Interest Rate Risk Management At Tenth District Banks

By Karlyn Mitchell

The higher level and volatility of interest rates since the mid-1970s have substantially complicated the management of financial portfolios for investors, borrowers, and institutions. Commercial banks have been particularly affected because financial intermediation—borrowing from savers and lending to borrowers—is still the main source of their profits. Higher interest rate levels increase the potential loss from poor portfolio management, while greater interest volatility increases the effort needed for successful management. Greater interest rate risk is largely responsible for the emergence of asset-liability management at commercial banks, a management strategy focused on controlling interest rate risk.

This article finds that most banks in the Tenth Federal Reserve District have been slow to adopt techniques for controlling interest rate risk. As a result, district banks remained exposed to interest rate risk during the 1976-83 period, although their exposure was significantly reduced by the end of 1983. It is argued that bankers should strive to broaden their range of risk management techniques to be viable in the more competitive environment of the future. The article first discusses the problems interest rate risk pose for bank portfolio management and gives an overview of techniques that have been developed for hedging against interest rate risk. The article then examines the experience of Tenth District banks in applying these techniques.

Asset-liability management and interest rate risk

Asset-liability management was developed in the mid-1970s as a means of maintaining bank performance in the face of high and volatile interest rates. The objective of asset-liability management—like the objective of asset management, which was in vogue during the 1940s and 1950s, and liability management, which was the fashion in the 1960s—is to

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maximize the wealth of bank shareholders while keeping risk at a level acceptable to shareholders. Operationally, asset-liability management reaches this objective by coordinating the functions that affect a bank's interest-bearing assets and liabilities, including liquidity management, investment management, loan management, and liability management. These functions need to be coordinated because high and fluctuating interest rates can drastically affect the net interest income earned from interest-bearing instruments, as well as the net value of the instruments.

Three steps are involved in the successful implementation of an asset-liability management program.[1] Bankers must first choose the length of the planning horizon. Then, they develop estimates of return and risk that might result from pursuing alternative programs during the planning horizon. Finally, they must choose the program most consistent with maximizing shareholder wealth at an acceptable level of risk.

The greatest pitfall to implementing asset-liability management lies in forecasting risks from alternative programs. Of these risks, interest rate risk is the most difficult to forecast.[2] Interest rate risk has two components. The first, referred to as income risk, is the risk of loss in net interest income from movements in borrowing and lending rates not being perfectly synchronized. The second, called investment risk, is the risk of loss in net worth due to unexpected interest rate changes. Net worth is the difference in the market values of assets and nonequity liabilities.

An example helps distinguish between the two components of interest rate risk. Suppose a bank holds a single asset—a $100, 10-percent three-year loan—financed primarily by a single liability—a $90, 8-percent time deposit that matures in a year, at which time it will be rolled over at the then-current market rate. The rest of the loan is financed by bank stockholders, who have invested $10. The 2-percentage point spread between lending and borrowing rates represents the cost of making the loan plus a return to risk bearing by stockholders. Case A in Table 1 shows the bank's income statement and balance sheet in current market terms at the end of the next two years. Interest rates are assumed to remain constant. In both years, the bank earns a net interest income of $2.80 from the difference between the lending and borrowing rates. The bank's net worth remains constant.[3]

Case B illustrates the effect of an unexpected increase in interest rates sometime during the first year. Suppose lending and borrowing rates both increase by 1 1/2 percentage points, to 11 1/2 percent and 9 1/2 percent, respectively. Although the book values of the loan and time deposit remain unchanged, the

[1] For an overview discussion of asset-liability management, see John Haslem, "Bank Portfolio Management," *The Bankers' Magazine*, May-June 1982, pp. 92-97. For a more detailed discussion based on a study of 60 U.S. commercial banks, see Barrett Binder and Thomas Lindquist, *Asset-Liability Handbook*, Bank Administration Institute, Rolling Meadows, Illinois, 1982.

[2] Besides interest rate risk, bankers must consider credit risk and liquidity risk. Credit risk is the risk that a decline in the credit rating of borrowers will cause the quality of earning assets to decline. Liquidity risk is the risk that liquidation of assets to meet unexpected cash needs will result in a loss.

[3] The market value of the loan remains constant and equal to its maturity value because interest rates remain constant. After paying $10 in interest at the end of the first year, the loan still promises to pay $10 in interest at the end of the second year and $110 in principal and interest at the end of the third year. The market value of the loan is $100 at the end of the first year because, by the present value formula,

$$\$100 = \frac{\$10}{(1.1)} + \frac{\$110}{(1.1)^2}$$

The market value of the loan is $100 at the end of the second year because

$$\$100 = \frac{\$110}{(1.1)}$$

TABLE 1
Year-end balance sheets and income statements for a hypothetical bank

	End of Year 1	End of Year 2
Case A		
Balance Sheet		
Asset	$100.00	$100.00
Liability	90.00	90.00
Net worth	10.00	10.00
Income Statement		
Income	$ 10.00	$ 10.00
Expenses	7.20	7.20
Net interest income	2.80	2.80
Case B		
Balance Sheet		
Asset	$ 97.45	$ 98.65
Liability	90.00	90.00
Net worth	7.45	8.65
Income Statement		
Income	$ 10.00	$ 10.00
Expenses	7.20	8.55
Net interest income	2.80	1.45

market prices of those instruments fall so they can earn the new higher rates of return. The time deposit matures at the end of the first year, paying its face value of $90, and a new, $90, one-year deposit is issued paying 9 1/2 percent. Net interest income for the first year is the same as in Case A, because the lending and borrowing rates were fixed for the year. But net worth is lower, reflecting bank stockholders being part-owners of a less valuable asset. At the end of the second year, both net worth and net interest income are lower than in Case A.[4]

The effect of the unexpected interest rate increase on net worth and net interest income correspond to investment risk and income risk,

[4] The market value of the loan falls because it earns a lower rate of interest than the new higher loan rate. The market value of the loan is $97.45 at the end of the first year because

$$\$97.45 = \frac{\$10}{(1.115)} + \frac{\$110}{(1.115)^2}$$

The market value of the loan is $98.65 at the end of the second year because

$$\$98.65 = \frac{\$110}{(1.115)}$$

respectively. In the example, the bank's choice of assets and liabilities left stockholders exposed to both components of interest rate risk. A careful strategy of asset-liability management can reduce both components of risk.

To facilitate control of interest rate risk, measures have been developed to gauge a bank's exposure to interest rate risk. The two most popular measures are "gap" and "duration gap." Asset-liability management strategies have been developed to use these measures in controlling interest rate risk.

Gap management

Gap management is used to insulate net interest income from income risk.[5] This technique uses gap to measure the exposure of net interest income to fluctuations in interest rates. Gap is defined in terms of rate-sensitive assets (RSA) and rate-sensitive liabilities (RSL), which are assets and liabilities that either mature or are repriced within the planning horizon used in asset-liability management. More precisely, gap is defined as rate-sensitive assets less rate-sensitive liabilities, as shown in the following equation.

$$(1) \quad \text{Gap} = \text{RSA} - \text{RSL}$$

Net interest income is fully insulated from interest rate risk when gap is set equal to zero. Suppose interest rates increase shortly after the start of a bank's one-month planning horizon. As risk-sensitive liabilities mature or are repriced, they are replaced with liabilities that carry the new, higher rates, thus increasing the bank's interest expenses and reducing net interest income. But as risk-sensitive assets mature or are repriced, they are replaced with assets that earn the new higher rates, thus increasing the bank's interest income. With an initial gap of zero, the income-reducing effects approximately offset the income-increasing effects, leaving net interest income essentially unchanged. Net interest income is also insulated if interest rates fall unexpectedly after the start of the planning horizon, because the decline in interest expenses approximately offsets the decline in interest income.[6]

Gap management is subject to two major criticisms. One criticism is that managing gap as defined by Equation 1 is a crude means of hedging against interest rate risk. As all interest rates do not move together, even with a zero-gap position, changes in interest income and expenses may not be the same. Unequal changes may also result from assets and liabilities being repriced at different times within the planning horizon. The longer the planning horizon, the greater is the probability that unequal changes will occur. But with a shorter planning horizon, the bank's exposure to interest rate risk beyond the planning horizon is ignored.

More sophisticated gap management techniques have been developed in response to this first criticism. Instead of defining gap for a single short planning horizon, more sophisticated techniques define incremental gaps for nonoverlapping subperiods of a more extended horizon. For example, a banker may choose

[5] For a discussion of gap management, see Alden L. Toevs, "Gap Management: Managing Interest Rate Risk in Banks and Thrifts," Federal Reserve Bank of San Francisco *Economic Review*, Spring 1983.

[6] Gap management can also be used to increase net interest income, but with greater exposure to interest rate risk. If interest rates are expected to rise during the planning horizon, a positive gap position is taken. If expectations are correct and interest rates rise, net interest income improves because more assets than liabilities are repriced at the new higher rates. But if expectations are incorrect and interest rates fall, net interest income worsens because interest income falls relative to interest expense. To increase net income when interest rates are expected to fall during the planning horizon, a negative gap position is taken.

an extended planning horizon of a year and define incremental gaps for the first and second halves of the year. The first gap measures the difference between assets and liabilities maturing or able to be repriced in the first six months, while the second gap measures the difference between assets and liabilities maturing or repriceable in the second six months. Maximum insulation from interest rate risk is then achieved by setting all the incremental gaps to zero. In principle, extended horizons can be of any length and incremental gaps can be defined for any number of subperiods. The incremental gap approach insulates net interest margins better from interest rate risk by extending the planning horizon while making sure that the maturing and repricing dates for risk-sensitive assets and liabilities more nearly coincide.[7]

A second, more serious, criticism of gap management is that it insulates a bank from the income risk component of interest rate risk but not from the investment risk component. This is because gap management focuses on net interest income but ignores net worth. Even if gap management is used to stabilize net interest income, interest rate fluctuations will affect the market values of assets and liabilities that are not rate sensitive, increasing the volatility of net worth and, therefore, risk to shareholders.[8]

Nevertheless, gap management remains the most widely used technique for managing interest rate risk. Its strongest advantage may be the ease of its implementation, which allows gap management to be practiced by medium and small banks as well as large banks.

Duration gap management

Duration gap management is used to insulate net worth from investment risk.[9] This technique uses duration to measure the exposure of net worth to interest rate fluctuations. The duration of a financial instrument is similar to its term to maturity, both being a measure of time. But where term to maturity is the number of years until the instrument matures, duration is the number of years until the instrument earns its average payment, in present value terms.[10]

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[7] For a further discussion of more sophisticated gap models, see Toevs.

[8] This criticism has also been raised by Donald G. Simonson and George H. Hempel, "Improving Gap Management for Controlling Interest Rate Risk," *Journal of Bank Research*, Summer 1982.

[9] For a thorough discussion of duration, see G. O. Bierwag, G. G. Kaufman, and A. Toevs, "Duration: Its Development and Use in Bond Portfolio Management," *Financial Analysts Journal*, July-August 1983, pp. 15-35; or G. G. Kaufman, "Measuring and Managing Interest Rate Risk: A Primer," Federal Reserve Bank of Chicago *Economic Perspectives*, January/February 1984, pp. 16-29.

[10] More precisely, the duration (D) of a financial instrument is defined by the formula:

$$D = \frac{\sum_t t\,PV_t}{P}$$

$$PV_t = \frac{C_t}{(1+r)^t}$$

where

$\sum_t$ = summation sign

t = number of years from the present

PV_t = present value of a payment, C_t, scheduled t years from the present

P = price of the instrument ($P = \Sigma PV_t$)

r = interest rate used to discount payments

Mathematically, duration is a weighted sum of the present value of payments made by a financial instrument. The present value of each payment, PV_t, is multiplied by a weight, t, equal to the number of years from the present that the payment is received. The weighted sum, $\Sigma\, t\, PV_t$, is then divided by the price or present value of the insrument, P. The dimension of the resulting quotient is years from the present. Duration is the number of years from the present that an instrument earns its average payment, in present value terms. The duration of an instrument is usually less than its term to maturity, the number of years from the present that an instrument makes its final payment.

To illustrate, consider the $100, 10-percent three-year loan used in Case A, Table 1. At the start of the first year, the bank expects to receive $10 at the end of the first year, $10 at the end of the second year, and $110 (principal plus interest) at the end of the third year. The loan's duration is 2.7 years because, in a theoretical sense, the bank receives its average payment in 2.7 years.[11]

Duration is important because it relates to the interest sensitivity of financial instrument prices. When interest rates change unexpectedly, the prices of financial instruments change. How much prices change is loosely related to the terms to maturity of the instruments. For example, an unexpected interest rate increase causes the price of a short-term financial instrument to fall slightly and the price of a long-term financial instrument to fall sharply. There is no simple relationship between interest rate change, price change, and term to maturity. But there is a simple relationship between interest rate change, price change, and duration. The percentage change in the price of an instrument is equal to the negative of duration multiplied by the unexpected interest rate change, as shown in the following equation.[12]

$$(2) \quad \begin{pmatrix} \text{percent change in} \\ \text{financial instrument} \\ \text{price} \end{pmatrix} = (\text{-duration}) \times \begin{pmatrix} \text{unexpected} \\ \text{interest rate} \\ \text{change} \end{pmatrix}$$

[11] The duration of the loan is computed by using the formula in footnote 10. Specifically,

$$2.7 = \frac{\frac{(1)(10)}{(1.1)} + \frac{(2)(10)}{(1.1)^2} + \frac{(3)(110)}{(1.1)^3}}{100}$$

[12] Equation 2, which holds for small interest rate changes, is an approximation of a more complicated relationship.

The equation also shows that the greater an instrument's duration, the larger the impact of a given change in interest rates on the instrument's price.

Duration is useful to bankers because it can be used to calculate the interest sensitivity of a bank's net worth. Net worth, the market value of assets minus the market value of liabilities, changes when interest rates change unexpectedly because the market values of assets and liabilities change. Since the effect of unexpected interest rate changes on financial instrument prices is related to duration, the effect of unexpected interest rate changes on net worth is related to the durations of the assets and liabilities held by the bank. If the durations of the assets and liabilities are approximately equal, an unexpected interest rate increase reduces the market value of assets and liabilities by about the same amount and leaves net worth essentially unchanged. Similarly, an unexpected decrease in interest rates increases the market value of assets and liabilities but leaves net worth relatively unchanged. Hence, net worth is insensitive to unexpected interest rate changes when the durations of bank assets and liabilities are approximately equal.

The interest sensitivity of net worth increases as the difference between asset and liability durations increases. Suppose a bank holds assets with relatively short durations and liabilities with relatively long durations. According to Equation 2, the effect of an unexpected interest rate change on financial instrument price increases with duration. Thus, an unexpected interest rate increase causes a slight decline in the market value of assets and a large decline in the market value of liabilities, causing net worth to increase. Conversely, net worth decreases if interest rates decline unexpectedly because the market value of assets rises slightly but the market value of liabilities rises sharply. By the same logic, it is clear that a bank holding assets with relatively long durations and liabilities with relatively short durations sees net worth increase with an unexpected decline in interest rates and decline with an unexpected increase in interest rates.

By managing "duration gap"—essentially the duration of bank assets minus the duration of bank liabilities—bankers control the interest sensitivity of bank net worth. Bankers can immunize net worth completely against unexpected interest rate changes by choosing a duration gap of zero.[13]

[13] More precisely, the duration gap (DG) is defined as:

$$DG = D_a - D_l\,[L/A]$$

where

D_a = duration of the asset side of the balance sheet
D_l = duration of the liability side of the balance sheet
A = the market value of bank assets
L = the market value of bank liabilities, excluding net worth.

The equation defines the duration gap as the duration of bank assets minus the duration of bank liabilities multiplied by a fraction. The fraction is the value of liabilities as a percentage of the value of assets.

A simple linear relationship exists between unexpected interest rate change, net worth change, and duration gap. In particular,

$$\frac{\Delta NW}{NW} = (-DG)\,(\Delta r)$$

where

$\Delta NW/NW$ = percent change in net worth
Δr = unexpected interest rate change

The equation says that the percentage change in net worth equals the negative of duration gap multiplied by the unexpected interest rate change. The equation also says that a given change in interest rates has a larger impact on net worth the larger the duration gap.

Duration management can also be used to increase shareholders' net worth, but with greater exposure to investment risk. If interest rates are expected to rise, a negative duration gap position is taken by reducing the duration of assets relative to liabilities. If expectations are correct and interest rates rise, the market value of liabilities falls more than the market value of assets, thereby increasing net worth. But if expectations are incorrect and interest rates fall, net worth declines because the market value of liabilities rises more than the market value of assets. To increase net worth if interest rates are expected to fall, a positive duration gap position is taken.

The major criticism of duration gap management is the difficulty of its implementation. Detailed information on maturity dates, interest rates, and payment schedules is required for all of a bank's instruments. And additional information and computations are necessary if an instrument, such as a mortgage, can be prepaid, or if an instrument, such as a variable-rate loan, can be repriced. Furthermore, there is no agreement on how to compute the durations of deposits that can be withdrawn with little or no notice. Regardless of how deposits are handled, the difficulty of computing duration requires the use of computers. These considerations appear to make the application of duration analysis infeasible for all but fairly large banks.

Gap or duration gap: which one?

A bank that maintains a zero gap may have a nonzero duration gap while another that maintains a zero duration gap may have a nonzero gap. Which of the gaps is the more important? This is like asking which is the more important component of interest rate risk, income risk or investment risk.

The answer depends partly on the preferences of bank stockholders. As pointed out earlier, the fundamental objective of any bank management strategy is to maximize the wealth of bank stockholders while keeping risk at a level acceptable to stockholders. If the bank is privately owned by a few long-term stockholders that prefer a steady income, stockholders may put more emphasis on controlling income risk and less on investment risk. In contrast, if the bank's shares are widely traded and ownership is dispersed among a large number of short-term stockholders, stockholders will probably prefer a management strategy that maintains the value of their shares and, therefore, puts more emphasis on controlling investment risk than income risk. While the importance of income risk versus investment risk depends on the preference of stockholders, in general, the strategy that gives primary emphasis to controlling investment risk is preferable because such a strategy stabilizes net worth and, thus, is more likely to maximize the wealth of bank stockholders.

Instruments for controlling interest rate risk

Gap and duration gap management are strategies for controlling interest rate risk by controlling a measure of risk, either gap or duration gap. To implement these strategies, bankers manage the composition of bank assets and liabilities to achieve the desired gap or duration gap. New instruments have been developed in recent years to facilitate the control of interest rate risk by increasing the flexibility of balance sheets, especially on the asset side. Two instruments that warrant particular attention are floating-rate loans and financial futures.

Although not a recent invention, floating-rate loans were not widely used until the dramatic increase in the level and volatility of interest rates in the mid-1960s.[14] With floating-rate loans, the rate borrowers pay is readjusted periodically to keep it in line with current market rates. By replacing the traditional fixed-interest rate with a floating rate, an otherwise rate-insensitive asset is converted to a rate-sensitive asset. This conversion is especially useful for a bank with a large number of rate-sensitive liabilities that wants to pursue a gap management strategy but cannot reduce the term to maturity of its loans.

When assets and liabilities cannot be restructured to achieve a zero gap or a zero duration gap, financial futures become a useful tool.[15] A financial futures contract is an agreement between two parties to exchange cash for an interest-bearing financial instrument on a future date at a price determined when the agreement was made. Under current institutional arrangements, the parties can agree to exchange assets as far as two years in the future. Exchanges, or "deliveries," occur four times a year, in the third week of March, June, September, and December. There are currently futures markets for seven kinds of financial instruments.[16]

Financial futures insulate a bank from interest rate changes by offsetting a potential loss (gain) of net interest income or net worth with a potential gain (loss) from futures trading. By agreeing on a price in advance, both parties to a financial futures contract wager a bet on interest rate movements between the agreement date and the delivery date. This gambling aspect of futures markets allows bankers to reduce interest rate risk. For example, if a

[14] See Randall C. Merris, "Business Loans at Large Commercial Banks: Policies and Practices," Federal Reserve Bank of Chicago *Economic Perspectives*, November/December 1979, pp. 15-23.

[15] For a further discussion of financial futures markets, see M. T. Belongia and G. J. Santoni, "Hedging Interest Rate Risk with Financial Futures: Some Basic Principles," Federal Reserve Bank of St. Louis *Review*, October 1984, pp. 15-25; and Mark Drabenstott and Anne McDonley, "Futures Markets: A Primer for Financial Institutions," Federal Reserve Bank of Kansas City *Economic Review*, November 1984, pp. 17-33.

[16] Financial futures markets exist for three-month Treasury bills, one-year Treasury bills, four-year Treasury notes, long-term Treasury bonds, commercial paper, three-month certificates of deposit, and 8-percent GNMA certificates. Bankers hedging against interest rate risk usually trade in the three-month Treasury bill market because of its larger volume.

bank's net interest income or net worth is susceptible to loss from a rise in interest rates (and gain from a fall), bankers would take a futures position that produces a gain if interest rates rise (and a loss if they fall). Since the gain (loss) from the futures position offsets the loss (gain) in net interest income or net worth, the bank is insulated from interest rate risk.

To see the benefits of financial futures, consider the situation faced by the bank in the Table 1 example on December 1, 30 days before the end of the first year. With the loan maturing in 25 months and the time deposit maturing in one month, the bank faces a negative gap and a positive duration gap. An interest rate increase before the end of the year would raise interest expenses and lower net interest income. It would also lower net worth by lowering the market value of assets relative to liabilities. To hedge, the bank might bet for an interest rate increase by selling a $90 three-month Treasury bill futures contract for delivery in the third week of December. The contract commits the bank to deliver three-month Treasury bills with a face value of $90 in exchange for a price set when the sale was made. If interest rates increase before the third week in December, the bank can purchase the Treasury bills needed to fulfill the contract at a price less than the contract price because the interest rate increase reduces the price of new Treasury bills. The profit from the futures contract offsets the loss in higher interest expenses when the time deposit is rolled over, as well as the loss in net worth.

Despite the usefulness of financial futures in reducing interest rate risk, only a few large banks use financial futures. There are several reasons. Successful hedging requires continuous reassessment of a bank's exposure to interest rate risk, a requirement that imposes heavy informational needs. Successful hedging also requires extensive monitoring and forecasting of financial market developments and, thus, specialized personnel. Bankers at many medium and small banks apparently feel that gap or duration gap management insulate their banks adequately from interest rate changes. Finally, regulations and accounting requirements tend to discourage use of financial futures.[17]

Empirical evidence on interest rate risk management at Tenth District banks

While much has been written on the management of interest rate risk, few studies have examined how well banks manage this risk.[18] The few that have generally show that net interest margins at large banks are affected little by interest rate changes while net interest margins at small banks rise and fall with interest rates. These results have been used to argue that large banks are well hedged against interest rate risk and that small banks have benefited from a small exposure. Only one of these studies examines, however, interest rate risk since the sharp increase in the level and

[17] For bankers' views of financial futures, see the recent surveys by Mark Drabenstott and Anne McDonley, "The Impact of Financial Futures on Agricultural Banks," Federal Reserve Bank of Kansas City *Economic Review*, May 1982; Donald Koch, Delores Steinhauser, and Pamela Whigham, "Financial Futures as a Risk Management Tool for Banks and S&Ls," Federal Reserve Bank of Atlanta *Economic Review*, September 1982; and James Booth, Richard Smith, and Richard Stolz, "Use of Interest Rate Futures by Financial Institutions," *Journal of Bank Research*, Spring 1984, pp. 15-20.

[18] Empirical studies of interest rate risk management include S. J. Maisel and R. Jacobson, "Interest Rate Changes and Commercial Bank Revenues and Costs," *Journal of Financial and Quantitative Analysis*, November 1978, pp. 687-700; Mark J. Flannery, "Market Interest Rates and Commercial Bank Profitability: An Empirical Investigation," *Journal of Finance*, December 1981, pp. 1085-1101; Mark J. Flannery, "Interest Rate and Bank Profitability: Additional Evidence," *Journal of Money, Credit, and Banking*, August 1983, pp. 355-362; and G. A. Hanweck and T. E. Kilcollin, "Bank Profitability and Interest Rate Risk," *Journal of Economics and Business*, February 1984, pp. 77-84.

volatility of interest rates in the mid-1970s, and none have tried to distinguish between the components of interest rate risk.

This section presents evidence on interest rate risk management at Tenth District banks during the 1976-83 period. The most direct way to examine interest rate risk management would be to examine banks' gaps and duration gaps. The data needed to compute these variables are unavailable for the 1976-83 period, but an analysis of income statement data and balance sheet composition reveals much about banks' exposure to interest rate risk.

Interest income, interest expense, and net interest margins

Chart 1 presents interest income and expense data for all Tenth District banks since 1976. The upper panel plots gross interest income and gross interest expense as a proportion of average assets, together with their difference—net interest margin.[19] The lower panel plots the federal funds rate, which serves as a proxy for the level of market interest rates, and the standard deviation of the federal funds rate, which gauges interest rate volatility.[20] The chart shows that both gross interest income and gross interest expense closely followed movements in the level and volatility of interest rates. While net interest margin was fairly stable by comparison, it nevertheless followed movements in interest rates. This suggests that district banks maintained positive gaps and negative duration gaps and, therefore, incurred some exposure to interest rate risk.

A disaggregation of district data shows differences in the stability of net interest margins at banks of different sizes. Table 2 reports net interest margins for banks of two sizes: those with more than $300 million in assets and those with less than $300 million in assets. The table shows that net interest margin was somewhat more stable at the larger banks, with a difference between the high and low values of only 0.7 percentage points. At the smaller banks, net interest margin had a 1.0 percentage point range. While other factors could account for the differences in the behavior of net interest margins at small and large district banks, an important factor was probably differences in interest rate risk management practices. Judging from net interest margins, large banks appear to have had a smaller

TABLE 2
Net interest margins, Tenth District banks, 1976-83

	Bank Size	
Year	**Small**	**Large**
1976	4.19	3.24
1977	4.28	3.47
1978	4.54	3.62
1979	4.72	3.68
1980	5.02	3.80
1981	5.18	3.93
1982	5.20	3.83
1983	4.85	3.55

Note: Net interest margins are expressed as a percentage of average assets, the average of assets outstanding at the beginning and end of the year. Net interest margins include taxable equivalent interest from state and local obligations.

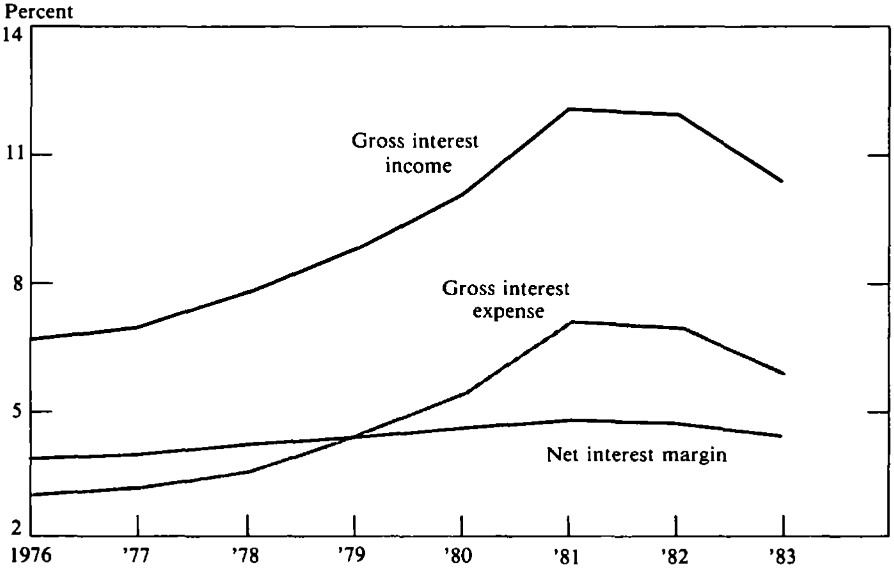
[19] Average assets is the average of assets outstanding at the beginning and end of the year. Gross interest income includes taxable equivalent interest from state and local obligations.

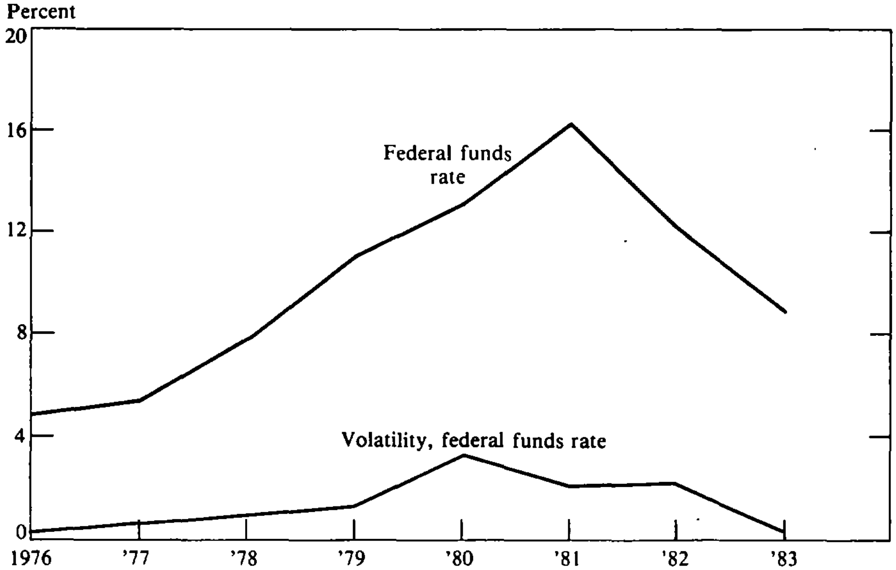
[20] For each year, the standard deviation of the Treasury bill rate was computed from 52 weekly observations of the rate using the formula

$$SD = \left[\frac{1}{51} \sum_{i=1}^{52} (r_i - \bar{r})^2 \right]^{1/2}$$

where $\bar{r}$ is the average Treasury bill rate for the year.

CHART 1
Interest income, expenses, and net margin
Tenth District banks, 1976-83





exposure to interest rate risk than small banks. Differences in interest rate risk management practices can be detected by analyzing the composition of district bank balance sheets.

Balance sheet composition

The average composition of district bank balance sheets during the 1976-83 period is reported in Table 3. Large and small banks show significant differences in balance sheet composition during this period. Large banks appear to have had significantly more rate-sensitive, short-duration assets and liabilities than small banks. This inference is based on differences in loan and deposit compositions and differences in the use of federal funds.

Available loan data allow a crude comparison of the rate-sensitivity and duration of loans at large and small district banks. Table 3 presents a breakdown of loans into long, medium, and short-term categories.[21] Long-term loans are loans with long durations and negligible interest rate-sensitivity. Medium-term loans have shorter durations and are somewhat more rate-sensitive. Short-term loans not only have very short durations, they also often carry floating rates, which makes them among the most rate-sensitive of assets. The table shows that large banks held a significantly higher proportion of their assets in short-term loans than small banks (25.1 percent versus 15.2 percent) and a somewhat smaller proportion of their assets in long-term loans (9.0 percent versus 13.7 percent). Thus, large banks apparently held more rate-sensitive, short-duration loans than small banks.

An analysis of deposit composition allows a comparison of the rate-sensitivity of deposits at large and small district banks. Table 3 presents a breakdown of deposits into rate-insensitive, small floating-rate, and large-time categories. Rate-insensitive deposits are primarily accounts with legal deposit rate ceilings, including traditional demand deposits, NOW accounts, and passbook savings accounts. By virtue of their binding deposit rate ceilings, these accounts are essentially rate-insensitive.[22] Small floating-rate deposits are more rate-sensitive. These deposits, most notably the six-month money market certificate, pay market-related rates and are held by households. Most rate-sensitive are large time deposits, which include large certificates of

TABLE 3
Average composition of balance sheets, Tenth District banks, 1976-83
(percent)

	Bank Size	
	Small	Large
Assets	100.0	100.0
Loans	53.2	47.7
Long-term	13.7	9.0
Medium-term	24.3	13.6
Short-term	15.2	25.1
Securities	27.5	15.3
Fed funds	5.3	12.9
Other	14.0	24.0
Liabilities and capital	100.0	100.0
Deposits	87.9	74.7
Rate-insensitive	58.9	48.0
Small floating-rate	16.1	5.1
Large-time	12.9	21.6
Fed funds	1.9	15.5
Other	2.1	3.5
Capital	8.1	5.9

[21] The long-term loan category consists of real estate loans. The medium-term category consists of consumer loans and agricultural loans. Commercial and industrial loans and loans to other financial institutions compose the short-term loan category.

[22] Although deposit rate ceilings usually prevent banks from paying depositors market-related rates, banks make up for this deficiency by offering depositors such services as free or below-cost checking, 24-hour automated teller machines, conveniently located branches, and the like. Even when account is taken of these "implicit interest" payments, however, deposits subject to ceilings are essentially rate-insensitive.

deposit (CD's). Held almost exclusively by businesses, CD's usually have original maturities of three months or less. The table shows that large banks held substantially more of their liabilities as large time deposits than small banks (21.6 percent versus 12.9 percent) and significantly less as rate-insensitive deposits (48.0 percent versus 58.9 percent). Thus, large banks apparently held significantly more rate-sensitive liabilities than small banks.

Differences in the relative use of federal funds also suggest that large banks had more rate-sensitive, short-duration assets and liabilities than small banks. Federal funds (overnight loans from one bank to another) are among the shortest term instruments available to banks. Table 3 shows that large banks held a larger share of assets in federal funds than small banks (12.9 percent versus 5.3 percent) and held a much larger proportion of liabilities in federal funds (15.5 percent versus 1.9 percent).

Evidence of exposure to interest rate risk, 1976-83

Financial statement data show that net interest margins were more stable at large district banks than small banks and that large district banks held more short-duration, rate-sensitive assets and liabilities than small banks. But these differences do not constitute differences in exposure to interest rate risk. Exposure to the income risk component of interest rate risk is gauged by gap (the difference between rate-sensitive assets and liabilities) while exposure to the investment risk component is gauged by duration gap (roughly equal to the difference between asset and liability durations). Nevertheless, financial statement data suggest that small banks were probably more prone to both income and investment risk than large banks.

Regarding exposure to income risk, small banks were probably more risk-prone than large banks, but risk-bearing was probably rewarded adequately by higher profits. Both large and small banks held more rate-sensitive assets than liabilities, as evidenced by the tendency for net interest margins to follow interest rates. The low rate-sensitivity of bank liabilities reflects the effect of deposit rate ceilings, which prevented deposit costs from following market rates closely. Liabilities were especially rate-insensitive at small banks, where regulated deposits made up more of total assets. Even with deposit ceilings, banks could have completely eliminated their exposure to income risk by balancing their holdings of regulated deposits and rate-insensitive assets.[23] But with interest rates well above deposit ceilings, the profits available by maintaining a nonzero gap exposure made such risk-bearing preferable to bank shareholders.

Regarding exposure to investment risk, small banks were probably also more risk-prone than large banks. This was because they probably had larger duration gaps. For both small and large banks, the durations of individual liabilities were either nearly zero—in the case of federal funds, large time deposits, and most small floating-rate time deposits—or undefined—in the case of rate-insensitive deposits and small floating-rate non-time deposits. A case can be made that the duration of these deposits should be defined as zero, since the value of these deposits is essentially insensitive to interest rate changes.[24] When

[23] This is essentially how savings and loan associations operated until the partial phaseout of deposit rate ceilings. While income risk is reduced by using regulated deposits to finance long-term fixed-rate assets, liquidity risk is increased because regulated deposits are payable either on demand or with little delay.

[24] To be convinced of this argument, one need only consider the recent plight of the thrift industry. For decades, savings and loan associations accepted savings deposits and relent the funds as

TABLE 4
Rate-sensitive assets and liabilities as a proportion of total assets, Tenth District banks, December 31, 1983
(percent)

	Bank Size	
	Small	Large
Rate-sensitive assets	54.8	49.8
Loans	39.1	34.6
Securities	9.5	5.0
Other assets	6.2	10.2
Rate-sensitive liabilities	53.4	52.2
Deposits	51.5	38.4
Other liabilities	1.9	13.8
Gap	1.4	-2.4

this view is taken, liability duration becomes almost equally short at small and large banks, and exposure to investment risk depends solely on asset duration. Since Table 3 suggests that large banks held assets of shorter durations than small banks, large banks were apparently less exposed to investment risk than small banks, at least during the 1976-83 period.

Gap at Tenth District banks

While small banks in the district were more exposed to interest rate risk than large banks during the 1976-83 period, the situation had improved by the end of 1983. Table 4 presents data on rate-sensitive assets, rate-sensitive liabilities, and gap at district banks at the end of 1983, the first year these data were available. Rate-sensitive instruments are defined here as instruments carrying floating rates or maturing in the next 12 months. All amounts are expressed as a proportion of total assets.

Table 4 shows that both large and small banks held gap positions very close to zero at the end of 1983. The table also shows that about half of all assets and liabilities were rate-sensitive at both large and small banks. The high degree of rate-sensitivity in small bank balance sheets at the end of 1983 contrasts sharply with the 1976-83 evidence from financial statement data and suggests that substantial changes have been made at small banks in the district.

Tables 5 and 6 document changes in the characteristics of bank assets and liabilities to help explain how small district banks achieved a near-zero gap position by the end of 1983. Table 5 shows rate-sensitive deposits as a proportion of total liabilities at large and small banks for the 1976-83 period. The table shows that between 1976 and 1983 the proportion of rate-sensitive deposits increased sharply at

long-term fixed-rate mortgages. When interest rates rose sharply beginning in the mid-1970s, the market value of these mortgages fell sharply while the market value of savings deposits remained relatively unaffected. The decline in net worth caused many S&L's to fail.

TABLE 5
Rate-sensitive deposits as a proportion of bank liabilities, Tenth District banks, 1976-83
(percent)

	Bank Size	
Year	Small	Large
1976	11.4	17.7
1977	11.2	18.2
1978	14.7	22.5
1979	25.2	23.9
1980	32.8	26.8
1981	36.1	29.6
1982	36.0	30.6
1983	51.5	38.4

Note: Rate-sensitive deposits include large-denomination time deposits, six-month money market certificates, small time deposits not subject to interest ceilings, Super NOW's, and MMDA's.

both large and small banks, increasing from 18 percent at large banks to 38 percent and from 11 percent at small banks to 51 percent.

Perhaps the most important factor increasing rate-sensitive liabilities was the partial phaseout of deposit rate ceilings. Table 5 shows that rate-sensitive deposits began increasing at all district banks after the introduction of six-month money market certificates in the summer of 1978. Rate-sensitive deposits surged again in 1983 after the introduction of Super NOW's and money market deposit accounts. The partial phaseout of deposit rate ceilings had more effect on small banks because they hold more small time and savings deposits, precisely the deposits that were deregulated during this period.

Since data on loan characteristics at district banks are not available for the 1976-83 period, Table 6 presents data on the characteristics of certain categories of loans from a national sample of banks. Specifically, the data are on the rate-sensitivity and average term to maturity of business and farm loans. The table shows that large U.S. banks reduced their floating-rate loans and the average maturity of loans. This move probably had little effect on the rate-sensitivity of large bank

TABLE 6
Loans at large and small U.S. banks

	Commerical and Industrial Loans*			
	Large banks		Small banks	
	Percent with Floating Rates	Months to Maturity	Percent with Floating Rates	Months to Maturity
1977	66.4	10.3	38.2	9.2
1978	63.6	11.3	49.8	7.8
1979	65.3	9.5	37.1	10.7
1980	52.7	8.9	42.1	8.3
1981	38.9	7.2	52.1	9.3
1982	29.6	5.2	45.5	7.6
1983	33.3	5.1	46.7	9.6

	Farm Loans†			
	Large Banks		Small Banks	
	Percent with Floating Rates	Months to Maturity	Percent with Floating Rates	Months to Maturity
1977	78.4	7.1	8.2	9.0
1978	80.7	7.1	10.4	8.1
1979	70.6	5.7	11.4	7.4
1980	74.6	6.5	8.4	7.3
1981	80.0	5.3	15.6	6.2
1982	65.6	6.0	26.4	6.6
1983	77.7	6.1	28.9	9.6

* Based on a survey of about 340 banks.

† Based on a survey of about 250 banks.

Source: *Survey of Terms of Bank Lending*, Statistical Release E.2, Board of Governors of the Federal Reserve System assets but made large banks less susceptible to investment risk by reducing asset duration. Small U.S. banks slightly increased the proportion of business loans carrying floating rates, but there was no trend in the average maturity of business loans. More significantly, Table 6 shows that, until the current farm crisis, small banks slightly reduced the average maturity of farm loans and sharply increased the proportion of floating-rate farm loans, thereby increasing the rate-sensitivity of farm loans. Since roughly 30 percent of small Tenth District banks hold 50 percent or more of their total loans as farm loans, the changing characteristics of farm loans probably increased the rate-sensitivity of bank assets at small district banks.

Two factors probably accounted for the increase in rate-sensitive assets at small district banks. One was the partial phaseout of deposit rate ceilings. Without changes in the rate-sensitivity of assets, the greater rate-sensitivity of bank liabilities created the potential for large negative gaps. By reducing the average maturity of assets and holding more floating-rate assets, small banks reduced income risk.

The other factor was the growing volatility of interest rates (Chart 1). As noted earlier, small banks were likely exposed to some investment risk from their positive duration gaps during the 1976-83 period. With positive duration gaps, the stability of net worth requires relatively stable interest rates. The increase in interest rate volatility beginning in the mid-1970s likely increased fluctuations in the net worth of small banks and provided an incentive for them to reduce asset duration. Since decreasing asset duration usually increases the rate-sensitivity of assets, growing interest rate volatility was a probable factor in the increase in rate-sensitive assets at small district banks.

Managing interest rate risk in the future

Although small district banks as a group had successfully insulated themselves against income risk by the end of 1983, these banks should give more emphasis to managing interest rate risk in the future. As deregulation of financial markets continues, greater competition among depository institutions and the ongoing phaseout of deposit rate ceilings will force small banks to pay more attention to interest rate risk.

Greater competition among depository institutions should intensify management of interest rate risk by shifting bank shareholders' wealth maximizing-risk minimizing possibilities. Small district banks have traditionally been more profitable than large district banks, maybe due to their often having more control over lending and borrowing rates. Because of the greater profitability of these banks, small bank shareholders may have been fairly unconcerned about potential losses from interest rate risk.[25] But increased competition reduces control over lending and borrowing rates by forcing banks to offer competitive rates. With smaller profits, banks are less able to absorb losses from unexpected movements in interest rates that are not favorable to them. Increased competition also forces banks to tailor loan and deposit characteristics to the needs of customers. This response affects the duration and rate-sensitivity of assets and liabilities and may expose banks to interest rate

[25] A different explanation of greater profitability of small banks is that larger profits are needed to compensate banks' shareholders for risk-bearing because small banks tend to be less well-diversified than large banks and are, therefore, riskier. While this explanation is at least partially correct, evidence suggests that small banks generally fail to maximize shareholder wealth for a given level of risk. See J. C. Francis, "Portfolio Analysis of Asset and Liability Management in Small-, Medium-, and Large-sized Banks," *Journal of Monetary Economics*, July 1978, pp. 459-480.

risk. Greater attention to interest rate risk management will be needed in the more competitive environment to maintain risk at a level acceptable to shareholders.

The continuing shift toward ceiling-free deposits should also lead to changes in interest rate risk management at small district banks. As noted earlier, small banks probably increased their rate-sensitive assets in response to the loosening of deposit rate ceilings in order to reduce income risk. Table 6 shows that the rate-sensitivity of assets was increased partly by changing the characteristics of loans. Further shifting toward ceiling-free deposits would likely lead to further loan changes.

Changing loan characteristics to increase rate-sensitive assets has two serious disadvantages. First, this strategy substitutes credit risk for interest rate risk by shifting interest rate risk to bank borrowers. Credit risk is the risk of decline in loan quality caused by a decline in a borrower's credit rating. Short-term and floating-rate loans increase credit risk by forcing banks' borrowers, who typically have few rate-sensitive assets, into a negative gap position. If interest rates rise unexpectedly, the interest rate on the loan increases and the return on borrowers' assets may not be enough to cover the higher interest payments, increasing the likelihood of default. Hence, even though floating-rate loans reduce the interest rate risk of banks, they increase credit risk.

The second disadvantage to changing loan characteristics to increase rate-sensitive assets is that the change reduces the amount of financial intermediation banks perform. An important function of financial intermediaries is to facilitate medium and long-term capital investment by borrowing short term from savers and lending longer term to investors at steady rates. This is particularly true of small banks, whose business customers may lack access to other forms of finance. Although they borrow short term, banks can lend longer term because they borrow from a large number of savers. When banks lend short term to increase their rate-sensitive assets, however, they cease to perform an important function of intermediation. This ultimately impairs medium and long-term capital investment.

In view of the disadvantages of changes in loan characteristics as the primary means of controlling interest rate risk, small district banks may wish to consider other risk management techniques. Shorter term securities could be used to increase rate-sensitive assets and reduce asset duration. Also, more use could be made of financial futures to hedge nonzero gap and duration gaps against interest rate risk.

Summary and Conclusion

This article has examined how Tenth District banks have coped with interest rate risk, a growing problem for banks since the mid-1970s. The first section reviewed techniques for hedging interest rate risk, including gap management, duration gap management, and financial futures. The second section reviewed the experience of Tenth District banks in applying these techniques. During the 1976-83 period, district banks were generally exposed to both the income and investment risk components of interest rate risk. Large district banks apparently managed their interest rate risk more vigorously than small district banks. By the end of 1983, small and large district banks were about equally well insulated from income risk. To reduce income risk, small banks have relied primarily on increasing the rate-sensitivity of loans. As the financial environment becomes more competitive and less regulated, however, small banks will probably be forced to use other techniques in managing their interest rate risk.