An Analysis of Commercial Bank Exposure to Interest Rate Risk

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Banks earn returns to shareholders by accepting and managing risk, including the risk that borrowers may default or that changes in interest rates may narrow the interest spread between assets and liabilities. Historically, borrower defaults have created the greatest losses to commercial banks, whereas interest margins have remained relatively stable, even in times of high rate volatility. Although credit risk is likely to remain the dominant risk to banks, technological advances and the emergence of new financial products have provided them with dramatically more efficient ways of increasing or decreasing interest rate and other market risks. On the whole, these changes, when considered in the context of the growing competition in financial services have led to the perception among some industry observers that interest rate risk in commercial banking has significantly increased.

This article evaluates some of the factors that may be affecting the level of interest rate risk among commercial banks and estimates the general magnitude and significance of this risk using data from the quarterly Reports of Condition and Income (Call Reports) and an analytic approach set forth in a previous *Bulletin* article.[1] That risk measure, which relies on relatively small amounts of data and requires simplifying assumptions, suggests that the interest rate risk exposure for the vast majority of the banking industry is not significant at present. This article also attempts to gauge the reliability of the simple measure's results for the banking industry by comparing its estimates of interest rate risk exposure for thrift institutions with those calculated by a more complex model designed by the Office of Thrift Supervision. The results suggest that this relatively simple model can be useful for broadly measuring the interest rate risk exposure of institutions that do not have unusual or complex asset characteristics.

1. James V. Houpt and James A. Embersit, "A Method for Evaluating Interest Rate Risk in Commercial Banks," *Federal Reserve Bulletin*, vol. 77 (August 1991), pp. 625–37.

Sources of Interest Rate Risk

Interest rate risk is, in general, the potential for changes in rates to reduce a bank's earnings or value. As financial intermediaries, banks encounter interest rate risk in several ways. The primary and most often discussed source of interest rate risk stems from timing differences in the repricing of bank assets, liabilities, and off-balance-sheet instruments. These repricing mismatches are fundamental to the business of banking and generally occur from either borrowing short term to fund long-term assets or borrowing long term to fund short-term assets.

Another important source of interest rate risk (also referred to as "basis risk"), arises from imperfect correlation in the adjustment of the rates earned and paid on different instruments with otherwise similar repricing characteristics. When interest rates change, these differences can give rise to unexpected changes in the cash flows and earnings spread among assets, liabilities, and off-balance-sheet instruments of similar maturities or repricing frequencies.

An additional and increasingly important source of interest rate risk is the presence of options in many bank asset, liability, and off-balance-sheet portfolios. In its formal sense, an option provides the holder the right, but not the obligation, to buy, sell, or in some manner alter the cash flow of an instrument or financial contract. Options may exist as standalone contracts that are traded on exchanges or arranged between two parties or they may be embedded within loan or investment products. Instruments with embedded options include various types of bonds and notes with call or put provisions, loans such as residential mortgages that give borrowers the right to prepay balances without penalty, and various types of deposit products that give depositors the right to withdraw funds at any time without penalty. If not adequately managed, options can pose significant risk to a banking institution because the options held by bank customers, both explicit and embedded, are generally exercised at the advantage of the holder and to the disadvantage of the bank. Moreover, an increasing array of options can involve significant leverage, which can magnify the influences (both negative and

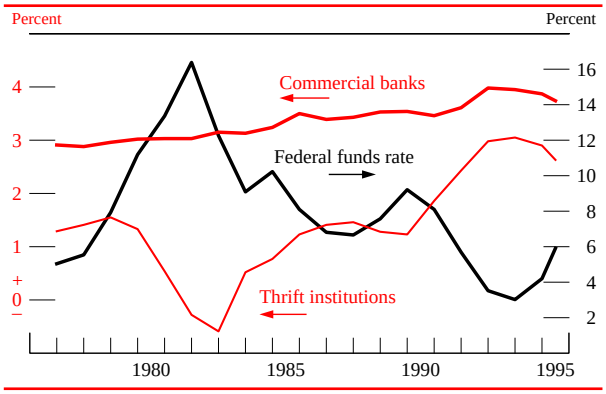
positive) of option positions on the financial condition of a bank.

CURRENT INDICATORS OF INTEREST RATE RISK

The conventional wisdom that interest rate risk does not pose a significant threat to the commercial banking system is supported by broad indicators. Most notably, the stability of commercial bank net interest margins (the ratio of net interest income to average assets) lends credence to this conclusion. From 1976 through midyear 1995, the net interest margins of the banking industry have shown a fairly stable upward trend, despite the volatility in interest rates as illustrated by the federal funds rate (chart 1). In contrast, over the same period thrift institutions exhibited highly volatile margins, a result that is not surprising given that by law they must have a high concentration of mortgage-related assets.

Interest margins, however, offer only a partial view of interest rate risk. They may not reveal longer-term exposures that could cause losses to a bank if the volatility of rates increased or if market rates spiked sharply and remained at high levels. They also say little about the potential for changing interest rates to reduce the "economic" or "fair" value of a bank's holdings. Economic or fair values represent the present value of all future cash flows of a bank's current holdings of assets, liabilities, and off-balance-sheet instruments. Approaches focusing on the sensitivity of an institution's economic value, therefore, involve assessing the effect a rate change has on the present value of its on- and off-balance-sheet instruments and whether such changes would increase or decrease the institution's net worth. Although banks typically focus on near-term earnings, economic value analysis can serve as a leading indicator of the quality of net interest margins over the long term and help identify risk exposures not evident in an analysis of short-term earnings.

1. Net interest margins of commercial banks and thrift institutions and the federal funds rate, 1976–95



NOTE. Year-end data, except for 1995, which is through June 30. Commercial banks are national banks, trust companies, and state-chartered banks, excluding savings banks insured by the Federal Deposit Insurance Corporation.

New Products and Banking Practices

If, as some industry observers have claimed, new products and banking practices have weakened the industry's immunity to changing interest rates, then the need for more comprehensive indicators of interest rate risk such as economic value analysis may have increased. In particular, commercial banks are expanding their holdings of instruments whose values are more sensitive to rate changes than the floating-rate or shorter-term assets traditionally held by the banking industry. The potential effect of this trend cannot be overlooked, but it should also be kept in perspective. Although commercial banks are much more active in mortgage markets than they were a decade ago, this activity has not materially altered their exposure to changing long-term rates. Indeed, the proportion of banking assets maturing or repricing in more than five years has increased only 1 percentage point since 1988, to a median value of only 10 percent of assets at midyear 1995. The comparable figure for thrift institutions at midyear 1995 was 25 percent.

However, the industry's concentration of long-term maturities is a limited indicator of risk inasmuch as banks have also expanded their concentration of adjustable rate instruments with embedded options that can materially extend an instrument's effective maturity. For example, although adjustable rate mortgages (ARMs) may reprice frequently and avoid some of the risk of long-term, fixed rate loans, they also typically carry limits (caps) on the amount by which their rates may increase during specific periods and throughout the life of the loan. Managers who do not take into account these features when identifying or managing risk may face unexpected declines in earnings and present values as rates change.

Collateralized mortgage obligations (CMOs) and so-called structured notes are other instruments with option features.[2] They may also contain substantial leverage that compounds their underlying level of interest rate risk. For example, as interest rates rose

2. In general structured notes are debt securities whose cash flow characteristics (coupon rate, redemption amount, or stated maturity) depend on one or more indexes, or these notes may have embedded forwards or options.

sharply during 1994, market values fell rapidly for certain structured notes and for CMOs designated as high risk.[3] However, these instruments accounted for less than 1 percent of the industry's consolidated assets at midyear 1995, although individual institutions may have material concentrations.

Off-balance-sheet instruments, on the other hand, have grown dramatically and are an important part of the management of interest rate risk at certain banks. The notional amount of interest rate contracts—such as interest rate options, swaps, futures, and forward rate agreements—has grown from $3.3 trillion in 1990 to $11.4 trillion as of midyear 1995.[4] These contracts are highly concentrated among large institutions, with fifteen banks holding more than 93 percent of the industry's total volume of these contracts in terms of their notional values. In contrast, 94 percent of the more than 10,000 insured commercial banks report *no* off-balance-sheet obligations. Although banks do not systematically disclose the price sensitivity of these contracts to the public, the regulatory agencies have complete access to this necessary information through their on-site examinations and other supervisory activities. Moreover, these contracts are concentrated at dealer institutions that mark nearly all their positions to market daily and that actively manage the risk of their interest rate positions. These dealer institutions generally take offsetting positions that reduce risk to nominal levels, and they are required by bank supervisors to employ measurement systems that are commensurate with the risk and complexity of their positions.

Competitive Pressures

Competitive pressures are also affecting banking practices and the industry's management of interest rate risk. Specifically, competition may be reducing the banking industry's ability to manage interest rate risk through discretionary pricing of rates on loans and deposits. For example, growing numbers of bank customers are requesting loan rates indexed to broad market rates such as the London interbank offered rate (LIBOR) rather than to the prime lending rates that banks can more easily control.[5] On the deposit side, sluggish domestic growth since 1990, when coupled with the more recent rise in loan demand, has caused shifts in the structure of funding. Traditionally deposits have funded 77 percent or more of banking assets; at midyear 1995, however, deposits funded less than 70 percent of industry assets—a record low. If the recent outflow of core deposits (demand deposits and money market, savings, and NOW accounts) continues, many banks may feel pressured to offer more attractive rates. However, the amount by which rates must increase to reverse the deposit outflow is difficult to judge.

To meet the recent rise in loan demand, banks have made up the funding shortfall with overnight borrowings of federal funds, securities repurchase agreements, and other borrowings. These funding changes may have effectively shortened the overall liability structure of the industry and, along with other pressures facing the industry, must be adequately considered in managing interest rate risk.

Analysis of Portfolio Values

In this environment of new products and competitive pressures, treasury and investment activities have become more important for many banks in managing interest rate risk. Although banks are constrained in their lending and deposit-taking functions by the preferences and demands of their customers, they have substantial flexibility in increasing or offsetting the resulting market risks through the securities and interest rate contracts they choose to hold. The risk profile of the investment securities portfolio can be evaluated by observing changes in the portfolio's fair value from actual rate moves. This analysis is possible because unlike most other banking assets and liabilities, the current market value of a bank's securities portfolio is easily determined and is publicly reported each quarter.

For example, the industry's aggregate securities portfolio (excluding securities held for trading) for 1993:Q4 had a 1.4 percent market value premium, which represented an unrealized gain of $11.5 billion (chart 2). The rise in interest rates during 1994 (as depicted by the two-year Treasury note yield) and the resulting drop in the value of securities produced a market value discount of 3.5 percent by 1994:Q4, which meant a loss in value of 4.9 percentage points ($40 billion). With the subsequent fall in interest rates during the first half of 1995, the portfolio recovered a portion of its loss and rose to a market value premium of 0.1 percent ($1 billion) at 1995:Q2. Although partly affected by changes in the composition of the portfolio, these results suggest that the

3. The Federal Financial Institutions Examination Council has designated CMOs as high risk when they fail to meet certain criteria regarding the sensitivity of their fair value to interest rate movements.

4. The notional amount of an interest rate contract is the face amount to which the rates or indexes that have been specified in the contract are applied to determine cash flows.

5. LIBOR is the rate at which a group of large, multinational banking institutions agree to lend to each other overnight.

average duration of the industry's securities portfolio may be roughly one and one-half to two years, a maturity range many might view as presenting banks with relatively little interest rate risk.[6] When applied to earlier periods, this analysis further suggests that the price sensitivity of the industry's securities portfolio has remained largely unchanged since at least the late 1980s.

Although this analysis of portfolio value may help in the evaluation of risks in the securities activities of banks, it does not consider any corresponding and potentially offsetting changes in the economic value of banks' liabilities or other on- or off-balance-sheet positions. That limitation helps to explain why the banking industry has typically ignored economic or long-term present value effects when measuring interest rate risk.

Techniques for Measuring Interest Rate Risk

Historically, banks have focused on the effect that changing rates can have on their near-term reported earnings. Spurred in part by supervisory interest in the matter, more recently many banks have also been examining the effect of changing rates on the economic value of their net worth, defined as the net present value of all expected future cash flows discounted at prevailing market rates. By taking this approach—or more typically, considering the potential effect of rate changes on economic value as well as on earnings—banks are taking a longer-term perspective and considering the full effect of potential changes in market conditions. As a result, they are more likely than before to avoid strategies that maximize current earnings at the cost of exposing future earnings to greater risk.

Several techniques are used to measure the exposure of earnings and economic value to changes in interest rates. They range in complexity from those that rely on simple maturity and repricing tables to sophisticated, dynamic simulation models that are capable of valuing complex financial options.

Maturity and Repricing Tables

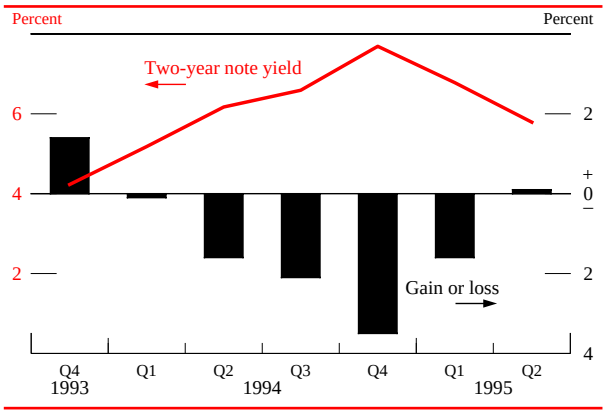
A maturity and repricing table distributes assets, liabilities, and off-balance-sheet positions into time bands according to the time remaining to repricing or maturity, with the number and range of time bands varying from bank to bank. Assets and liabilities that lack specific (that is, contractual) repricing intervals or maturities are assigned maturities based often on subjective judgments about the ability of the institution to change—or to avoid changing—the interest rates it pays or receives. When completed, the table can be used as an indicator of interest rate risk exposure in terms of earnings or economic value.

For evaluating exposure to earnings, a repricing table can be used to derive the mismatch (gap) between the amount of assets and the amount of liabilities that mature or reprice in each time period. By determining whether an excess of assets or liabilities will reprice in any given period, the effect of a rate change on net interest income can be roughly estimated.

For estimating the amount of economic value exposed to changing rates, maturity and repricing tables can be used in combination with risk weights derived from the price sensitivity of hypothetical instruments. These weights can be based either on a representative instrument's duration and a given interest rate shock or on the calculated percentage change in the instrument's present value for a specific rate scenario.[7] In either case, when multiplied by the balances in their respective time bands, these weights

6. The duration of a security is a statistical measure used in financial management to estimate the price sensitivity of a fixed rate instrument to small changes in market interest rates. Specifically, it is the weighted average of an instrument's cash flows in which the present values serve as the weights. In effect, it indicates the percentage change in market value for each percentage point change in market rates.

2. Unrealized gains or losses on securities, all insured commercial banks, and the yield on two-year Treasury notes, 1993:Q4–1995:Q2



7. Though duration is a useful measure, it has the shortcoming of assuming that the rate of change in an instrument's price is linear, whether for rate moves of 1 or 500 basis points. The second approach, analyzing present values for a specific rate scenario, recognizes that many instruments have price sensitivities that are nonlinear (a characteristic called convexity) and tailors adjustments to cash flows (such as principal prepayments) to the specific magnitude and level of the rate shock.

provide an estimate of the net change in the economic value of an institution's assets, liabilities, and off-balance-sheet positions for a specific change in market rates. When expressed as a percentage of total assets, the net change, or "net position," can also provide an index for comparing the risk of different institutions. Although rough, such relatively simple measures can often provide reasonable estimates of interest rate risk for many institutions, especially those that do not have atypical mortgage portfolios nor hold material amounts of more complex instruments such as CMOs, structured notes, or options.

Simulation Techniques

Simulation techniques provide much more sophisticated measures of risk by calculating the specific interest and principal cash flows of the institution for a given interest rate scenario. These calculations can be made considering only the current holdings of the balance sheet, or they can also consider the effect of new lending, investing, and funding strategies. In either case, risk can be identified by calculating changes in economic value or earnings from any variety of rate scenarios. Simulations may also incorporate hundreds of different interest rate scenarios (or "paths" through time) and corresponding cash flows. The results help institutions identify the possible range and likely effect of rate changes on earnings and economic values and can be most useful in managing interest rate risk, especially for institutions with concentrations in options that are either explicit or embedded in other instruments. Instrument valuations using simulation techniques may also be used as the basis for sensitivity weights used in simple time band models. However, such simulations can require significant computer resources and, as always, are only as good as the assumptions and modeling techniques they reflect.

Indeed, whether a bank measures its interest rate risk relative to earnings or to economic value or whether it uses crude or sophisticated modeling techniques, the results will rely heavily on the assumptions used. This point may be especially important when estimating the interest rate risk of depository institutions because of the critical effect core deposits can have on the effective level of risk. The rate sensitivity of core deposits may vary widely among banks depending on the geographic location of the depositors or on their other demographic characteristics. The sensitivity may also change over time, as depositors become more aware of their investment choices and as new alternatives emerge. Recognizing these variables, few institutions claim to measure this sensitivity well, and most banks use only subjective judgments to evaluate deposits that fund one-half or more of their total assets. This measurement conundrum makes estimates of interest rate risk especially difficult and underscores the lack of precision in any measure of bank interest rate risk.

The Basic Screening Model

In recent years, the Federal Reserve has used a simple screening tool, the "basic model," to identify commercial banks that may have exceptionally high levels of interest rate risk. The basic model uses Call Report data to estimate the interest rate risk of banks in terms of economic value by using time bands and sensitivity weights in the manner previously described. The available data, however, are quite limited, with total loans, securities, large time deposits, and subordinated debt divided into only four time bands on the basis of their final maturities or next rate adjustment dates, and with small CDs and other borrowed money split into even fewer time bands.[8] No data are available for coupon rates or for the rate sensitivity of off-balance-sheet positions or trading portfolios.

These data limitations require analysts to supplement the available maturity data with other information provided in the Call Report and to make important assumptions about the underlying cash flows and actual price sensitivities of many assets and liabilities of banks. For example, the timing of cash flows from loans on autos, residential mortgages, and other portfolios may differ widely as a result of their unique amortization requirements, caps, prepayment options, and other features. Yet Call Report data provide no details on the types of loans or securities contained within each time band. To distinguish among key instrument types within each time band, each bank's balance sheet is used as a guide to divide the balances in the time bands into major asset types. The appendix describes that process and the derivation of risk weights for price sensitivity.

Table 1 provides an example of the calculations used to derive a bank's change in economic value for a rise in rates of 200 basis points. To begin, assets and liabilities are divided into time bands according to their maturity; the basic model uses four time

8. Two additional time bands of data are available for subordinated debentures because of the informational requirements of the risk-based capital standard. However, relatively few institutions have outstanding subordinated debt, and in any event, these balances do not reflect a material source of funds.

bands. Risk weights based on the price sensitivity of a hypothetical instrument are then applied to each balance to derive the estimated dollar change in value of each time band. Finally, the net of total changes in asset and liability values gives the net change in economic value.

As rates rise, longer-maturity assets become less valuable to a bank, while longer-term liabilities become more valuable. In the example shown in table 1, the rise in rates causes the economic value of the bank's assets to fall by a larger amount than liabilities increase in economic value; as a result, a net decline of $13.5 million occurs in the bank's economic value.[9] To provide an index measure, that amount is divided by total assets to derive a "net position" ratio of −1.97 percent.

1. Worksheet for calculating risk-weighted net positions in the basic model

Dollar amounts in thousands

Balance sheet item	Total (dollars)	Risk weight (percent)	Change in economic value (dollars)
	(1)	(2)	(1) × (2)
INTEREST-SENSITIVE ASSETS			
Fixed rate mortgage products			
0–3 months	0	–.20	0
3–12 months	0	–.70	0
1–5 years	0	–3.90	0
More than 5 years	233,541	–8.50	–19,851
Adjustable rate mortgage products	2,932	–4.40	–129
Other amortizing loans and securities			
0–3 months	0	–.20	0
3–12 months	0	–.70	0
1–5 years	28,858	–2.90	–837
More than 5 years	0	–11.10	0
Nonamortizing assets			
0–3 months	132,438	–.25	–331
3–12 months	7,319	–1.20	–88
1–5 years	182,373	–5.10	–9,301
More than 5 years	11,194	–15.90	–1,780
Total interest-sensitive assets	598,655	. . .	–32,317
All other assets	85,696	. . .	. . .
Total assets	**684,351**	. . .	. . .
INTEREST-SENSITIVE LIABILITIES			
Core deposits			
0–3 months	56,082	.25	140
3–12 months	39,634	1.20	476
1–3 years	157,785	3.70	5,838
3–5 years	50,600	7.00	3,542
5–10 years	28,167	12.00	3,380
Total	332,269	. . .	13,376
CDs and other borrowings			
0–3 months	117,491	.25	294
3–12 months	77,303	1.20	928
1–5 years	78,140	5.40	4,220
More than 5 years	0	12.00	0
Total interest-sensitive liabilities	605,204	. . .	18,817
Other liabilities	112	. . .	. . .
Total liabilities	**605,316**	. . .	. . .
Equity capital	79,035	. . .	. . .
Summary			
Change in asset values	. . .	. . .	–32,317
Change in liability values	. . .	. . .	18,817
Net change in economic value	. . .	. . .	–13,500
Net position ratio (change in economic value divided by total assets) (percent)	. . .	. . .	–1.97

COMPARISON OF THE BASIC MODEL WITH THE OTS MODEL

Despite its limitations, the basic model seems to be a useful indicator of the general level of an institution's interest rate risk. This conclusion is based on a recent study using the more extensive interest rate risk information reported by thrift institutions and comparing the results of the basic model with the model developed by the Office of Thrift Supervision (OTS).[10] To help ensure that the large losses from interest rate exposures experienced by many thrift institutions during the 1980s are not repeated, the OTS collects extensive interest rate risk data on them and uses a fairly complex and sophisticated simulation model (the OTS model) to estimate their levels of risk.

The data reported by thrift institutions consists of more than 500 items of information about the maturities and repricing characteristics of financial instruments. These data are used in the OTS model to calculate changes in economic value under a number of interest rate scenarios. Although other sophisticated interest rate risk models can be used to evaluate the effectiveness of the basic model, only the OTS provides both a sophisticated measure of risk and an extensive database with which to compare "bottom line" results from hundreds of institutions.

The OTS model calculates price changes based on data specific to each portfolio rather than relying on time bands and hypothetical instruments. For instruments without embedded options, the model discounts static cash flows that are derived from a portfolio's weighted-average maturity and coupon. For instruments such as adjustable rate mortgages that have embedded options, the OTS model uses Monte Carlo simulation techniques and data on coupons, maturities, margins, and caps to derive market

9. As mentioned earlier, the existing Call Report provides no information on the rate sensitivity of off-balance-sheet positions, and therefore those positions are not included in the calculation of economic value.

10. The authors would like to thank Anthony Cornyn and Donald Edwards of the Office of Thrift Supervision for providing the thrift industry regulatory input data and the output of the OTS Net Portfolio Value model for the present study.

value changes. To measure interest rate risk, the model estimates fair values under prevailing interest rates (base case) and at alternatively higher and lower rate levels, including a uniform increase of 200 basis points for all points along the yield curve. Any decline in economic value relative to the base case reflects the potential interest rate risk of the institution.

Like other models, however, the OTS model relies on key assumptions, particularly those related to the rate sensitivity of core deposits. Since informed parties can disagree on the proper treatment of these deposits, standard estimates of core deposit sensitivities were used in both models for the purpose of comparing the results.

To perform a comparison, OTS data were obtained for the 1,414 of 1,548 thrift institutions that supplied such data for year-end 1994. For each thrift institution, the more than 500 pieces of OTS data were reduced to the 24 inputs required by the basic model. After applying the basic model's risk weights to each position and incorporating the OTS core deposit estimates, the dollar change in economic value and a net position ratio were calculated for each institution.

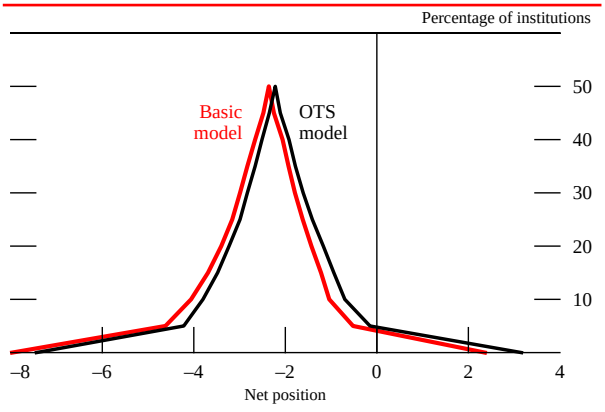
The interest rate exposures for the thrift industry as calculated by the two models revealed strikingly similar results. The distribution curves for interest rate risk produced by each model (chart 3) nearly overlap. By both measures, the median change in economic value was about –2.3 percent of assets. Other measures of industry dispersion of interest rate risk were similar in most respects.

These frequency distributions, however, do not reveal differences in the two measures for individual institutions. Identifying those differences requires regressions, scatter plots, rank ordering, and other statistical techniques, which have been used in similar research.[11] Plotting the results generated for each thrift institution by the OTS model along one axis and the results of the simple risk measure along the other reveals a substantial correlation between the results of the two models on a thrift-by-thrift basis (chart 4). If the modeling results for each institution were identical, they fell along the 45 degree line shown; if they were significantly different, they fell away from the line. A regression line drawn through the points indicates that although the two measures are substantially correlated, the basic model tends to estimate higher risk than the OTS model, especially for above-average risk levels.

Another way to evaluate the similarity of exposure estimates made by the two models is to compare the percentage of thrift institutions that fall within a given level of difference. On that basis, the two models calculated exposures that came within ½ percent of assets or less for about half the institutions and within 1 percent or less for almost 80 percent of them. Given that industry interest rate exposures showed a broad range of 11 percentage points (roughly +3 to –8 percent), these differences appear fairly small and suggest that the basic model performs well relative to a more complex model in placing an institution along the risk exposure spectrum. However, depending on the model's purpose, these differences may not be satisfactory. For example, the level of acceptable precision should vary depending on whether the model is for identifying and monitoring the general magnitude of risk, for making strategic decisions that precisely adjust the bank's risk levels, or for evaluating capital adequacy.

In evaluating a model, other characteristics of its performance may also be significant to users. For example, if the model is to be used by regulators for surveillance purposes, the model should also be evaluated on its ability to identify institutions that are taking relatively high levels of risk. In this context, the basic model identified nearly two-thirds of the institutions ranked by the OTS model in the top risk quintile of all institutions and 90 percent of the institutions that were ranked by the OTS model in the top 40 percent. Assuming that the OTS model has correctly identified high-risk institutions, these results

3. Comparison of interest rate risk exposures of the thrift industry calculated with the basic model and the OTS model, December 31, 1994



NOTE. Observations are the net positions for 1,414 thrift institutions. The net position is the change in economic value for a rise of 200 basis points in rates expressed as a percentage of total assets.

11. James M. O'Brien, "Measurement of Interest Rate Risk for Depository Institution Capital Requirements and Preliminary Tests of a Simplified Approach" (paper presented at the Conference on Bank Structure and Competition sponsored by the Federal Reserve Bank of Chicago, May 6–8, 1992).

suggest that there is clear room for improvement in the basic model's identification of high-risk institutions but that, even so, a simple model can provide a useful screen. When used as a supervisory tool, the model and its results can be validated during on-site examinations of interest rate risk.

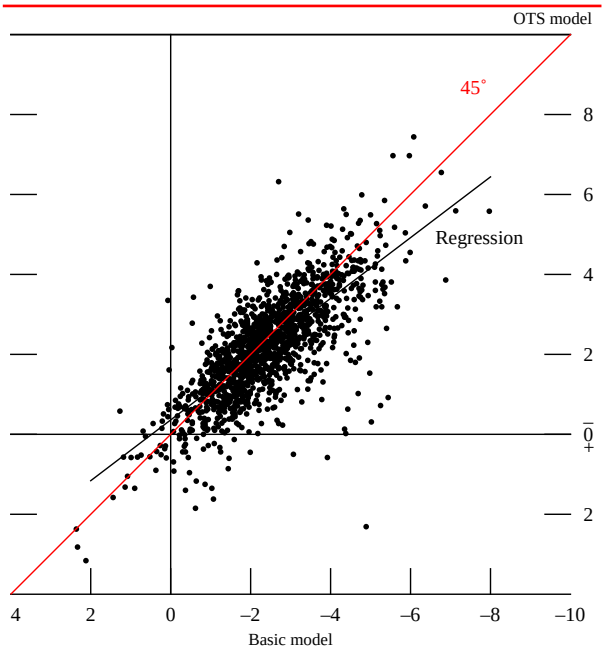
Differences in Estimates of Interest Rate Risk Exposure

The magnitude of differences between exposure estimates from the two models will depend on two factors: (1) the difference in price sensitivity calculated for a given portfolio and (2) the relative prominence of a particular portfolio relative to the balance sheet. So, for example, a relatively small difference in an adjustable rate mortgage portfolio that makes up three-quarters of the balance sheet may translate into fairly large differences in the net position ratio. On the other hand, a large difference in the valuation of a high risk CMO that makes up less than 1 percent of assets would have a minimal effect on the net position ratio.

The largest differences between the two models' estimates of risk exposure for thrifts arise from adjustable rate and fixed rate mortgage portfolios, which make up the bulk of the assets of most thrift institutions. The differences in calculations of mortgage price sensitivity occur when the basic model's generic assumptions regarding maturity, coupon, cap, or other characteristics do not reflect actual portfolio characteristics that are taken into account by the OTS model. For roughly half the institutions, these simplifying assumptions produce differences of ½ percent or less in the two models' estimates of risk exposure relative to assets.

For institutions classified as high risk by one model but not the other, the largest differences arose from three principal sources. First, some high-risk thrift institutions held high concentrations of equities and equity mutual fund balances (15–40 percent of assets), which were assigned a price sensitivity by the OTS model of –9.0 percent but were not given a price sensitivity by the basic model. Because the vast majority of banks have minimal or no equity holdings, the basic model was not designed to address them. Second, for thrifts with large holdings of certain types of adjustable rate mortgages, the single risk weight used by the basic model translated into a fairly large underestimation of risk relative to that estimated by the OTS model. And third, the basic model tended to overstate the risk of longer-term amortizing assets relative to the results of the OTS.

4. Comparison of interest rate risk exposures of individual thrift institutions calculated with the basic model and the OTS model, December 31, 1994



Note. Observations are the net positions for 1,414 thrift institutions. The net position is the change in economic value for a rise of 200 basis points in rates expressed as a percentage of total assets.

Potential Enhancements to the Basic Model

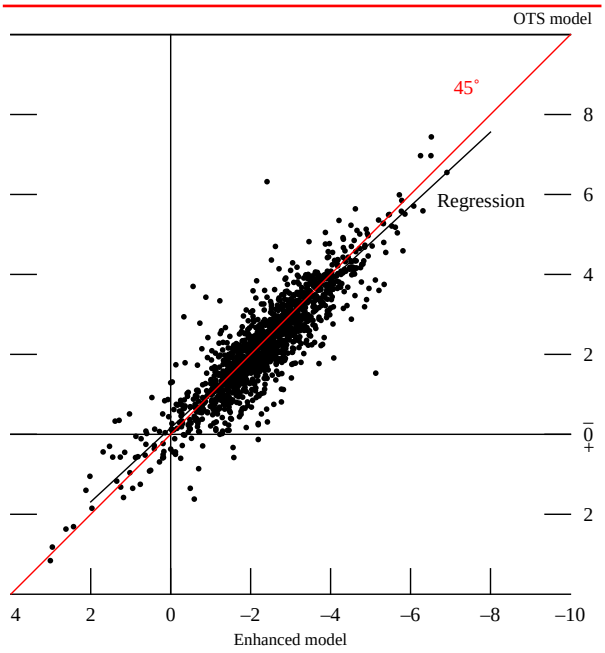
To evaluate the potential measurement benefits of using more data than are currently available from the four time bands of bank Call Reports, the basic model was expanded and run using thrift data. The changes to the basic model produced results that are much closer to those generated by the OTS model. These enhancements are similar to certain features recently described by the banking agencies in their proposed "baseline" measure of interest rate risk.[12] They include expanding the number of time bands from four to seven by dividing the existing one- to five-year time band into one- to three-year and three- to five-year periods and splitting the more than five-year band into three periods separated at the ten-year and twenty-year points.

12. "Proposed Interagency Policy Statement Regarding the Measurement of Interest Rate Risk, *Federal Register* (August 2, 1995), pp. 39490–572.

Further changes involved obtaining minimal information about the repricing frequency and lifetime caps on adjustable rate loans, separately identifying low- or zero-coupon assets, and requiring institutions to self-report the effects of a specific rate movement on the market values of CMOs, servicing rights, and off-balance-sheet derivatives. For this exercise, the values calculated by the OTS model for CMOs, servicing rights, and off-balance-sheet derivative items were used as a proxy for values that would be self-reported by the institution. Such changes expanded the number of items evaluated by the model from twenty-four to sixty-three and the number of risk weights from twenty-two to forty.

Such relatively small improvements virtually eliminated the differences in how the enhanced and OTS models evaluate the thrift industry's overall interest rate risk. As shown in chart 5, the regression and 45 degree lines (which were already close) almost converge, and the two models produce results that are within 100 basis points of each other for more than 90 percent of all thrifts (table 2). In addition, the enhanced version of the basic model (the enhanced model) significantly improved the rank ordering of risk achieved by the basic model by increasing the percentage of thrifts that were ranked by both the enhanced and the OTS models in the top quintile from 62.9 percent to 76.0 percent. The vast majority of the measured improvement resulted from the increase in time bands.

5. Comparison of interest rate risk exposures of individual thrift institutions calculated with the enhanced model and the OTS model, December 31, 1994



NOTE. Observations are the net positions for 1,414 thrift institutions. The net position is the change in economic value for a rise of 200 basis points in rates expressed as a percentage of total assets.

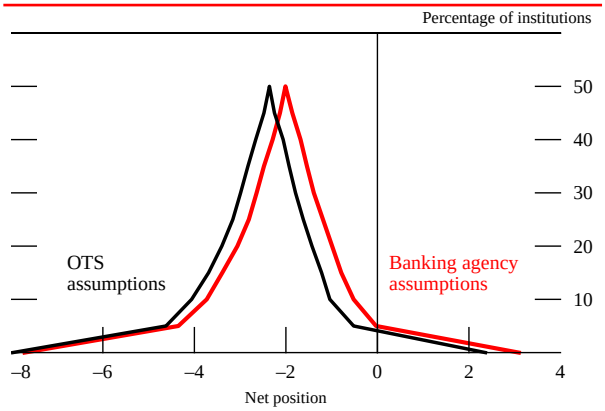
2. Percentage of thrift institutions falling within a given range of difference in net position

Range of difference in net position (basis points)	Basic model v. OTS model	Enhanced model v. OTS model
0–50	48.8	67.6
0–100	79.4	91.0

THE IMPORTANCE OF ASSUMPTIONS ABOUT CORE DEPOSITS

All the previous comparisons of the results of the models and all the previous estimates of risk used a uniform assumption for core deposits. The importance of assumptions regarding the rate sensitivity of core deposits has been stressed several times. For example, replacing the assumptions used by OTS with those proposed by the banking agencies produces a difference of 30–40 basis points in the average measure of the thrift industry's interest rate risk as calculated with the basic model (chart 6). Given sufficient flexibility in the treatment of core deposits, the results of different interest rate risk models could easily vary widely, regardless of whether the models are similar in complexity and sophistication.

6. Effect of different assumptions for core deposits on interest rate risk exposures of the thrift industry calculated with the basic model, December 31, 1994



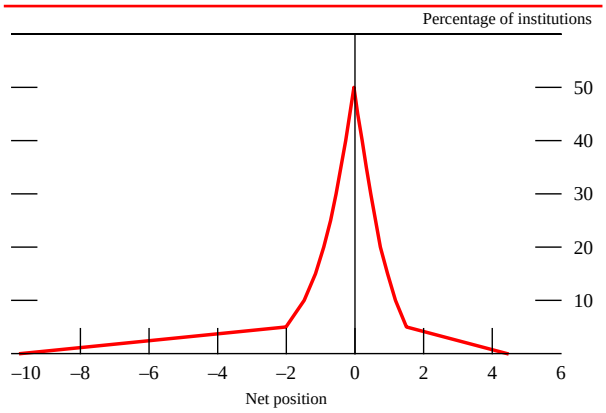
NOTE. Observations are the net positions for 1,414 thrift institutions. The net position is the change in economic value for a rise of 200 basis points in rates expressed as a percentage of total assets.

Estimated Interest Rate Risk of Commercial Banks

Because the basic and OTS models produced fairly similar results for thrift institutions (charts 3 and 4), the basic approach was considered a workable model for commercial banks, especially given that mortgage products (the primary source of differences) are much less important in bank balance sheets. When applied to the data submitted at year-end 1994 by 10,452 commercial banks, the basic model shows, *on average*, little interest rate risk posed by an instantaneous parallel rise in rates of 200 basis points (chart 7). The median exposure was –0.03 percent of assets, although 5 percent of all banks had exposures worse than –2.0 percent. Of course, this relatively balanced view of the banking industry's exposure is highly dependent on the subjective estimates of the price sensitivity of core deposits (in the case of chart 7, those assumed by the federal banking agencies) and should be viewed in that context.

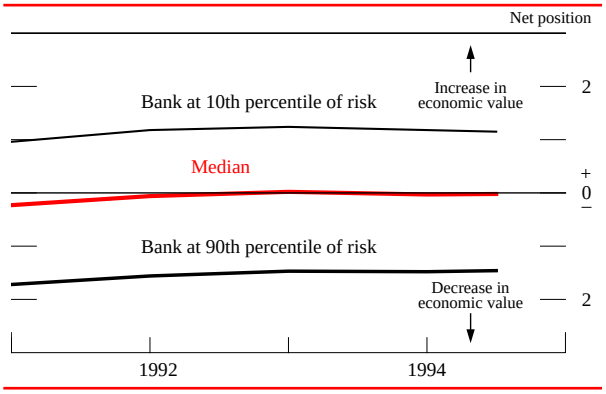
The net exposures of the industry will change over time as institutions respond to changes in market opportunities and in customer demands. The generally neutral overall position of commercial banks may not be uncharacteristic, however. Since 1991, the industry's median net position ratio calculated with the basic model has been close to zero most of the time and was –23 basis points at year-end 1991 (chart 8). Even a commercial bank consistently ranked at the 90th percentile (top 10 percent) of risk had a measured exposure of no worse than –1.7 percent.

7. Distribution of interest rate risk exposure of the commercial banking industry calculated with the basic model, December 31, 1994



Note. Observations are the net positions of commercial banks. The net position is the change in economic value for a rise of 200 basis points in rates expressed as a percentage of total assets.

8. Interest rate risk trends in the commercial banking industry, calculated with the basic model, December 31, 1991–June 30, 1995

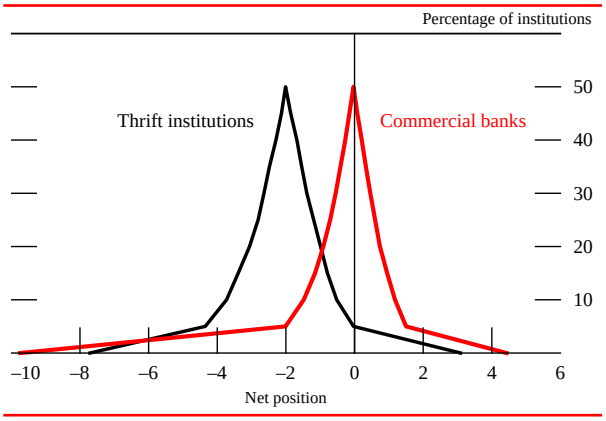


Note. Observations are the net positions of more than 10,000 commercial banks calculated with the basic model under banking agency assumptions about core deposits. The net position is the change in economic value for a rise of 200 basis points in rates expressed as a percentage of total assets. Year-end data except for 1995.

Comparison of the Thrift and Banking Industries

With the distributions of interest rate risk for commercial banks and thrift institutions, we can compare their exposures and consider the relative importance of interest rate risk to each group. Applying the core deposit assumptions proposed by the banking agencies to both groups, the comparison shows, not surprisingly, that thrift institutions have significantly higher risk exposures than banks (chart 9). As before, net exposures of the banking industry are centered

9. Comparison of interest rate risk exposures of the thrift and banking industries calculated with the basic model, December 31, 1994



Note. Observations are the net positions of more than 10,000 commercial banks and 1,414 thrift institutions calculated with the basic model and banking agency assumptions for core deposits. The net position is the change in economic value for a rise of 200 basis points in rates expressed as a percentage of total assets.

around zero and skewed noticeably to the left, suggesting that most bank outliers are exposed to rising rates. Thrift institutions, however, have an average exposure of −2.0 percent (exposing them, too, to rising rates), with the distribution centered rather evenly around that point.

Although some commercial banks may have as much interest rate risk as many thrift institutions, this analysis suggests that the exposure of the two industries is much different, a conclusion consistent with current and past indicators. The primary cause of the difference is, of course, the heavier concentration of mortgage products among thrift institutions. The median price sensitivity of thrift assets was calculated at 5.1 percent, compared with 3.0 percent for banks. The median figures for liabilities were much closer, at 3.7 percent and 3.4 percent respectively.

Limitations of Findings

Conclusions regarding the reliability of the basic model are limited to a single interest rate scenario; further research must be conducted to determine whether the basic model's performance can be maintained over more diverse interest rate scenarios such as falling rates and nonparallel shifts in yield curves. Moreover, despite a strong correlation with exposure estimates produced by the OTS model, limitations in commercial bank data could conceal an increase in the industry's risk profile. For example, if an institution lengthened the maturity of assets in the longest time band (more than five years) from ten to twenty years, the related risk would not be identified by the data currently collected. Such deficiencies suggest that relatively minor enhancements to regulatory reporting, such as one or more additional time bands, could materially improve supervisors' understanding and monitoring of bank risk profiles.

Conclusion

Interest rate risk does not currently appear to present a major risk to most commercial banks. Nevertheless, for individual institutions, interest rate risk must be carefully monitored and managed, especially by institutions with concentrations in riskier or less predictable positions.

Measuring interest rate risk is a challenging task and is made even more difficult for depository institutions because of the uncertainty regarding core deposit behavior and the options embedded throughout their balance sheets. Critical assumptions are needed regarding customer behavior, and those assumptions may often determine a model's results, making precise estimates of risk unattainable. Financial innovations and the evolution in banking markets have made the measurement of interest rate risk even more challenging; nonetheless, the limited banking industry data suggest that the majority of bank risk profiles have not been significantly altered by these developments. Although ''blind spots'' arising from data limitations exist, the relatively small industry concentrations of complex instruments or instruments maturing in more than five years suggest that errors from insufficient data are unlikely to materially change conclusions regarding the industry's overall risk profile.

Comparing the results of a simple risk measure (the basic model) with those of a more sophisticated technique that uses substantially more data (the enhanced model) suggests that a simple measure performs well in measuring an industry's risk exposure and may be capable of identifying the general magnitude of risk for most institutions. Fairly small increases in the amount of data on maturities and other factors appear to improve significantly a simple model's performance in measuring the risk of individual institutions and identifying those taking the greatest amount of risk. Considering that rough assumptions must be made about the price sensitivity of core deposits and the potential that simple models appear to have for measuring risk, supervisors and managers may find simple measurement approaches useful for monitoring an institution's interest rate risk.

Appendix: The Derivation of Time Band Categories and Risk Weights

The basic model divides an institution's balance sheet into several categories and distributes the balances among four time bands on the basis of their final maturities or repricing frequency. The amounts within each band are then multiplied by a risk weight based on the estimated percentage change in value of a representative instrument for a given change in market interest rates. For mortgage products these risk weights also reflect the effect of loan prepayments that are expected to result from the designated rate change. Once the estimated effects on assets and liabilities are combined, they can be expressed as a percentage of total assets to derive an index measure of interest rate risk.

The key asset categories used in the basic model are the following: fixed rate mortgage products,

adjustable rate mortgage products, other amortizing assets, and nonamortizing assets. Because time band data on the Call Report are limited to two asset categories, total loans and total securities, each bank's balance sheet is used as a guide to slot its assets into these four major asset types.

The four time bands for total loans and total securities are analytically divided into the four asset categories using some assumptions and the process of elimination. For example, the balance of fixed rate residential mortgage loans is deducted from the longest asset time band (the fourth) and placed in the fourth time band of the mortgage category. If the mortgage balance is larger than the available amount of the asset time band, then any residual balance is deducted from the next longest time band (the third) and so on until the total fixed rate mortgage balance is accounted for. This procedure is repeated throughout the program for other assets such as mortgage pass-through securities, consumer installment loans, and so forth. Once fixed rate mortgage products, other amortizing assets, and adjustable rate mortgages are accounted for and totaled by time band, all residual time band balances are assumed to be nonamortizing.

For liabilities other than core deposits, the process is straightforward because CDs, other borrowings, and subordinated debentures are generally homogeneous, nonamortizing products and usually do not contain embedded prepayment or other options. Therefore specific assumptions regarding the composition of these time bands are unnecessary.

The category presenting the greatest challenge for evaluating price sensitivity is nonmaturity core deposits, which fund one-half of a typical bank's balance sheet. Because these deposits have no stated maturity and typically do not reprice as quickly as general market rates, their effective maturity or repricing frequency must be analytically derived. The lack of historical data and of commonly accepted methodologies to adequately measure their price sensitivity makes uncertain the slotting of these deposits into their appropriate time bands. Though many banks believe that their core deposits are especially insensitive to interest rate moves and therefore are of fairly long effective maturity, increased competitive pressures and changing customer demographics raise questions in that regard. The time bands used in the enhanced model are those used by the federal banking agencies in their proposed Joint Agency Policy Statement on Measuring Interest Rate Risk (Policy Statement) (*Federal Register*, August 2, 1995). Core deposits are divided into three categories and slotted among five possible time bands (table A.1).

A.1. Core deposits, grouped by type of account and distributed by assumed effective maturity or repricing frequency

Percent

Type of account	0–3 months	3–12 months	1–3 years	3–5 years	5–10 years	All
Commercial demand deposit	50	0	30	20	. . .	100
Retail demand deposits, savings, and NOWs	0	0	60	20	20	100
Money market deposits	0	50	50	. . .	. . .	100

NOTE. Core deposits have no stated maturity and therefore are not slotted into time bands in the Call Report. Because the number of time bands was not limited to the four used in the Call Report, five were derived and used in both the basic and enhanced models. Five time bands were derived because this breakdown was considered the most analytically useful.

Derivation of Risk Weights

The risk weights are derived from a present value analysis that estimates the expected change in value of hypothetical instruments in response to a shift in rates of 200 basis points (table A.2). As a surveillance tool, the basic model's risk weights are recalculated when changes in market conditions are considered large enough to require it. As used for this article, the risk weights for the seven-time-band model of the banking agencies' policy statement are adapted to the basic model.

The assumed coupons of the hypothetical instruments—7.5 percent for assets and 3.75 percent for interest-bearing liabilities—are thought to be generally representative of those in the banking industry during 1994. In addition, instruments are assumed to mature or reprice at the midpoints of the time bands. To adapt risk weights for seven time bands to four time bands, an average of the two risk weights for the one- to three-year and three- to five-year time bands is used. For instruments maturing in more than five years, the risk weight relates to the time bands for five to ten years, ten to twenty years, or more than twenty years based on the likely portfolio maturity for that category. For mortgage products, whose value is dependent on prepayment rates and the behavior of periodic and lifetime caps, risk weights were derived from estimates calculated by the OTS model, which factors in the effect of these embedded options in their values.

Potential Errors of the Basic Approach

Obviously the basic model contains potential estimation errors. One misestimation of risk can occur

when actual bank financial instruments vary from the assumed hypothetical instrument's maturity. For example, in the most extreme scenario, all the assets slotted in the one- to five-year time band for non-amortizing assets could have a maturity skewed to just under five years rather than the midpoint maturity of three years. In that case the actual price change for an increase of 200 basis points in rates would be 7.8 percent rather than the assumed 5.1 percent change of the hypothetical instrument.

A.2. Derivation of the risk weights for the basic and enhanced model

Percent

Time band	Maturity[1]	Coupon (percent)	Enhanced model		Basic model	
			Price (percent of par)	Risk weights[2] (percent)	Price (percent of par)	Risk weights[2] (percent)
OTS Derived Risk Weights						
Fixed-rate mortgages						
0–3 months	1.5 months	7.50	99.80	–.20	99.80	–.20
3–12 months	7.5 months	7.50	99.30	–.70	99.30	–.70
1–3 years	2 years	7.50	98.00	–2.00	. . .	. . .
1–5 years	3 years	7.50	. . .	. . .	96.10	–3.90
3–5 years	4 years	7.50	94.30	–5.70	. . .	. . .
5–10 years	7.5 years	7.50	92.40	–7.60	. . .	. . .
10–20 years	15 years	7.50	91.50	–8.50	91.50	–8.50
More than 20 years	25 years	7.50	88.50	–11.50	. . .	. . .
Adjustable-rate mortgages[3]						
Reset frequency						
0–6 months[4]	6 months	7.50	95.80	–4.20	. . .	. . .
6 months–1 year[5]	12 months	7.50	95.60	–4.40	95.60	–4.40
More than 1 year[6]	3 years	7.50	93.40	–6.60	. . .	. . .
Near lifetime cap[7]	12 months	7.50	93.00	–7.00	. . .	. . .
Static Discounted Cash Flows						
Other amortizing instruments						
0–3 months	1.5 months	7.50	99.80	–.20	99.80	–.20
3–12 months	7.5 months	7.50	99.30	–.70	99.30	–.70
1–3 years	2 years	7.50	98.00	–2.00	. . .	. . .
1–5 years	3 years	7.50	. . .	. . .	97.10	–2.90
3–5 years	4 years	7.50	96.30	–3.70	. . .	. . .
5–10 years	7.5 years	7.50	93.50	–6.50	. . .	. . .
10–20 years	15 years	7.50	88.90	–11.10	88.90	–11.10
More than 20 years	25 years	7.50	84.90	–15.10	. . .	. . .
All other instruments						
0–3 months	1.5 months	7.50[8]	99.75	–.25	99.75	–.25
3–12 months	7.5 months	7.50[8]	98.80	–1.20	98.80	–1.20
1–3 years	2 years	7.50	96.40	–3.60	. . .	. . .
1–5 years	3 years	7.50	. . .	. . .	94.90	–5.10
3–5 years	4 years	7.50	93.40	–6.60	. . .	. . .
5–10 years	7.5 years	7.50	89.40	–10.60	. . .	. . .
10–20 years	15 years	7.50	84.10	–15.90	84.10	–15.90
More than 20 years	25 years	7.50	81.00	–19.00	. . .	. . .
Liabilities						
0–3 months	1.5 months	3.75[8]	100.25	.25	100.25	.25
3–12 months	7.5 months	3.75[8]	101.20	1.20	101.20	1.20
1–3 years	2 years	3.75	103.70	3.70	. . .	. . .
1–5 years	3 years	3.75	. . .	. . .	105.40	5.40
3–5 years	4 years	3.75	107.00	7.00	. . .	. . .
5–10 years	7.5 years	3.75	112.00	12.00	112.00	12.00
10–20 years	15 years	3.75	119.90	19.90	. . .	. . .
More than 20 years	25 years	3.75	126.30	26.30	. . .	. . .
Zero- or low-coupon securities[9]						
0–3 months	1.5 months	0	99.75	–.25	. . .	. . .
3–12 months	7.5 months	0	98.80	–1.20	. . .	. . .
1–3 years	2 years	0	96.20	–3.80	. . .	. . .
3–5 years	4 years	0	92.60	–7.40	. . .	. . .
5–10 years	7.5 years	0	86.60	–13.40	. . .	. . .
10–20 years	15 years	0	75.00	–25.00	. . .	. . .
More than 20 years	25 years	0	61.90	–38.10	. . .	. . .

Note. All estimates are based on a rise in interest rates of 200 basis points.

1. With the exception of fixed rate and adjustable rate mortgages, no prepayments are assumed for these hypothetical instruments.
2. Calculated using a rounding convention.
3. Coupons on adjustable rate mortgages (ARMs) are assumed to adjust to an index based on Treasury yields on actively traded issues adjusted to constant maturities. On the first reset date, the coupon rate will adjust to the index yield plus the margin. Most ARMs also have caps on the amount the rate can change. A periodic cap limits the amount by which a coupon rate may adjust on the reset date. A lifetime cap prevents the coupon rate from adjusting above a preset limit during the life of the mortgage.
4. Six-month Treasury yield; the margin is 275 basis points; the periodic cap is 100 basis points; the lifetime cap is 500 basis points.
5. Twelve-month Treasury yield; the margin is 275 basis points; the periodic cap is 200 basis points; the lifetime cap is 500 basis points.
6. Three-year Treasury yield; the margin is 275 basis points; the periodic cap is 200 basis points; the lifetime cap is 500 basis points.
7. Twelve-month Treasury yield; the margin is 275 basis points; there is no periodic cap; the lifetime cap is 200 basis points.
8. Actual initial price is slightly less than par.
9. Price is represented as a percentage of purchase price.

In addition, errors can result from using incorrect coupon rates. For example rather than the hypothetical coupon of 7.5 percent, a bank's actual assets could have coupons skewed to 10.5 percent, resulting in an actual price change of 4.9 percent rather than 5.1 percent. Though coupon differences for most instruments result in minor errors, coupon differences for mortgage products can create much larger errors because the coupon also strongly influences the mortgage's prepayment behavior and thus its value. Nevertheless, assuming a bank's actual maturities and coupons are fairly evenly distributed or centered around the hypothetical instrument's maturity and coupon, errors should not be material.

Another source of error could come from instruments such as CMOs and structured notes whose time band slotting is based on contractual maturities or repricing dates but whose detailed features can cause highly specific and unusual cash flow behavior. These instruments could cause potentially more significant errors for the basic model; and the errors would be further compounded for institutions that use off-balance-sheet derivative instruments because no data are available to evaluate whether those instruments reduce or increase an institution's risk. As of year-end 1994, 578 of the 10,452 commercial banks used off-balance-sheet derivative contracts based on interest rates. □