

Interest Rate Risk Modeling

An Overview

Financial institutions and other market participants manage many types of risks, including interest rate risk, credit risk, foreign exchange risk, liquidity risk, market risk, and operational risk. This book, the first volume of a trilogy on fixed-income modeling, gives a detailed introduction to various modeling techniques used by practitioners for measuring and managing interest rate risk. The importance of managing interest rate risk cannot be overstated. The total notional amount of outstanding over-the-counter (OTC) single-currency interest rate derivatives was about \$165 trillion as of June 2004, of which 85 percent represented swaps and forward contracts (see Table 1.1). This amount is 62 percent higher than what it was just 18 months before in December 2002. The explosive growth of OTC interest rate derivatives over the past quarter century suggests that managing interest rate risk remains a chief concern for many financial institutions and other market participants, even as U.S. interest rates have declined steadily since reaching their peak in 1980 to 1981. With near record low interest rates prevailing in January 2005, a potential change in the interest rate regime is likely and could lead to huge wealth transfers among various counterparties in the OTC interest rate derivatives market. This could be painful if these participants have not used swaps wisely to hedge against the mismatches in the asset-liability cash flow structures.

The use of swaps or any other derivatives to hedge any type of risk can be thought of as similar to the consumption of medicine. In the right dosage, swaps or derivatives are effective but can be quite harmful in an overdose or if used for a purpose not intended. The perceived abuse of derivatives by Warren Buffett and others does not imply that derivatives should be shunned, but that these should be used wisely in the right dosage and at the appropriate time (Buffett, 2002).

TABLE 1.1 Notional Amounts Outstanding of OTC Single-Currency Interest Rate Derivatives by Instrument Maturity and Contract Type (in billions of U.S. dollars)—All Counterparties (net)

	December					June	
	1998	1999	2000	2001	2002	2003	2004
<i>Forwards and Swaps</i>							
Maturity of one year or less	16,059	21,787	21,683	25,115	33,213	41,084	49,397
Maturity over 1 year and up to 5 years	17172	18761	21217	25233	33898	49866	56,042
Maturity over 5 years	8,773	10,164	12,291	16,286	20,801	31,028	35,275
Total	42,017	50,711	55,191	66,634	87,912	121,978	140,714
<i>Options</i>							
Maturity of one year or less	2,116	3,087	2,424	2,770	3,725	5,390	7,760
Maturity over 1 year and up to 5 years	4,233	4,418	4,706	5,333	6,239	9,048	10,052
Total	7,997	9,380	9,478	10,933	13,746	20,012	23,912
<i>All Contracts</i>							
Maturity of one year or less	18,185	24,874	24,107	27,886	36,938	46,474	57,157
Maturity over 1 year and up to 5 years	21,405	23,179	25,923	30,566	40,137	58,914	66,093
Maturity over 5 years	10,420	12,038	14,638	19,115	24,583	36,603	41,376
Total of all contracts	50,015	60,091	64,668	77,568	101,658	141,991	164,626

Source: From the web site of Bank for International Settlements, <http://www.bis.org/statistics/derstats.htm>.

A typical example of a market participant interested in managing interest rate risk is a commercial bank whose assets mostly consist of fixed and floating rate loans (some with embedded options), while its liabilities consist of deposits in checking, savings, money market accounts, and some debt securities. Naturally, for most large banks, the average maturity of the assets is longer than the average maturity of the liabilities, as banks typically lend in the intermediate to long maturity sector and borrow in the short maturity sector. Average maturity, more popularly known as the *duration* of a security, is the most commonly used risk measure for measuring the interest rate risk exposure of the security. Duration has been shown to explain perhaps 70 percent of the returns of default-free securities; however, since bank assets are also exposed to credit risk, bank asset duration explains a lower percentage of the asset returns. Generally, other risk measures, such as default-prone bond duration, slope duration, and others, are needed to explain the asset returns not explained by traditional duration.

Due to a positive gap between the asset duration and the liability duration, bank equity duration is generally positive. Since banks are highly leveraged financial institutions, the bank equity duration tends to be a lot higher than its asset duration. The high-equity duration resulting from an asset-liability duration mismatch has been of major concern not only for the shareholders of the banking firms, but also for the regulating institutions assigned with the responsibility of avoiding major banking crises. An illustrative example of a crisis unleashed by the asset-liability duration mismatch is the savings and loans (S&Ls) bank crisis that unfolded in the late 1970s and 1980s in the United States. The factors causing that crisis are many, including an artificial ceiling on the interest rates that the S&Ls could pay to their depositors, causing an exodus of the bank customers to other more lucrative investments; a sharp increase in interest rates triggered by the high inflation of the early 1980s; controversial responses by the Federal Reserve Bank, which increased the cost of capital for S&Ls (when they offered new products to circumvent the interest rate ceiling); and a reluctance by regulatory authorities to take timely steps to keep this crisis from snowballing. These factors ultimately resulted in a huge mismatch between the cost of funds and the earnings generated from the assets. Many S&Ls made negative net income margins, leading to a general deterioration of capital solvency ratios, and even resulting in negative book values of equity in some instances.

The ultimate bailout efforts of the government cost U.S. taxpayers around \$180 billion. Yet, that loss was only 3.2 percent of the U.S. gross domestic product (GDP). Banking crises in other developing countries have caused even higher economic losses. For example, the restructuring costs of the 1980s bank crises in Argentina and Chile were 55.3 percent and 40 percent of their respective GDPs (Caprio and Klingebiel, 1996). The huge costs

to many Asian economies, including the Hong Kong economy, during the Asian currency crises of 1997 to 1998 are well known. These events highlight the importance of risk management for the banking industry, especially in the developing world.

The surge in oil prices to almost \$50 a barrel in year 2005, the continued rise in commodity prices, pick-up of inflation in China and other parts of Asia, and the strengthening economies of the United States and Europe have made financial institutions concerned about the effects of higher interest rates on their profitability measures and capital solvency ratios. Increases in interest rates can significantly erase the equity values of highly leveraged institutions such as commercial banks, government agencies such as Fannie Mae and Freddie Mac, fixed-income hedge funds, and other investment companies. Many financial institutions also hold some percentage of their assets in mortgage loans, which are likely to experience a lengthening of average maturity or *duration* as interest rates rise. Given that much of the world has recently witnessed record low interest rates, and many nations are still at record high valuations for real estate, significant risks exist for losses in this market. A potentially sharp increase in interest rates may also lead to additional costs tied to provisions for losses in other sectors, as the creditworthiness of corporate customers may deteriorate due to higher borrowing costs. On the positive side, to the extent that many banks now have a bigger percentage of earnings tied to non-interest income, they will be somewhat immune to the increases in the interest rates.

Near term increases in the interest rates are likely to be nonparallel, rising more at the shorter end, as the currently steep shape of the U.S. Treasury yield curve flattens out. It is well known that the traditional duration and convexity risk measures are valid only when the whole yield curve moves in a parallel fashion. If short rates increase more than the long rates, then the slope of the yield curve will experience a negative shift, while the curvature will most likely experience a positive shift (from a high negative curvature to a low negative curvature) as shown in Figure 1.1. Though this is the more likely scenario, other scenarios may lead to other types of shifts in the yield curve.

How do the managers of financial institutions, such as banks, insurance companies, and index bond funds hedge against the effects of non-parallel yield curve shifts? How do hedge funds managers design speculative strategies based upon yield curve movements? This book addresses these issues by giving a detailed introduction to the widely used models in the area of interest rate risk management over the past two decades.¹ We discuss five types of interest rate risk models in the fixed-income literature. These models are given as the duration and convexity models (Chapter 2), M-Absolute/M-Square models (Chapter 4), duration

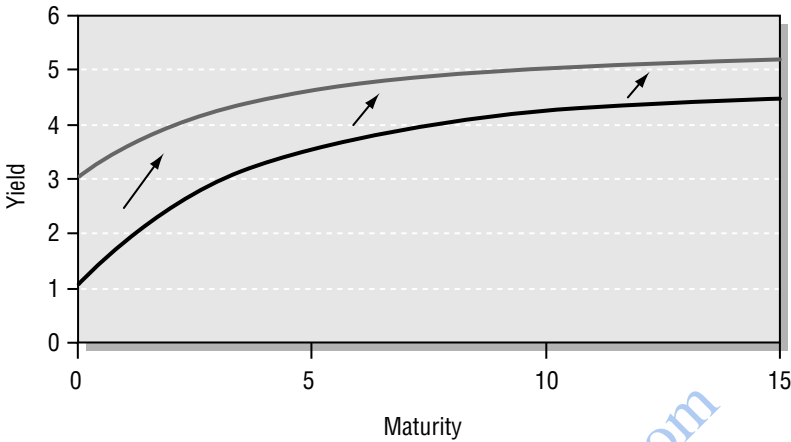


FIGURE 1.1 Nonparallel Yield-Curve Shift

vector models (Chapter 5), key rate duration models (Chapter 9), and principal component duration models (Chapter 10). We consider applications of these models to regular bonds (Chapters 2, 4, 5, 9, and 10); T-Bill futures, T-Note futures, T-Bond futures, and Eurodollar futures (Chapter 6); call and put options on bonds, and interest rate options, such as caps, floors, and collars (Chapters 7 and 8); forward rate agreements, interest rate swaps, and swaptions (Chapter 8); mortgage-backed securities (Chapter 10); and default-prone corporate bonds and stocks (Chapter 11). Virtually all chapters of the book have Excel/VBA spreadsheets that allow the reader to work with these models. In the remaining part of this chapter, we briefly summarize the five types of models covered in this book and discuss how financial institutions can use these models.

DURATION AND CONVEXITY MODELS

Consider a bond with cash flows C_t , payable at time t . The bond sells for a price P , and is priced using a term structure of continuously compounded zero-coupon yields given by $y(t)$. The traditional duration model can be used to approximate percentage change in the bond price as follows:

$$\frac{\Delta P}{P} \cong -D\Delta y \quad (1.1)$$

where

$$D = \text{Duration} = \sum_{t=t_1}^{t=t_N} t w_t$$

and

$$w_t = \left[\frac{C_t}{e^{y(t) \times t}} \right] / P$$

Duration is given as the weighted-average time to maturity of the cash flows, where the weights are defined as the present values of the cash flows divided by the bond price. The duration model given in equation 1.1 assumes that the yield curve experiences infinitesimal and parallel shifts. Hence, the change in the yield Δy , is assumed to be *equal* for all bonds regardless of their coupons and maturities. However, we know that shorter maturity rates are more volatile than the longer maturity rates, so the assumption of parallel yield curve shifts is obviously false.

Convexity is given as the weighted average of maturity-squares of a bond, where weights are the present values of the bond's cash flows, given as proportions of the bond's price. Convexity can be mathematically expressed as follows:

$$\text{CON} = \sum_{t=t_1}^{t=t_N} t^2 w_t \quad (1.2)$$

For large changes in the interest rates, the definitions of duration and convexity in equations 1.1 and 1.2, respectively, are used to derive a two-term Taylor series expansion for approximating the percentage change in the bond price as follows:

$$\frac{\Delta P}{P} \cong -D\Delta y + \frac{1}{2} \text{CON}(\Delta y)^2 \quad (1.3)$$

Equation 1.3 suggests that for bonds with identical durations, higher convexity is always preferable. This is because if CON is positive, then regardless of whether Δy is positive or negative $(\Delta y)^2$ is always positive, making a higher-convexity bond preferable to a lower-convexity bond.

However, the above result is based on the assumption of a large and parallel shift in the yield curve. Not only are large and parallel shifts in the yield

curve inconsistent with arbitrage-free term structure dynamics, such shifts occur rarely in the bond markets. Even under slight violations of the assumption of parallel yield curve shifts, higher convexity may not be desirable.

M-ABSOLUTE AND M-SQUARE MODELS

An alternative view of convexity, which is based on a more realistic economic framework, relates convexity to *slope shifts* in the term structure of interest rates. This view of convexity was proposed by Fong and Vasicek (1983, 1984) and Fong and Fabozzi (1985) through the introduction of the new risk measure, M-square, which is a linear transformation of convexity. The M-square of a bond portfolio is given as the weighted average of the squares of the distance between cash flow maturities and the planning horizon of the portfolio:

$$M^2 = \sum_{t=t_1}^{t=t_N} (t - H)^2 \times w_t \quad (1.4)$$

where the weights are defined in equation 1.1, and H is the planning horizon. A bond portfolio selected with minimum M-square has cash flows clustered around the planning horizon date and, hence, protects the portfolio from immunization risk resulting from nonparallel yield curve shifts. Though both convexity and M-square measures give similar information about the riskiness of a bond or a bond portfolio (since one is a linear function of the other), the developments of these two risk measures follow different paths. Convexity emphasizes the *gain* in the return on a portfolio, against large and parallel shifts in the term structure of interest rates. M-square emphasizes the *risk exposure* of a portfolio due to slope shifts in the term structure of interest rates. Hence, the convexity view and the M-square view have exactly opposite implications for bond risk analysis and portfolio management. Lacey and Nawalkha (1993) find that high convexity (which is the same as high M-square) adds risk but not return to a bond portfolio using U.S. Treasury bond price data over the period 1976 to 1987.

Unlike the M-square model, that requires two risk measures for hedging (i.e., both duration and M-square), Nawalkha and Chambers (1996) derive the M-absolute model, which only requires one risk measure for hedging against the nonparallel yield curve shifts. The M-absolute of a bond portfolio is given as the weighted average of the absolute distances between cash flow maturities and the planning horizon of the portfolio.

$$M^A = \sum_{t=t_1}^{t=t_N} |t - H| \times w_t \quad (1.5)$$

where the weights are defined in equation 1.1, and H is the planning horizon.

Though the M-absolute model immunizes only partially against the height shifts, it reduces the immunization risk caused by the shifts in the slope, curvature, and all other term structure shape parameters by selecting a minimum M-absolute bond portfolio with cash flows clustered around its planning horizon date. The relative desirability of the duration model or the M-absolute model depends on the nature of term structure shifts expected. If height shifts completely dominate the slope, curvature, and other higher order term structure shifts, then the duration model will outperform the M-absolute model. If, however, slope, curvature, and other higher order shifts are relatively significant—in comparison with the height shifts—then the M-absolute model may outperform the traditional duration model. Using McCulloch and Kwon's (1993) term structure data over the observation period 1951 through 1986, Nawalkha and Chambers (1996) find the M-absolute model reduces the immunization risk inherent in the duration model by more than half.

DURATION VECTOR MODELS

Though both M-absolute and M-square risk measures provide significant enhancement in the immunization performance over the traditional duration model, perfect immunization is not possible using either of the two measures except for the trivial case in which the portfolio consists of a zero-coupon bond maturing at the horizon date. Further gains in immunization performance have been made possible by the duration vector model, which uses a vector of higher order duration measures to immunize against changes in the shape parameters (i.e., height, slope, curvature) of the yield curve. The immunization constraints of the duration vector model are given by:

$$D(m) = \sum_{t=t_1}^{t=t_N} t^m \times w_t = H^m, \text{ for } m = 1, 2, 3, \dots, Q \quad (1.6)$$

where the weights are defined in equation 1.1, and H is the planning horizon. About three to five duration vector constraints (i.e., $Q = 3$ to 5) have

shown to almost perfectly immunize against the risk of nonparallel yield curve shifts.

Since the shifts in the height, slope, curvature, and other parameters of the term structure of interest rate shifts are generally larger at the shorter end of the maturity spectrum, it is possible that an alternative set of duration measures that are linear in $g(t)$, $g(t)^2$, $g(t)^3$, and so on, and which put relatively more weight at the shorter end of the maturity spectrum due to the specific choice of the function $g(t)$, may provide enhanced immunization performance. Consistent with this intuition, Nawalkha, Soto, and Zhang (2003) and Nawalkha, Chambers, Soto, and Zhang (2004) derive a class of *generalized duration vector models* using a Taylor series expansion of the bond return function with respect to specific functions of the cash flow maturities. These papers find that $g(t) = t^{0.25}$ or $g(t) = t^{0.5}$ perform significantly better than the traditional duration vector for short planning horizons when three to five risk measures are used. Though the duration vector and the generalized duration vector models, significantly outperform the M-absolute and M-square models, the improvement in performance comes at the cost of higher portfolio rebalancing costs required by these models.

KEY RATE DURATION MODELS

The key rate duration model of Ho (1992) describes the shifts in the term structure as a discrete vector representing the changes in the *key* spot rates of various maturities. Interest rate changes at other maturities are derived from these values via linear interpolation. Key rate durations are then defined as the sensitivity of the portfolio value to key rates at different points along the term structure. The key rate duration model can be considered an extension of the traditional duration model given in equation 1.1, as follows:

$$\frac{\Delta P}{P} = -\sum_{i=1}^m KRD(i) \times \Delta y(t_i) \quad (1.7)$$

where the yield curve is divided into m different key rates.

Similar to the duration vector models, an appealing feature of the key rate model is that it does not require a *stationary* covariance structure of interest rate changes (unless performing a VaR analysis). Hence, it doesn't matter whether the correlations between the changes in interest rates of different maturities increase or decrease or even whether these changes are positively or negatively correlated. Also, the model allows for any number

of key rates, and, therefore, interest rate risk can be modeled and hedged to a high degree of accuracy.

However, unlike the duration vector models, which require at most three to five duration measures, the number of duration measures to be used and the corresponding division of the term structure into different key rates, remain quite arbitrary under the key rate model. For example, Ho (1992) proposes as many as 11 key rate durations to effectively hedge against interest rate risk. Hedging against a large number of key rate durations implies larger long and short positions in the portfolio, which can make this approach somewhat expensive in terms of the transaction costs associated with portfolio construction and rebalancing.

PRINCIPAL COMPONENT DURATION MODELS

The principal component model assumes that the yield curve movements can be summarized by a few composite variables. These new variables are constructed by applying a statistical technique called *principal component analysis* (PCA) to the past interest rate changes. The use of PCA in the Treasury bond markets has revealed that three principal components (related to the height, the slope, and the curvature of the yield curve) are sufficient in explaining almost all of the variation in interest rate changes. An illustration of the impact of these components on the yield curve is shown in Figure 1.2.

The first principal component c_h , basically represents a parallel change in the yield curve, which is why it is usually named the level or the height factor. The second principal component c_s , represents a change in the steepness or the slope, and is named the slope factor. This factor is also called the “twist factor” as it makes the short-term rates and long-term rates move in opposite directions. The third principal component c_c , is called the curvature factor, as it basically affects the curvature of the yield curve by inducing a butterfly shift. This shift consists of short rates and long rates moving in the same direction and medium-term rates moving in the opposite direction.

The yield changes can be given as weighted linear sums of the principal components as follows:

$$\Delta y(t_i) \approx l_b \Delta c_h + l_{is} \Delta c_s + l_{ic} \Delta c_c \quad i = 1, \dots, m \quad (1.8)$$

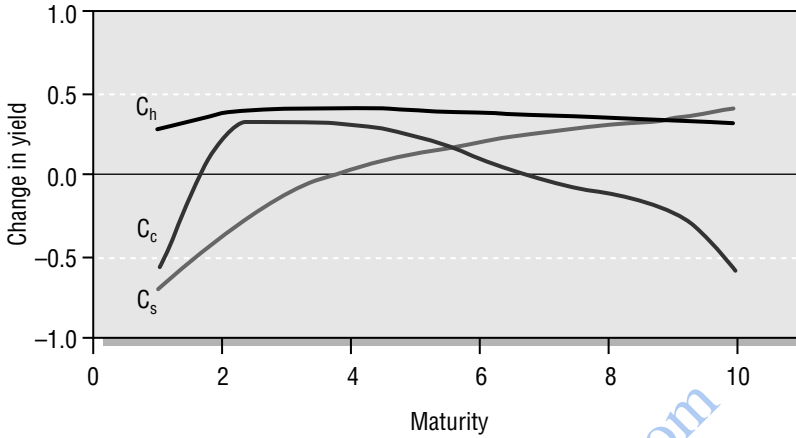


FIGURE 1.2 Shape of the Principal Components

where Δc_b = Change in the first component
 Δc_s = Change in the second component
 Δc_c = Change in the third component

The variables l_{ib} , l_{is} , and l_{ic} are the factor sensitivities (or loadings) of the yield change $\Delta y(t_i)$ on the three principal components respectively. They correspond to the three curves shown in Figure 1.2. The sensitivity of the portfolio value to these three risk factors is measured by principal component durations (PCDs) given as follows:

$$\frac{\Delta P}{P} = - \sum_{i=b,s,c} PCD(i) \times \Delta c_i \quad (1.9)$$

The first three principal component durations given in equation 1.1 explain anywhere from 80 percent to 95 percent of the ex-post return differentials on bonds, depending on the time period chosen.

Since the principal component model explicitly selects the factors based on their contributions to the total variance of interest rate changes, it should lead to some gain in hedging efficiency. Further, in situations where explicit or implicit short positions are not allowed, the duration vector or the key rate duration model cannot give a zero immunization risk solution,

except for some trivial cases. With short positions disallowed, significant immunization risk is bound to remain in the portfolio, and this risk can be minimized with the knowledge of the factor structure of interest rate changes using a principal component model.

However, the principal component model has a major shortcoming: It assumes that the covariance structure of interest rate changes is stationary. In situations where this assumption is violated, the use of the model might result in poor hedging performance.

APPLICATIONS TO FINANCIAL INSTITUTIONS

The five types of models discussed can be applied in a variety of contexts by financial institutions, from designing and executing simple duration-based hedging strategies to the most sophisticated dynamic immunization programs based on multiple risk measures, with off balance sheet positions in swaps, interest rate options, and interest rate futures. A few examples of these applications are discussed next.

Consider an insurance company that sells guaranteed investment products (GICs) to institutional investors and/or individuals. To guarantee a high yield over a prespecified horizon, the insurance company may use high-quality AAA-rated corporate bonds to design a dynamic immunization strategy, instead of simply investing in a riskless zero-coupon bond (e.g., Treasury STRIPs). The extra yield on high-quality bonds will compensate for the additional risk introduced by the AAA spread changes over the Treasury yield curve changes. Since the largest portion of the yield changes for high-quality corporate bonds are due to changes in the Treasury yield curve, a one- to three-factor duration vector model (see equation 1.6), or one to five risk measure based key rate duration model (see Figure 1.2) can be used. Though using more risk measures will lead to better immunization performance, doing so will require higher transaction costs and may even require explicit or implicit short positions.² Hence, the number of risk measures should be carefully selected after running many yield curve scenarios with transactions cost analysis.

As a second example, consider a commercial bank interested in protecting the value of shareholder equity from interest rate risk. The equity duration can be computed using the asset duration and the liability duration. An appropriate model that can be used to protect a bank's equity is the M-square model with a prespecified target equity duration. This model does not require that the M-square of the assets be set equal to the M-square of the liabilities, but that the difference between the M-squares of the assets

and the liabilities be minimized. Since by the nature of their business (lend in long maturity sector, borrow in short maturity sector), banks cannot fully adjust the maturity structure of their assets and liabilities, the M-square model is more suited for a bank, instead of the duration vector model or the key rate duration model.

Next, consider a bond fund that attempts to replicate or beat the return on an index such as the Lehman U.S. government bond index. A principal component (PC) model can be used to get the empirical PC durations of the Lehman bond index by first obtaining the PCs using the historical data on changes in the Treasury rates of different maturities, and then running regressions of the returns on the Lehman index on the three important PCs. These regressions give three empirical PC durations, related to the so-called height, slope, and curvature factors (see equation 1.7). The bond fund can then select from a pool of bonds with an objective function that maximizes the yield, while constraining the empirical PC durations of the fund to equal those of the Lehman index. Since both the PCs and empirical PC durations change with time, the bond fund managers can use the most recent data (i.e., past six months) to design these strategies, which can be updated periodically, every two weeks, or every month.

Finally, consider a bond hedge fund manager who wishes to *speculate* on the changes in the shape of the yield curve. The type of yield curve shift depicted in Figure 1.1 is quite likely given the current economic scenario and the U.S. central bank policy. The figure shows a positive height shift, a negative slope shift, and a positive curvature shift, as the steep yield curve moves up, and flattens out. In order to benefit from this type of expected yield curve shift, the hedge fund manager can create a portfolio with cash bonds and Treasury futures, with a negative $D(1)$, a positive $D(2)$, and a negative $D(3)$. The exact magnitudes of $D(1)$, $D(2)$, and $D(3)$ (see equation 1.4) will depend on the confidence the hedge fund manager places in the particular types of shifts, and risk/return trade-off that she desires. For example, if she feels strongly that the slope shift will be negative, but unsure about the curvature shift, then she will take more exposure to slope shifts by increasing the $D(2)$ of the portfolio, but have the $D(3)$ of the portfolio close to zero.

The examples above demonstrate how managers of different financial institutions with varying objectives can use various multifactor models for hedging or speculating against the risk of nonparallel yield curve shifts. Of course, transactions costs and other market frictions require that managers simulate the performance of the trading strategies under realistic market conditions before putting these models to use.

INTERACTION WITH OTHER RISKS

The analysis until now has focused on interest rate risk measures for default-free securities. However, a typical bank balance sheet also includes corporate and individual loans that are exposed to credit risk, call risk, foreign exchange risk, liquidity risk, and other risks. The interaction between interest rate risk and the other risks is of crucial importance in implementing an overall risk protection strategy. Major banks in the United States, including Bank of America, are developing systems to measure different risks in an integrated manner. Since the focus of this book is on interest rate risk, we now consider how some of these other risks interact with interest rate risk. This not only provides insights into the overall effects of interest rate changes on bank assets and liabilities, but also allows for integrating interest rate risk with other types of risks in designing a total risk management system.

The interaction between credit risk and interest rate risk is of crucial importance as most bank loans are subject to the risk of credit downgrade or default. Many studies document the inverse relationship between credit spread changes and interest rate changes. In a rising interest rate environment, credit spreads tend to narrow, and vice-versa, which in general implies that corporate loans are *less* sensitive to interest rate changes (or have lower durations and convexities) than the equivalent default-free bonds. However, this is not always true. Nayalkha (1996) outlines specific conditions under which the credits spreads could either narrow or widen as interest rates increase, implying that the durations of corporate bonds could be either lower or higher than those of default-free counterparts. He finds that relatively short (long) maturity loans issued to corporations with high (low) interest rate sensitive assets, have longer (shorter) durations than those of equivalent default-free bonds.

The interaction between the call risk (due to the prepayment option) and interest rate risk may prove to be the most challenging aspect of risk management for some banks in the current environment in which most homeowners have already refinanced at record low interest rates. The mortgage prepayment options would lose much of their value if interest rates were to rise by a few percent in the next couple of years. This could significantly lengthen the duration of mortgage loans and mortgage-backed securities. Interest rates have been trending downward for most of the past quarter century, and a potential switch in the interest rate regime is likely, given the recent surge in oil prices, the continued rise in commodity prices, and the rising world GDP. The interaction of the lengthening of the mortgage durations with interest rate increases could expose the banks with significant holdings in mortgage assets to a high level of interest rate risk. This risk could get compounded further, if increases in interest rate also deflate

the sky-high valuations of real estate in many parts of the world, reducing loan to value ratios, and increasing provisions for loan losses related to the mortgage assets.

The effects of foreign exchange risk can be devastating as many banks and regulators learned during the Asian currency crisis of 1997 to 1998. Like stock market bubbles and crashes, currencies also go through periodic upswings and downswings, which can wreck havoc on the balance sheets of financial institutions exposed to explicit or implicit currency-related risks. Further, economies such as Hong Kong, which have a fixed exchange rate system, must rely on a domestic exchange fund to support the currency peg. The artificially imposed currency peg creates a strong link between currency and interest rate risk. For example, during the Asian currency crisis, the speculative attack on the Hong Kong dollar led to an increase in the overnight rate all the way up to 280 percent on October 23, 1997. Although this quickly subsided, medium term rates remained higher than usual for many weeks, creating a panic in the stock market and wiping out much value from the banking and real estate stocks. The spread between London Interbank Offer Rate (LIBOR) and the Hong Kong Interbank Offer Rate (HIBOR) also increased significantly during this period, making it more costly to borrow dollars from the local banks. In general, currency crises have more severe effects on banks with more extreme duration gaps resulting from severe maturity mismatches between the assets and the liabilities, making the values of assets and liabilities deviate more sharply.

A good risk management system must consider the interactions of all risks in a unified framework. Duration and other interest rate risk measures are sensitive to credit risk, call risk, and foreign exchange risk, among other risks. Only by considering the combined effects of these risks on the interest rate risk profile of a bank can senior bankers get a perspective on the true risk exposure of a bank to interest rate changes.

NOTES

1. See Nawalkha (1999) for a review of this literature.
2. For example, the purchase of put options on Treasury bond futures creates implicit short positions.