-rate risk using combinations of gap management and derivatives. We first test whether the coefficients on the interacted ASHORT and ADERIV variables jointly differ from zero for each of the respective sample years. Where tests on the single coefficient tests are separately indicative of whether BHCs employed gap management or interest-rate derivatives, these joint tests consider whether either or both methods were used in a current year. Wald tests find that in all years save 2003, BHCs appear to have used at least one of these methods to control their exposure to interest-rate risk.[5] Were managers of BHC interest-rate risk to believe the term structure of interest rates to be determined by a single factor such as the short-term rate, incremental interest-rate risk could be managed using either gap management or derivatives. Consistent with that belief, the coefficients on the yearly interactions of ASHORT and ADERIV should be equal. We test for that using a Wald test for the differences in the interactions coefficients being zero. Save for 1999, we reject equality of the coefficients.[6] This suggests that managers of interest-rate risk separate their efforts to control exposure to interest-rate risk, using gap-management approaches to control their exposure to changes in short-term rates and interest-rate derivatives to control residual rate exposures such as those from changes in the slope of the term structure.

6. Concluding Remarks

Commercial banks employ different methods, including the use of interest-rate derivatives, to manage interest-rate risk. The use of these derivative instruments by banks increased markedly during the 1998-2003 sample period, rising from notional amounts of $25 trillion at the end of December 1997 to $63 trillion at the end of December 2003. The increase in interest-rate derivative usage is consistent with their being a relatively inexpensive means for banks to change their interest-rate exposure.

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[5] Wald test statistics (chi square) for the joint test that both the interaction terms on ASHORT and ADERIV are zero: 21.39 for 1998, 23.79 for 1999, 54.68 for 2000, 9.24 for 2001, 8.54 for 2002, and 2.74 for 2003.

[6] Wald test statistics (chi square) for differences in the coefficients on the interaction terms are 0.18 for 1998, 14.19 for 1999, 1.18 for 2000, 1.66 for 2001, 0.04 for 2002, and 0.08 for 2003.

Table 3
Interest-Rate Beta Decomposition

	Specification				
Parameter	(1)	(2)	(3)	(4)	(5)
D1: 1998	0.09897**	0.09946**	0.13630	0.14883	0.15263
D2: 1999	-0.08350*	-0.08152	-0.04312	-0.02876	-0.02716
D3: 2000	-0.07286	-0.07387	-0.03106	-0.01923	-0.01586
D4: 2001	0.04630**	0.04802	0.08868	0.10336	0.10239
D5: 2002	-0.10022**	-0.10026**	-0.05685	-0.04412	-0.04523
D6: 2003	0.02896**	0.02985**	0.06884	0.08277	0.08308
ADERIV			-0.00892*	-0.00720**	
LNASST			-0.00294	-0.00389	-0.00395
ASHORT	-0.00267		-0.00259		
D1*ASHORT		-0.01011**		-0.01036**	-0.01048**
D2*ASHORT		-0.00058**		-0.00035	-0.00034
D3*ASHORT		-0.00520		-0.00487	-0.00479
D4*ASHORT		-0.00744**		-0.00759**	-0.00754**
D5*ASHORT		-0.00255**		-0.00262*	-0.00260*
D6*ASHORT		-0.00392		-0.00416	-0.00414
D1*ADERIV					-0.06318
D2*ADERIV					-0.00940
D3*ADERIV					-0.01423
D4*ADERIV					-0.00293
D5*ADERIV					0.00312
D6*ADERIV					0.00142
Adjusted R^2	0.05580	0.05710	0.05820	0.06640	0.06890

Notes: Alternative specifications decomposing interest-rate coefficients from first-stage regressions.

$$\bar{\beta}_{Ij\tau} = \alpha_0 + \sum_{\tau=2}^{k} \alpha_\tau D_\tau + \alpha_{k+1}\left(\frac{SHORT}{TA}\right)_{j\tau} + \alpha_{k+2}\left(\frac{DERIV}{TA}\right)_{j\tau} + \alpha_{k+3} Log(TA_\tau) + \omega_{Ij\tau}$$

ADERIV is the ratio of notional amount of interest-rate derivatives to total assets. ASHORT is the ratio of maturity-gap variable to total assets. LNASST is the logarithm of total assets. Parameters labeled D1*ASHORT, D2*ASHORT, D3*ASHORT, D4*ASHORT, D5*ASHORT, and D6*ASHORT are interactions between ASHORT and the respective indicator variable. Parameters labeled ADERIVD1, ADERIVD2, ADERIVD3, ADERIVD4, ADERIVD5, and ADERIVD6 are interactions between ADERIV and the respective indicator variable. Sample size is 1186 observations for the period 1998 through 2003. Standard errors are computed using Newey-West errors. * indicating significance at 5% and ** at 1% or better.

In theory, the existence of an active derivative market should increase the potential for banks to move toward their desired levels of interest-rate risk. The potential of derivative instruments has been widely recognized, and the question that has consequently arisen is whether banks have used derivatives primarily to reduce the risks arising from their other banking activities (for hedging) or to achieve higher levels of interest-rate risk exposure (for speculation). If banks use derivatives for hedging, is there a significant association between derivative activities and stock return interest-rate sensitivity? In this study, we test Diamond's (1984) hypothesis that derivative instruments provide banks with better control over their interest-rate risk exposure. Specifically, we examine the role of derivatives in determining the interest-rate sensitivity of bank holding companies' (BHC) net worth while controlling for the influence of on-balance sheet activities and other bank-specific characteristics. We also investigate the possibility of coordinated management of interest-rate risk using combinations of gap management and interest-rate derivatives.

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