



Managing Interest Rate Risk: Duration GAP and Market Value of Equity

A fundamental criticism of GAP and earnings-sensitivity analysis is that they emphasize a bank's risk profile over the short run and largely ignore cash flows beyond one or two years. Yet, a bank's assets and liabilities may be substantially mismatched beyond two years and thus exhibit considerable risk, which goes undetected. Duration gap and market value of equity sensitivity analysis represent alternative methods of analyzing interest rate risk. They emphasize the price sensitivity of assets and liabilities to changes in interest rates and the corresponding impact on stockholders' equity. As the labels suggest, they incorporate estimates of the duration of assets and duration of liabilities, which reflect the value of promised cash flows through final maturity. As such, they provide a comprehensive measure of the interest rate risk embodied in the entire balance sheet of a bank. In most cases, the implications concerning when banks win and lose are comparable to those of GAP and earnings-sensitivity analysis, but the magnitude of the estimated effects may differ sharply.

At year-end 2004, PNC conducted a simulation analysis that produced the following summary of outcomes regarding the bank's interest rate risk:

Effect on value of on- and off-balance sheet positions as a percentage of economic value of equity from instantaneous change in interest rates of:

200 basis point increase	-7.00%
200 basis point decrease	-0.20%

The model used to generate these results differs from earnings sensitivity, but has similar implications. What do the figures mean? Does a rate increase help or hurt PNC? What about a rate decrease? How much does PNC have at risk? After reading the material in this chapter, you will be able to assess PNC's aggregate interest rate risk according to these figures and explain why it is useful to assess interest rate risk under both earnings-sensitivity and economic value of equity-sensitivity analysis.

This chapter examines the management of a bank's interest rate risk position in terms of duration gap and the sensitivity of the market value of stockholders' equity to changes in interest rates. In this framework, interest rate risk refers to the volatility in the market value of stockholders' equity attributable to changes in the level of interest rates and associated changes in balance sheet and off-balance sheet mix and volume. A bank that assumes substantial risk will see its value of equity rise or fall sharply when interest rates change unexpectedly.

Duration gap analysis represents an application of duration concepts to a bank's entire balance sheet. As such, the model builds on the discussion of Macaulay's duration applied to single securities that was introduced in Chapter 4. It parallels static GAP and earnings-sensitivity analysis in the sense that both duration gap and the potential variation in market value of stockholders' equity are viewed as measures of risk, with more sophisticated

users focusing on the latter. Some banks set targets for allowable risk in terms of how much equity values are allowed to change for specific 2 or 3 percent rate shocks. The analysis is dynamic in the sense that it incorporates the impact of potential rate increases and decreases and it recognizes that customers' exercise of embedded options will affect a bank's true risk exposure depending on how interest rates change. As such, the analytical procedure is similar to that for earnings-sensitivity analysis. This analysis appears under such labels as market value of equity (MVE), economic value of equity (EVE) and net portfolio value (NPV) analysis.

MEASURING INTEREST RATE RISK WITH DURATION GAP

Economic value of equity analysis differs from earnings-sensitivity analysis in its focus on stockholders' equity rather than net interest income and its emphasis on all cash flows, not just those arising one or two years after the analysis. It takes a longer-term perspective of risk. The analysis is based on the use of duration estimates of each class of assets and liabilities. Changes in the market value of equity reflect differences in the durations of assets and liabilities and thus differences in the market value sensitivity of assets and liabilities.

As Chapter 4 demonstrates, duration is most easily understood as an elasticity measure. As such, it provides information regarding how much a security's price will change when market interest rates change. Recall that the longer is duration, the greater is price sensitivity. Thus, the price of a 5-year duration bond will change more than the price of a 1-year duration bond for a similar change in interest rates. **Duration gap analysis** compares the price sensitivity of a bank's total assets with the price sensitivity of its total liabilities to assess whether the market value of assets or liabilities changes more when rates change. Any differential impact will indicate how the bank's market value of equity will change. Before introducing the model, we provide a brief review of duration concepts.

DURATION, MODIFIED DURATION, AND EFFECTIVE DURATION

Market participants often use three different duration measures—Macaulay's duration, modified duration, and effective duration—as if they were the same. In fact, while the interpretations are similar, they differ in terms of how they are calculated and how they should be used.¹

Macaulay's duration (D) is computed as a weighted average of the time until cash flows are received. The weights equal the present value of each cash flow as a fraction of the security's current price, and time refers to the length of time in the future until payment or receipt. It is measured and quoted in units of time. Conceptually, duration measures the average life of an instrument. In the context of immunization, an investor knows that by matching duration with the preferred holding period, interest rate risk can be minimized because price risk is balanced with reinvestment risk. For example, a bond with four years until final maturity with a duration of 3.5 years indicates that an investor with a 3.5-year holding period could lock in a rate of return by buying a 3.5-year duration instrument. If interest rates increase, the decrease in market value of the bond will be just offset by higher reinvestment income from the periodic coupon interest payments, so that the promised return is realized after 3.5 years. If interest rates decrease, the price appreciation will offset the lost reinvestment income. Thus, value and total return are fixed.²

Following is Macaulay's duration (D) formula for a security with n cash flows discounted at the market interest rate i , with an initial price P^* , and t equal to the time until the cash payment is made.

$$D = \frac{\sum_t \frac{[\text{cash flow}_t / (1 + i)^t] \times t}{P^*}}{\sum_t \frac{[\text{cash flow}_t / (1 + i)^t]}{P^*}} \quad (6.1)$$

We use this measure of price sensitivity in the approximate price elasticity relationship:

$$\frac{\Delta P}{P} \cong - \frac{D}{(1 + i)} \times \Delta i \quad (6.2)$$

with

$$\text{modified duration} = D / (1 + i) \quad (6.3)$$

Modified duration equals Macaulay's duration divided by $(1 + i)$. It has the useful feature of indicating how much the price of a security will change in percentage terms for a given change in interest rates. A 5-year zero coupon bond will have a Macaulay's duration of 10 semiannual periods or five years. Assume that its current

¹There are many other definitions of duration, using different discount rates and cash flow assumptions, that are ignored here. For a useful discussion, see Bierwag (1987), Ho (1992), and Phoa (1997).

²This ignores the fact that duration will change as time passes and immunization would require a rebalancing of the security or portfolio's duration. To be useful, the user must specify *ex ante* (beforehand) what rebalancing is appropriate.

price is \$7,441 and market rate of interest is 6 percent (3 percent semiannual compounding). The bond's modified duration equals 9.71 semiannual periods ($10/1.03$) or 4.85 years. If the market interest rate rises to 7 percent ($\Delta i = 0.01$), the bond's price will fall by 4.85 percent, or by \$361 ($0.01 \times 4.85 \times \$7,441$). Securities can be easily ranked by modified duration to determine which ones are most price volatile.

Both of these measures calculate duration assuming that all promised cash flows will be realized. While this is true for option-free securities, it does not hold for securities with options. When a loan is prepaid or a bond is called, the exercise of the underlying option changes the instrument's duration. For example, a 3-year bond may be callable in one year. If market rates fall and the bond is called, its duration changes compared to when rates are higher and the bond is not called. The concept of **effective duration** is used to estimate how price sensitive a security is when the security contains embedded options. It compares a security's estimated price in a falling rate environment with an estimated price in a rising rate environment relative to the initial price times the assumed rate differential. Formally, effective duration (Eff Dur) equals:

$$\text{Eff Dur} = \frac{P_{i-} - P_{i+}}{P_0(i+ - i-)} \quad (6.4)$$

where

- P_{i-} = price if rates fall,
- P_{i+} = price if rates rise,
- P_0 = initial (current) price,
- $i+$ = initial market rate plus the increase in rate, and
- $i-$ = initial market rate minus the decrease in rate.

Consider a 3-year, 9.4 percent coupon bond selling for \$10,000 par to yield 9.4 percent to maturity. This bond is callable at par and will presumably be called if rates fall 50 basis points or more. The Macaulay's duration for the option-free version of this bond with semiannual coupons and compounding was calculated in Chapter 4 to be 5.36 semiannual periods, or 2.68 years at the market rate of 4.7 percent semiannually. The modified duration was 5.12 semiannual periods or 2.56 years. If this bond is callable at par, its price will never increase much more than \$10,000. When the call option is in the money—that is, when market rates fall by 0.5 percent (25 basis points semiannually) or more and the bond will likely be called—the bond's price will equal its call price of \$10,000. If rates rise, the bond will not be called and its price will fall as it would without any embedded option. As noted in Chapter 4, a 30 basis point increase in rate to 5 percent semiannually will lower the price to \$9,847.72. Thus, the callable bond's effective duration for a 30 basis point (0.3 percent) semiannual movement in rates either up or down is 2.54.

$$\text{Eff Dur} = \frac{\$10,000 - \$9,847.72}{\$10,000(0.05 - 0.044)} = 2.54$$

As expected, the chance that the bond will be called shortens duration from what it would be if all cash flows materialized as originally scheduled.

The use of effective duration allows the cash flows of the underlying instrument to change when interest rates change. An analyst must have rate forecasts and a model to explain the pricing of the security in different interest rate environments to calculate effective duration. It is just an approximation, but is useful because it recognizes that an embedded option may be exercised and thus dramatically alter the expected cash flows and value of a security. Effective duration also demonstrates how some securities can exhibit negative duration. Negative duration actually refers to an effective duration calculation that is negative. For this to happen, the price of a security in a declining rate environment must fall below the price in a rising rate environment, such that the numerator of Equation 6.4 is negative. This can occur when some types of mortgage-backed securities prepay so rapidly that the promised cash flow stream collapses.³

DURATION GAP MODEL. Duration gap (DGAP) models focus on managing net interest income or the market value of stockholders' equity, recognizing the timing of all cash flows for every security on a bank's balance sheet.⁴ The following analysis emphasizes duration's use as an elasticity measure. Unlike static GAP analysis, which

³The standard example is a high coupon, interest-only (IO) mortgage-backed security that currently prepays at a high speed. The holder of this IO receives only the interest payments on the principal outstanding for a pool of mortgages. If rates fall, the pool prepays even faster so that expected interest payments fall—perhaps to zero. With fewer payments made, the price drops. If rates increase, the pool prepays slower so that expected interest payments increase and will appear over a longer period of time. Thus, the IO's price might increase. This security will have a negative effective duration.

⁴The following discussion focuses on the market value of stockholders' equity as a target variable and follows the discussion in Kaufman (1984). Toews (1983) addresses the use of net interest income as a target measure of performance.

CONTEMPORARY ISSUES

**RATE SENSITIVITY VERSUS PRICE SENSITIVITY**

GAP and duration gap represent two ways of viewing interest rate risk. To best understand the differences, you should understand how rate sensitivity differs from price sensitivity. Rate sensitivity refers to the ability to reprice the principal on an asset or liability. Price sensitivity refers to how much the price of an asset or liability will change when interest rates

change. If an instrument is very rate sensitive, it is typically not very price sensitive, and vice versa.

GAP and earnings-sensitivity analysis focus on how frequently the principal amount of an asset or liability will reprice. For example, if a bank's federal funds sold mature daily, this asset is extremely rate sensitive because the bank can reinvest the principal amount at the prevailing rate every 24 hours. The same federal funds sold loan is not price sensitive. Because the rate changes daily when the principal matures, the loan will be priced at par or face value daily. The changing interest will reflect the change in rates. In contrast, a 10-year zero coupon bond is not very rate sensitive because the owner cannot reinvest the principal for 10 years without selling the bond. This same bond is very price sensitive, however, because its value will rise or fall sharply in percentage terms as rates either fall or rise. Thus, rate sensitivity and price sensitivity are two alternate, but consistent, ways of interpreting a security's features.

focuses on rate sensitivity or the frequency of repricing, duration gap analysis focuses on price sensitivity. The Contemporary Issues Box, "Rate Sensitivity versus Price Sensitivity," clarifies the difference. Duration is an attractive measure because it is additive across securities in a portfolio. A bank's interest rate risk is indicated by comparing the weighted average duration of assets with the weighted average duration of liabilities. As with GAP analysis, the sign and magnitude of DGAP provide information about when a bank potentially wins and loses, and the magnitude of the interest rate bet. Management can adjust DGAP to hedge or accept interest rate risk by speculating on future interest rate changes.

Duration gap analysis compares the duration of bank assets with the duration of bank liabilities and examines how the market value of stockholders' equity will change when interest rates change. As with GAP and earnings-sensitivity analysis, the analysis produces different outcomes in different interest rate environments. After introducing the framework of the analysis and defining duration gap, the following discussion extends this to incorporate embedded options and sensitivity analysis for potential variation in the market value of stockholders' equity.

There are four steps in duration gap analysis:

1. Forecast interest rates.
2. Estimate the market value of bank assets, liabilities, and stockholders' equity. The economic (market) value of equity (EVE) equals the amount that makes the market value of assets equal to the market value of liabilities plus EVE.
3. Estimate the weighted average duration of assets and weighted average duration of liabilities. The effects of both on- and off-balance sheet items are incorporated. These estimates are used to calculate duration gap.
4. Management forecasts changes in the market value of stockholders' equity across different interest rate environments.

The weighted average duration of bank assets (DA) is calculated as:

$$DA = \sum_{i=1}^n w_i Da_i \quad (6.5)$$

where

- A_i = market value of asset i (i equals 1, 2, . . . n),
- w_i = A_i divided by the market value of all bank assets (MVA); ($MVA = A_1 + A_2 + \dots + A_n$),
- Da_i = Macaulay's duration of asset i , and
- n = number of different bank assets.

The weighted duration of bank liabilities (DL) is calculated similarly as:

$$DL = \sum_j^m z_j DL_j \quad (6.6)$$

where

L_j = market value of liability j (j equals $1, 2, \dots, m$),
 z_j = L_j divided by the market value of all bank liabilities (MVL); ($MVL = L_1 + L_2 + \dots + L_m$),
 DL_j = Macaulay's duration of liability j , and
 m = number of different bank liabilities.

With the focus on the economic value of stockholders' equity (EVE) and the general level of interest rates (characterized by y):

$$\Delta EVE = \Delta MVA - \Delta MVL \quad (6.7)$$

Using Equation 6.2 we know that $\Delta A_i = -Da_i[\Delta y/(1 + y)]A_i$; and $\Delta L_j = -Dl_j[\Delta y/(1 + y)]$, such that:

$$\Delta EVE = -[DA - (MVL/MVA) DL] [\Delta y/(1 + y)] MVA \quad (6.8)$$

If we define a bank's duration gap (DGAP) as

$$(DGAP) = DA - (MVL/MVA)DL$$

then

$$\Delta EVE = -DGAP[\Delta y/(1 + y)]MVA \quad (6.9)$$

Note that both DA and DL take into account the present value of all promised or expected cash flows. There is no need for time buckets or classifying assets and liabilities. Thus, duration gap indicates the difference between the weighted average duration of assets and the leverage-adjusted weighted average duration of liabilities. Hence it is an approximate estimate of the sensitivity of the EVE to changes in the level of interest rates. The leverage adjustment takes into account the existence of equity as a means of financing assets. The interest factor (y) is typically measured as some weighted average of earning asset yields across all interest-earning assets. According to Equation 6.9, the greater is DGAP, the greater is the potential variation in EVE for a given change in interest rates. As such, DGAP provides information about when a bank wins and loses and the amount of risk assumed. If DGAP is positive, an increase in rates will lower EVE, while a decrease in rates will increase EVE. If DGAP is negative, an increase in rates will increase EVE, while a decrease in rates will lower EVE. The closer DGAP is to zero, the smaller is the potential change in EVE for any change in rates.

A DURATION APPLICATION FOR BANKS

Most bank managers are concerned with the bank's total risk exposure from all assets and liabilities. When it receives cash inflows from assets prior to making its obligated payments on liabilities, it bears the risk that it may have to reinvest the proceeds at reduced rates. When it makes debt payments before it receives cash inflows, it bears the risk that borrowing costs will increase. Any differential in the timing of asset and liability cash flows is reflected in average durations.

Duration gap analysis requires that a bank specify a performance target, such as the market value of equity, and strategically manage the difference between the average duration of total assets and the average duration of total liabilities. Consider the balance sheet of the hypothetical bank in Exhibit 6.1. The bank just opened for business and all dollar amounts are market values. It owns \$1,000 worth of three assets: cash, a 3-year final maturity commercial loan earning 12 percent, and a 6-year Treasury bond earning 8 percent. It pays interest on 1-year time deposits (TDs) at 5 percent and on 3-year CDs at 7 percent. The market value of equity represents the residual (plug figure) between asset and liability values and equals \$80, or 8 percent of assets. The analysis assumes that there will be no defaults, prepayments, or early withdrawals. All securities make equal annual interest payments with annual compounding. Macaulay's duration for each item is listed beside the current market rate. The duration of cash is zero because cash doesn't change in value when interest rates change. Duration measures for the commercial loan, the 3-year CD, and the weighted average total asset and liability durations are computed at the bottom of the exhibit. Initially, the average duration of assets equals 2.88 years and exceeds the 1.61 year average duration of liabilities by over one year. Expected net interest income, assuming no change in interest rates, is \$48 per \$1,000 of assets.⁵

⁵This analysis uses economic income instead of accounting income. Economic interest is calculated as the product of the market value of each asset or liability and its market interest rate. Economic income varies directly with accounting income in these examples, although the relationship is not linear. Note that the use of Macaulay's duration ignores the impact of embedded options.

**EXHIBIT
6.1**

EVE Analysis: Hypothetical Bank Balance Sheet

Assets	Market Value	Rate	Duration	Liabilities and Equity	Market Value	Rate	Duration
Cash	\$ 100			1-yr. Time deposit	\$ 620	5%	1.00 yr.
3-yr. Commercial loan	700	12%	2.69 yrs.	3-yr. Certificate of deposit	300	7%	2.81
6-yr. Treasury bond	200	8	4.99	Total liabilities	920		1.59 yrs.
			2.88 yrs.	Equity (MVE)	\$ 80		
Total	\$1,000				\$1,000		

Weighted avg. duration of assets (DA) = $(\$700/\$1,000)(2.69) + (\$200/\$1,000)(4.99) = 2.88$ yrs.

Weighted avg. duration of liabilities (DL) = $(\$620/\$920)(1) + (\$300/\$920)(2.81) = 1.59$ yrs.

Expected economic net interest income = $0.12(\$700) + 0.08(\$200) - 0.05(\$620) - 0.07(\$300) = \$48.00$

DGAP = $2.88 - (\$920/\$1,000)(1.59) = 1.42$ yrs.

Sample Duration Calculations Using Equation 9.1

$$\text{Commercial loan} = \frac{\frac{84}{(1.12)^1} + \frac{84(2)}{(1.12)^2} + \frac{784(3)}{(1.12)^3}}{\$700} = .107(1) + .096(2) + .797(3) = 2.69 \text{ years}$$

$$\text{Certificate of deposit} = \frac{\frac{21}{(1.07)^1} + \frac{21(2)}{(1.07)^2} + \frac{321(3)}{(1.07)^3}}{\$300} = .065(1) + .061(2) + .874(3) = 2.81 \text{ yrs.}$$

Interest rate risk is evidenced by the mismatch in average durations of assets and liabilities and the DGAP of 1.42 years. When interest rates change, the market values of assets and liabilities will change by different amounts, and future interest income will change relative to future interest expense. The fact that the average duration of assets exceeds the average duration of liabilities (adjusted for leverage) indicates that the market value of assets will change more than the market value of liabilities if all rates change by comparable amounts. For example, suppose that all interest rates increase by 1 percent immediately after the bank contracts for its assets and liabilities. An adjusted balance sheet at market values appears in Exhibit 6.2. It shows that with the increase in rates, the market value of assets declines by \$26, the market value of liabilities decreases by \$14, and the market value of equity falls by \$12 to \$68.

This result reflects the positive duration gap. The new value of each instrument can be obtained using Equation 6.2. The value of assets falls more than the value of liabilities because the weighted duration of assets (2.86 years) exceeds the weighted duration of liabilities (1.58 years) by a substantial amount. The equity-to-asset ratio declines from 8 percent to 7.1 percent. Expected net interest income similarly decreases because the bank will pay higher rates on liabilities relative to the higher yields it receives on reinvested cash inflows over the combined lifetime of the securities. Clearly, this bank's operating position has worsened with the increase in rates.

A decrease in rates produces the opposite result. Because of the duration mismatch, the market value of assets will increase more than the market value of liabilities so that the market value of equity will increase. Net interest income also rises, and the bank is better off. The general relationship between the sign of a bank's duration gap and the impact of changing rates on EVE is summarized below:

DGAP Summary

DGAP	Change in Interest Rates	Change in Economic (Market) Value		
		Assets	Liabilities	Equity
Positive	Increase	Decrease	>	Decrease → Decrease
Positive	Decrease	Increase	>	Increase → Increase
Negative	Increase	Decrease	<	Decrease → Increase
Negative	Decrease	Increase	<	Increase → Decrease
Zero	Increase	Decrease	=	Decrease → None
Zero	Decrease	Increase	=	Increase → None

Bank management can use duration measures to evaluate interest rate risk. It is, however, a static measure. The greater is the absolute value of DGAP, the greater is interest rate risk. A bank that is perfectly hedged will have a DGAP of zero and thus operate with its average asset duration slightly below its average liability duration.

DGAP measures can be used to approximate the expected change in market value of equity for a given change in interest rates. In particular, Equation 6.9 can be used to estimate the change in market value of equity.

**EXHIBIT
6.2**

EVE Analysis: Hypothetical Bank Balance Sheet after an Immediate 1 Percent Increase in All Interest Rates

Assets	Market Value	Rate	Duration	Liabilities and Equity	Market Value	Rate	Duration
Cash	\$100			1-yr. Time deposit	\$614	6%	1.00 yr.
3-yr. Commercial loan	683	13%	2.68 yrs.	3-yr. Certificate of deposit	292	8	2.80
6-yr. Treasury bond	191	9	4.97	Total liabilities	\$906		1.58 yrs.
Total	\$974		2.86 yrs.	Equity (MVE)	\$68		
					\$974		

Duration of assets = $.702(2.68) + .196(4.97) = 2.86$ yrs.

Duration of liabilities = $.68(1) + .32(2.80) = 1.58$ yrs.

Expected economic net interest income = \$45.81

DGAP = $2.86 - (\$906/\$974)(1.58) = 1.36$

Change in market value of: assets = $-\$26$

liabilities = $-\$14$

equity = $-\$12$

Sample Duration Calculations of Market Value Using Equation 9.2

Commercial loan: $\Delta P = (.01/1.12)(-2.69)(\$700) = -\$16.8$

Certificate of deposit: $\Delta P = (.01/1.07)(-2.81)(\$300) = -\$7.9$

Applying this to the hypothetical bank in Exhibit 6.1, the 1 percent increase in interest rates lowered the market value of equity by approximately 1.27 percent of assets, or \$12.70.⁶

$$\Delta \text{EVE} = -\text{DGAP}[\Delta y/(1 + y)]\text{MVA}$$

$$\Delta \text{EVE} = -1.42[.01/1.10]\$1,000$$

$$= -.0127[\$1,000]$$

$$= -\$12.70$$

The actual decrease was \$12. This bank's assets will change in value by approximately 90 percent more than the value of its liabilities for any interest rate change, as measured by the leverage-adjusted relative average durations, and EVE will vary accordingly.

AN IMMUNIZED PORTFOLIO

To insulate, or immunize, the market value of equity from rate changes, the hypothetical bank would need to either shorten its asset duration by 1.42 years, increase its liability duration by 1.54 years ($.92 \times 1.54 = 1.42$), or use some combination of these adjustments. For example, immunization as measured by obtaining a DGAP equal to zero, could be accomplished by reducing time deposits to \$340 and issuing \$280 in new 6-year zero coupon CDs (see Exhibit 6.3). With this profile, DGAP approximately equals zero and any immediate rate change leaves EVE unchanged. This is demonstrated in the bottom part of the exhibit, where all interest rates are assumed to increase by 1 percent. The market value of every price-sensitive account declines. Equity value remains constant at \$80 because the \$26 decrease in market value of assets just equals the \$26 decrease in market value of liabilities. There are, of course, many other alternatives to adjust the size of DGAP to zero, but each would produce the desired hedge.

Banks may choose to target variables other than the market value of equity in managing interest rate risk. Many banks, for example, are interested in stabilizing the book value of net interest income. This can be done for a 1-year time horizon, with the appropriate duration gap measure shown below:⁷

$$\text{DGAP}^* = \text{MVRSA}(1 - \text{DRSA}) - \text{MVRSL}(1 - \text{DRSL}) \quad (6.10)$$

⁶As an approximation, it is acceptable to use the average yield on total assets as the market interest rate, y . In the case of the hypothetical bank of Exhibit 6.1, y equals 10 percent $[(700/1,000) .12 + (200/1,000) .08 = 0.10]$.

⁷Toevs (1983) introduces this formula and discusses its implications in detail. Alternatives include targeting the market value of net interest income by setting the duration of a bank's equity equal to the length of the time horizon that the bank wishes to use in hedging net interest income. Duration of equity (DUR EQ) can be approximated as follows, where MV refers to market value:

$$\text{DUR EQ} = \frac{\text{MV of assets} \times \text{duration of assets} - \text{MV of liabilities} \times \text{duration of liabilities}}{\text{Economic value of equity}}$$

**EXHIBIT
6.3**

Immunized Portfolio

Bank Balance Sheet: DGAP = 0

Assets	Market Value	Rate	Duration	Liabilities and Equity	Market Value	Rate	Duration
Cash	\$ 100			1-yr. Time deposit	\$ 340	5%	1.00 yr.
3-yr. Commercial loan	700	12%	2.69 yrs.	3-yr. certificate of deposit	300	7	2.81
6-yr. Treasury bond	200	8	4.99	6-yr. zero-coupon CD*	280	8	6.00
			2.88 yrs.	Total liabilities	\$ 920		3.11 yrs.
				Equity	\$ 80		
Total	\$1,000				\$1,000		
DGAP = 2.88 - .92(3.11) \cong 0							
1% Increase in All Rates							
Cash	\$ 100			1-yr. Time deposits	\$ 337	6%	1.00 yr.
3-yr. Commercial loan	683	13%	2.68 yrs.	3-yr. certificate of deposit	292	8	2.80
6-yr. Treasury bond	191	9	4.97	6-yr. certificate of deposit	265	9	6.00
			2.86 yrs.	Total liabilities	\$ 894		3.07 yrs.
				Equity	\$ 80		
Total	\$ 974				\$ 974		

*Par (maturity) value = \$444.33

where

MVRSa = cumulative market value of rate-sensitive assets (RSAs),

MVRSL = cumulative market value of rate-sensitive liabilities (RSLs),

DRSA = composite duration of RSAs for the given time horizon; equal to the sum of the products of each asset's duration with the relative share of its total asset market value, and

DRSL = Composite duration of RSLs for the given time horizon; equal to the sum of the products of each liability's duration with the relative share of its total liability market value.

If DGAP* is positive, the bank's net interest income will decrease when interest rates decrease, and increase when rates increase. If DGAP* is negative, the relationship is reversed. Only when DGAP* equals zero is interest rate risk eliminated. The important point is that banks can use duration analysis to stabilize a number of different variables reflecting bank performance.

ECONOMIC VALUE OF EQUITY—SENSITIVITY ANALYSIS

Many bank managers use an EVE-sensitivity analysis framework like that for earnings sensitivity to better assess interest rate risk. The framework extends the static duration gap analysis by making it dynamic. This can be accomplished by model simulation. As with earnings-sensitivity analysis, the procedure consists of conducting "what if" analysis of all the factors that affect EVE across a wide range of interest rate environments. The analysis repeats static DGAP analysis under different assumed interest rates. It is often labeled net portfolio value (NPV) or market value of equity (MVE) analysis.

The basic output of this analysis is a comparison of changes in EVE across different interest rate environments. It signals how volatile MVE might be compared with some base case or most likely rate scenario. Again, the typical comparison looks at seven rate environments beginning with the base case, and other scenarios that alternatively consider rates 1 percent, 2 percent, and 3 percent higher and lower, respectively. An important component of this sensitivity analysis is the projection of when embedded customer options will be exercised and what their values will be. Management also varies assumptions about rate spreads and shifts or twists in the yield curve. The same embedded options that affect earnings sensitivity, such as loan prepayments, callable and puttable bonds, and early deposit withdrawals, sharply influence the estimated volatility in EVE. The greater is the potential volatility in EVE, the greater is risk.

Generally,

1. Prepayments that exceed (fall short of) that expected will shorten (lengthen) duration.
2. A bond being called will shorten duration.
3. A deposit that is withdrawn early will shorten duration. A deposit that is not withdrawn as expected will lengthen duration.

Unanticipated changes in interest rates typically cause durations to vary over time. The effective duration calculation supposedly accounts for some of this variation, and should be used in MVE analysis. Alternatively, an analyst may use an estimated price consistent with call price, expected prepayment impact, and so on, for each asset or liability with an embedded option.

EVE-SENSITIVITY ANALYSIS: AN EXAMPLE

Consider First Savings Bank (FSB) with the rate sensitivity report introduced in Exhibit 5.6 of Chapter 5. This bank had a portfolio of relatively long-term, fixed-rate mortgages and other loans financed largely by liabilities that were more rate sensitive. Charts A and B of Exhibit 5.7 summarize the most likely rate environment and six alternative rate environments. Exhibit 6.4 provides a summary of the same balance sheet data in

EXHIBIT 6.4

First Savings Bank's Economic Value of Stockholders' Equity

Market Value/Duration Report as of 12/31/2001 Most Likely Rate Scenario—Base Strategy

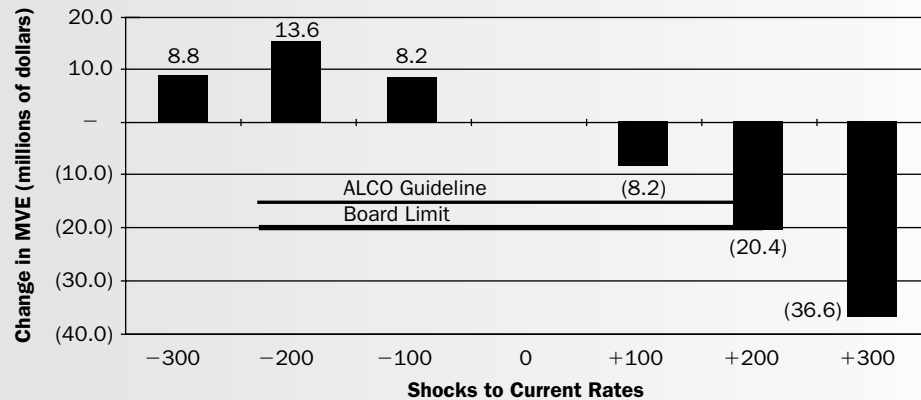
	Book Value	Market Value	Book Yield	Duration*	
Loans					
Prime Based Ln	100,000	102,000	9.00%	—	
Equity Credit Lines	25,000	25,500	8.75%	—	
Fixed Rate > 1 yr.	170,000	170,850	7.50%	1.1	
Var Rate Mtg 1 Yr.	55,000	54,725	6.90%	0.5	
30-Year Mortgage	250,000	245,000	7.60%	6.0	
Consumer Ln	100,000	100,500	8.00%	1.9	
Credit Card	25,000	25,000	14.00%	1.0	
Total Loans	725,000	723,575	8.03%	2.6	
Loan Loss Reserve	(15,000)	(11,250)	0.00%	8.0	
Net Loans	710,000	712,325	8.03%	2.5	
Investments					
Eurodollars	80,000	80,000	5.50%	0.1	
CMO Fix Rate	35,000	34,825	6.25%	2.0	
US Treasury	75,000	74,813	5.80%	1.8	
Total Investments	190,000	189,638	5.76%	1.1	
Fed Funds Sold	25,000	25,000	5.25%	—	
Cash & Due From	15,000	15,000	0.00%	6.5	
Non-Int Rel Assets	60,000	60,000	0.00%	8.0	
Total Assets	1,000,000	1,001,963	6.93%	2.6	
Deposits					
MMDA	240,000	232,800	2.25%	—	
Retail CDs	400,000	400,000	5.40%	1.1	
Savings	35,000	33,600	4.00%	1.9	
NOW	40,000	38,800	2.00%	1.9	
DDA Personal	55,000	52,250		8.0	
Comm'l DDA	60,000	58,200		4.8	
Total Deposits	830,000	815,650		1.6	
TT&L	25,000	25,000	5.00%	—	
L-T Notes Fixed	50,000	50,250	8.00%	5.9	
Fed Funds Purch	—	—	5.25%	—	
NIR Liabilities	30,000	28,500		8.0	
Total Liabilities	935,000	919,400		2.0	
Equity	65,000	82,563		9.9	
Total Liab & Equity	1,000,000	1,001,963		2.6	
Off-Balance Sheet					
Int Rate Swaps	—	1,250	6.00%	2.8	Notional 50,000
Adjusted Equity	65,000	83,813		7.9	

NOTE: Values are in thousands of dollars.

*Duration is reported in years.

**EXHIBIT
6.5**

Sensitivity of Economic Value of Equity (EVE) versus Most Likely (Zero Shock) Interest Rate Scenario



NOTE: *Sensitivity of Market Value of Equity* measures the change in the economic value of the corporation's equity under various changes in interest rates. Rate changes are instantaneous changes from current rates. The change in market value of equity is derived from the difference between changes in the market value of assets and changes in the market value of liabilities.

both book value and market value terms. The final two columns of data list the book yield and estimated duration under the most likely rate scenario. Under the most likely scenario, the market value of assets exceeds the book value by \$1,963,000 and the market value of equity equals \$82,563,000 or \$17,563,000 more than book value. Note that the average duration of assets equals 2.6 years while the average duration of liabilities equals 2 years. For this discussion, ignore how the duration estimates for demand deposit accounts (DDAs) are obtained.⁸

Using these duration estimates and the market values listed, FSB's duration gap is 0.765 years [$2.6 - (919,400/1,001,963) 2.0$]. In light of the previous DGAP discussion and assuming no change in duration when rates change, a 1 percent increase in rates would be expected to reduce FSB's market value of equity by approximately \$7.2 million ($0.765)(0.01/1.0693) (1,001,963,000)$).

This estimate ignores the impact of interest rates on embedded options and the effective duration of assets and liabilities. It also ignores the impact of swaps that are noted at the bottom of the exhibit.⁹ EVE sensitivity analysis incorporates these influences. Exhibit 6.5 presents a summary of the changes in eVE for six interest rate environments compared with the most likely (zero shock) rate scenario. Three of the scenarios are for higher rates (+100, +200, and +300 basis points) and three are for lower rates (-100, -200, and -300 basis points). The vertical axis lists the estimated change in EVE from the most likely case for each scenario. In contrast with earnings-sensitivity analysis, which projected earnings one year forward and two years forward, there is only one comparative exhibit because duration analysis incorporates the present value of all cash flows.

Note that higher rates are associated with a decline in EVE while lower rates are associated with an increase in EVE. This is consistent with FSB having a positive duration gap in all rate environments. It is also expected given FSB's huge portfolio of long-term, fixed-rate mortgages. If rates rise unexpectedly, market values will drop substantially. If rates fall sharply, prepayments will temper the potential gains in market value because borrowers will refinance such that the bank will replace high-rate loans with lower-rate ones. Thus, the benefit of selling the prepayment option to borrowers effectively places a cap on potential portfolio gains. According to Exhibit 6.5, FSB's EVE will change by \$8.2 million either up or down if rates are 1 percent lower or higher than the base case. By definition, duration measures the percentage change in market value for a given change in interest rates, hence a bank's *duration of equity* measures the *percent* change in EVE that will occur with a 1 percent change in rates. Thus, FSB's duration of equity is 9.9 ($\$8,200/\$82,563$).

⁸Remember that demand deposits do not pay interest. A crucial part of duration analysis involves determining the effective duration of these liabilities, which typically make up a substantial portion of most banks' liabilities.

⁹The nature and influence of interest rate swaps are described in Chapter 7.

CONTEMPORARY ISSUES



INTEREST RATE RISK AT FREDDIE MAC AND FANNIE MAE

The Federal Home Loan Mortgage Corporation (Freddie Mac) and the Federal National Mortgage Association (FNMA, or Fannie Mae) have long been the dominant government sponsored enterprises (GSEs). These entities were formed to assist the housing market and for years generated large profits and grew at very high rates. During the early 2000s, several economists and members of the U.S. Congress argued that their growth was excessive and not supported by

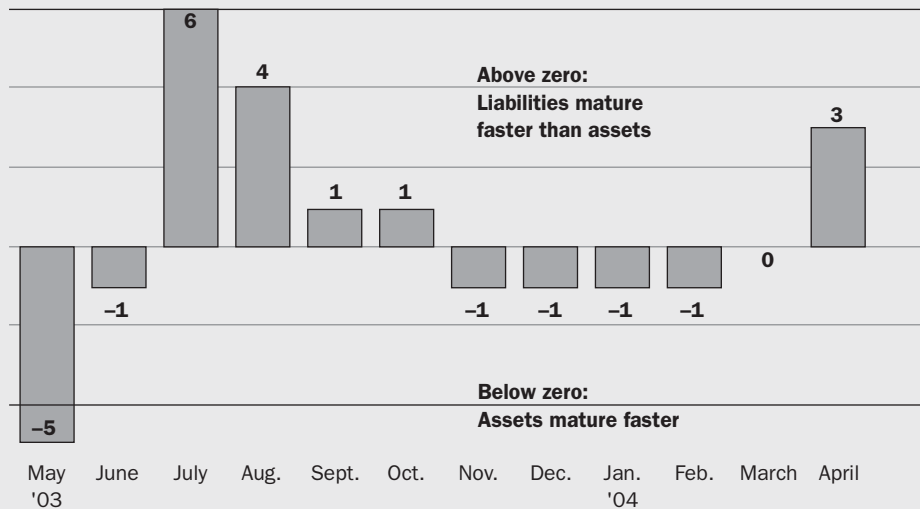
adequate capital. While both Fannie and Freddie claimed to hedge interest rate risk, they provided little evidence to support the claims.

Both Fannie and Freddie report duration gap information to analysts. Fannie Mae reported the data in the following chart in April 2004. At that time, the duration gap was equal to a positive 3 months. Over the previous year, it had ranged from -5 months to +6 months—all of which suggested that there was little interest rate risk in its operations given its asset size of almost \$900 billion.

Unfortunately, both Freddie and Fannie may have been consistently minimizing reported interest rate risk. In 2003, Freddie's management admitted that the bank had understated profits by more than \$1 billion. In 2004, Fannie's auditors claimed that Fannie's management had used unacceptable hedge accounting to smooth earnings over the prior years. In one instance, management had presumably deferred expenses so that senior management could be paid incentive bonuses in a year when the bonus payments totaled more than \$70 million for the top 21 managers.

Spring Swing

Fannie Mae's duration gap, in months



EVE-sensitivity analysis clearly provides a different type of information to FSB's management. In contrast to the earnings-sensitivity results, the bank is exposed to substantive losses in market value of equity if rates increase sharply above that expected. This is further evidenced by the fact that FSB will see its EVE decline more than the asset and liability management committee (ALCO) guideline if rates increase 2 percent or more from the base case. The EVE decline will exceed the limit set by the bank's board of directors in a +3 percent rate environment. FSB's management must address these violations of policy.

EARNINGS-SENSITIVITY ANALYSIS VERSUS EVE-SENSITIVITY ANALYSIS: WHICH MODEL IS BETTER?

Bankers use both static GAP and duration gap models as well as earnings-sensitivity and eVE-sensitivity analysis when assessing interest rate risk. Each has slightly different objectives and implications. GAP and earnings-sensitivity analysis focus on the potential volatility of net interest income over distinct time intervals. Net interest income is calculated in book value terms, not market values. A bank manages the effects of volatile interest rates within each time period separately. In contrast, the duration and EVE-sensitivity approach focuses on the potential variability of a bank's market value of equity. Duration gap is a single measure that summarizes the cumulative impact of interest rate changes on a bank's total portfolio. Thus, the bank continuously manages total firm rate risk according to this one number. Because the models have different objectives, they address different issues.

STRENGTHS AND WEAKNESSES: DGAP AND MVE-SENSITIVITY ANALYSIS

The principal attraction of duration analysis is that it provides a comprehensive measure of interest rate risk for the total portfolio. The smaller the absolute value of DGAP, the less sensitive the market value of equity is to interest rate changes. Unlike GAP, DGAP recognizes the time value of each cash flow, avoiding the difficulty with time buckets. Cash flows that arise after one year are included in duration calculations, but often ignored in GAP calculations. Duration measures are also additive so the bank can match total assets with total liabilities rather than match individual accounts. Finally, duration analysis takes a longer-term viewpoint and provides managers with greater flexibility in adjusting rate sensitivity because they can use a wide range of instruments to balance value sensitivity.

Duration and EVE sensitivity analysis have weaknesses as well. First, it is difficult to compute duration accurately. Duration measurement requires numerous subjective assumptions. Data needs are complex, requiring information on each account's interest rate, repricing schedule, possibility of principal prepayment, call and put options, early withdrawal potential, and default probability. A bank must routinely assess the probability that contracted cash flows will be received on a timely basis, forecast the timing of base rate changes and the level of rates at the time of future cash flows, and constantly monitor whether actual cash flows conform to expectations. To be meaningful, DGAP and sensitivity analysis further require accurate forecasts of when embedded options will be exercised and what their value is. Of course, this is the same information necessary to conduct earnings-sensitivity analysis.

Second, to be correct duration analysis requires that each future cash flow be discounted by a distinct discount rate reflecting the expected future rate at the time the cash flow arises. Most analysts use forward rates from the Treasury spot yield curve for this purpose. To eliminate coupon bias, they first estimate a zero coupon-equivalent yield curve, then compute forward rates. It is well known, however, that these forward rates do not accurately predict future interest rates. The complexity of calculating duration then, increases further when nonparallel shifts in the yield curve are considered.

Third, a bank must continuously monitor and adjust the duration of its portfolio. As Macaulay's duration measure indicates, duration changes with changes in interest rates. Thus, a bank should recalculate duration and EVE sensitivity and potentially restructure its balance sheet whenever rates change substantially, which could be daily or weekly. As discussed in Chapter 4, the duration calculation is only accurate for small changes in interest rates. Furthermore, even when rates are constant, duration changes with the passage of time as the time factor decreases over time. The duration of assets and liabilities may "drift" at different rates and require constant rebalancing. These problems are compounded by difficulties in estimating price effects and effective durations when there are embedded options.

Finally, it is difficult to estimate the duration on assets and liabilities that do not earn or pay interest. To get an accurate assessment of cash flows and market value changes, a bank must estimate the true rate sensitivity of demand deposits and estimate their duration. There is little agreement as to how this should be done. As noted in Exhibit 6.4, the management of FSB estimated the duration of personal DDAs at 8 years and the duration of

commercial DDAs at 4.8 years. The difference presumably reflects the greater propensity of businesses to move DDAs in rising rate environments. Still, what are the estimated cash flows when DDAs have no stated fixed maturity or periodic cash payments? Many models attempt to estimate a core amount of DDAs that remain on deposit and classify these funds as having a long duration. Other, noncore DDAs are more volatile and have a shorter duration. The key point is that these are imprecise estimates. Given the size of most banks' DDA balances, any misestimate, in turn, can produce wide swings in a bank's DGAP value and wide variations in EVE sensitivity.

In summary, duration measures are highly subjective. Active management requires constant tinkering with the bank portfolio to adjust the duration gap. For many firms with simple balance sheets without significant amounts of customer options that are commonly exercised, the costs may exceed the benefits.

A CRITIQUE OF STRATEGIES TO MANAGE EARNINGS AND MARKET VALUE OF EQUITY SENSITIVITY

The business of banking involves taking risks. Most bankers feel comfortable making loans to individuals and businesses because they spend a considerable amount of time nurturing customer relationships and measuring and monitoring credit risk. In general, bankers are less comfortable taking interest rate risk. This may reflect a lack of familiarity with the relationship between risk and return or a belief that the returns have not historically warranted the risks taken. Because most banks depend on net interest margin to generate earnings growth, it is imperative that managers develop strategies to maintain or grow their net interest income over time and to maintain and grow the market value of stockholders' equity. The following discussion emphasizes the type of risks assumed in managing GAP, DGAP, and the sensitivity of net interest income and EVE to changes in interest rates. The important implication can be summarized as "know your bets."

GAP AND DGAP MANAGEMENT STRATEGIES: WHAT ARE YOUR BETS?

Chapter 5 introduced a variety of objectives and strategic approaches to manage a bank's GAP and earnings sensitivity. The discussion was incomplete because it did not address how to implement the approaches to changing asset and liability sensitivity and did not identify their risk and return trade-offs. Generally, it is widely accepted that banks do and should assume some interest rate risk. The issue is to determine how much risk is acceptable and how to best achieve the desired risk profile.

Unfortunately, it is difficult to actively vary GAP or DGAP and consistently win. First, interest rate forecasts are frequently wrong. To change an asset or liability's rate or price sensitivity accurately and increase earnings and EVE, management must predict future interest rates better than consensus market forecasts embedded in current rates and act accordingly. Second, even when rate changes are predicted correctly, banks have limited flexibility in varying GAP and DGAP and must often sacrifice yield to do so. Loan customers and depositors select terms from a range of alternatives provided by the bank such that banks have only partial control over pricing and maturities. To entice a customer to select the bank's preferred alternative, management must often offer favorable yields or prices as an inducement. This has a cost because profits are below what they otherwise would be without the inducement.

These difficulties can be demonstrated by an example. Suppose a bank is liability sensitive and operates with a negative GAP through one year and a positive DGAP. Management believes that interest rates will rise and decides to hedge by taking steps that move the GAP closer to zero through one year. At this time, the yield curve is upsloping because the consensus forecast is that interest rates will increase over time. Active GAP management strategies typically focus on increasing RSAs and lowering RSLs. If a stable EVE were desired, DGAP strategies would emphasize shortening average asset durations and lengthening average liability durations.

Consider the effect of the following strategies: the bank (1) shortens the maturities of its bond portfolio, and (2) reprices its CDs to attract long-term deposits relative to short-term deposits. With an upsloping yield curve, long-term interest rates exceed short-term interest rates. The bank will accept a lower yield initially when it buys short-term securities, and can only attract long-term deposits by paying a premium rate over short-term deposit rates. The first strategy lowers interest income near-term while the second increases interest expense. Both tend to reduce a bank's initial net interest margin, which is a cost of hedging. More importantly, management should know the explicit bets that it has made regarding future interest rates by implementing these strategies. Specifically, the bank gains in terms of an increase in net interest income and EVE only when interest rates move and remain above current forward rates. The investment in short-term rather than long-term securities is advantageous only if interest rates rise above forward rates; that is, only if rates increase above the "break-even" yield contained in the yield curve. Long-term deposits are better than short-term deposits only in

the same instance when market rates ultimately rise above forward rates. The bank loses if rates remain below forward rates because it would earn less interest income on the short-term securities versus long-term securities and could have borrowed at lower cost by issuing a series of short-term deposits rather than a long-term deposit. By adjusting GAP or DGAP, management is speculating that its interest rate forecast is better than the consensus.

AN EXAMPLE

Consider the case where a liability-sensitive bank loses when rates rise and management decides to reduce risk by marketing 2-year time deposits paying 6 percent to retail customers rather than 1-year time deposits paying 5.5 percent. As described in Chapter 4, these two spot rates embody a 1-year forward rate, one year from the present. The following time line and analysis indicate that this forward rate equals 6.5 percent ignoring compounding and assuming annual interest payments. This represents the deposit holder's break-even rate when comparing the two alternatives.

Cash flows from investing \$1,000 either in a 2-year security yielding 6 percent or two consecutive 1-year securities, with the current 1-year yield equal to 5.5 percent.

	0		1		2
2-year security					
	————— \$60 ————— ————— \$60 ————— \$120 at 6 percent per year				
1-year security; then another 1-year security					
	————— \$55 ————— ————— ? ————— \$120				

Of course, it is not known today what a 1-year security will yield in one year. For the two consecutive 1-year securities to generate the same \$120 in interest, ignoring compounding, the 1-year security must yield 6.5 percent one year from the present. This break-even rate is a 1-year forward rate, one year from the present

$$6\% + 6\% = 5.5\% + ?$$

where the forward rate (?) equals 6.5 percent

The depositor is effectively speculating on future interest rates unless he or she has another position that this transaction offsets. Ignoring that, a depositor who acquires a 1-year time deposit today rather than the 2-year deposit is positioned to benefit relatively if a 1-year rate exceeds 6.5 percent one year from today. The depositor will lose (give up potential income) if the 1-year rate is anything less than 6.5 percent. In contrast, a depositor who buys the 2-year time deposit will benefit (lose) if the 1-year rate, one year from the present, is anything below (above) 6.5 percent. By choosing one or the other, the depositor has "placed a bet" that the actual rate in one year will differ from the forward rate of 6.5 percent.

Importantly, a bank that markets the 2-year deposit has placed a similar bet. Specifically, the bank will benefit (as a borrower) by lowering its borrowing cost only if the 1-year rate exceeds 6.5 percent in one year. If this occurs, the bank will have locked in a customer with a below-market rate (6 percent versus an average of more than 6 percent). Of course, the depositor will lose, which may create a different set of problems. The implication is that even though management tries to reduce risk by reducing the bank's liability sensitivity, it could see its interest expense rise and NIM fall because of the bet against the forward rate.

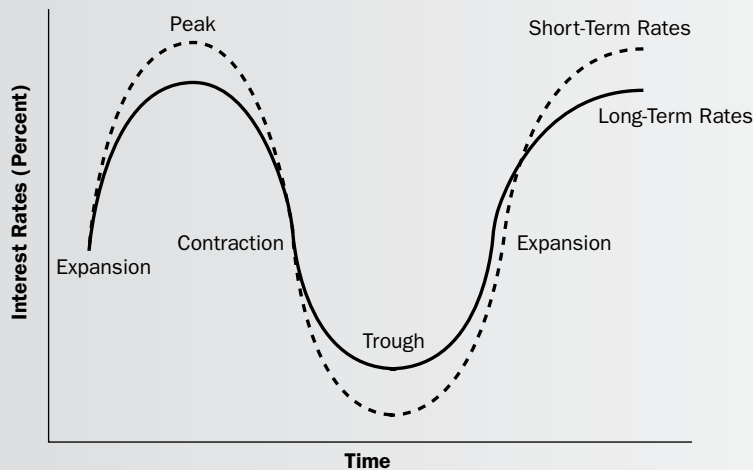
The second cost follows in similar fashion. Suppose, for example, that a retail bank desires to increase RSAs because it expects interest rates to increase. While the bank plans to make only variable-rate or floating-rate loans, its customers seek fixed-rate loans because they also expect rates to rise. The bank must offer a substantial inducement, such as a significantly lower interest rate, to increase asset sensitivity and position itself for earnings growth in a rising rate environment. This would lower the interest spread and offset part of the benefit from increasing the GAP. If the bank refused to make fixed-rate loans, it would not be competitive and might lose considerable goodwill. When adjusting asset and liability maturities and durations and making pricing decisions, a bank may have to make yield concessions or assume additional interest rate risk. Active strategies to adjust earnings or EVE in light of rate forecasts may be highly speculative.

YIELD CURVE STRATEGIES

Many portfolio managers are aware of general macroeconomic and business cycle impacts on the U.S. Treasury yield curve and try to take advantage of long-term trends in rates. Exhibit 6.6 characterizes movements in the level of rates over time and shifts in the shape of the yield curve. Typically, analysts view business cycle effects in terms

**EXHIBIT
6.6**

Interest Rates over the Business Cycle with Constant Inflation Expectations



The inverted yield curve has predicted the last five recessions

DATE WHEN 1-YEAR RATE FIRST EXCEEDS 10-YEAR RATE	LENGTH OF TIME UNTIL START OF NEXT RECESSION
Apr. '68	20 months (Dec. '69)
Mar. '73	8 months (Nov. '73)
Sept. '78	16 months (Jan. '80)
Sept. '80	10 months (July '81)
Feb. '89	17 months (July '90)
Dec. '00	15 months (March '01)

Expansion: Increasing consumer spending, inventory accumulation, rising loan demand, Federal Reserve begins to slow money growth.

Peak: Monetary restraint, high loan demand, little liquidity.

Contraction: Falling consumer spending, inventory contraction, falling loan demand, Federal Reserve accelerates money growth.

Trough: Monetary ease, limited loan demand, excess liquidity.

source: Federal Reserve.

of how the 10-year (long-term) Treasury yield varies relative to the 1-year (short-term) Treasury yield.¹⁰ Starting at the left of the diagram, the yield curve is inverted (1-year rate above the 10-year rate) during the latter stages of an expansionary period and during the peak. Both of these are characterized by strong consumer spending, strong and growing loan demand, and limited liquidity at banks because the Federal Reserve has slowed money growth out of fear that inflation expectations will get out of control. The peak is followed by a contractionary period as consumer and business spending decline along with loan demand. At some point, the Federal Reserve gets concerned that growth has slowed too much and starts to increase money growth. At the trough or recession, the Fed is providing ample liquidity to banks, but loan demand is low due to high unemployment and slow spending. Eventually, low interest rates stimulate retail spending and business investment and the economy starts to grow again.

Many analysts believe that this pattern repeats itself over time. If so, it has interesting implications for interest rate risk management. For example, when the U.S. economy hits its peak the yield curve inverts. After the yield curve inversion, the economy falls into recession. Note the data at the bottom-right corner of the exhibit. This documents the last five times that the 1-year Treasury rate has exceeded the 10-year Treasury rate and the length of time until the U.S. economy was in recession. In every instance a recession followed the yield curve inversion. Since World War II, only twice has the yield curve inverted and a recession not followed. This occurred in 1965 during the Vietnam War and in 1999 when the U.S. Treasury instituted a program to buy back outstanding long-term Treasury bonds. The average lag since 1968 is just over 14 months. The implication is that when the yield curve inverts, a recession will follow in a fairly short period of time.

Portfolio managers who want to take advantage of this trend will do the following when the yield curve inverts:

1. Buy long-term noncallable securities.
2. Make fixed-rate noncallable loans.
3. Price deposits on a floating-rate basis.
4. Follow strategies to become more liability sensitive and/or lengthen the duration of assets versus the duration of liabilities.

¹⁰In February 2001 the Treasury stopped issuing 1-year T-bills, so the comparison will involve a different short-term rate, perhaps the 6-month T-bill rate.

Note that during the deepest part of the recession, the yield curve is typically at its steepest. Portfolio managers often attempt to do the opposite of that above to best position the bank. Of course, this analysis is very simplistic. Interest rates do not follow the straightforward pattern of Exhibit 6.6. Interest rates alternatively rise and fall even within general rate moves upward and downward. Managers, in turn, have internal pressures to meet loan demand at the peak, after which asset quality will deteriorate, and find higher yields at the trough, which can largely be attained by taking added credit risk or interest rate risk (buying long-term, fixed-rate assets). Still, managers should be aware of these general trends and the impact on forward rates.

S U M M A R Y

A bank's ALCO is responsible for monitoring the bank's risk and return profile. Traditional asset and liability management focuses on measuring interest rate risk and monitoring performance, setting policies to stabilize or increase net interest income. This chapter introduces an alternative duration gap model and market value of equity–sensitivity analysis to analyze interest rate risk. Duration gap analysis considers a bank's entire balance sheet and calculates measures of the weighted average durations of all assets and all liabilities. The difference in these weighted durations adjusted for financial leverage is labeled duration gap, which provides a measure of how the market value of stockholders' equity will change when interest rates change. With duration gap analysis the target measure of performance is typically the market value of bank equity. Risk is measured by the sign and size of duration gap and the potential variation in market value of equity. A bank's ALCO again conducts sensitivity analysis across different assumed interest rate environments to assess this potential variation in market value of stockholders' equity. Greater risk is evidenced by greater potential variation.

Duration measures have their limitations, including the fact that the effective price sensitivity and duration of individual assets and liabilities change with changes in interest rates. It is also difficult to accurately forecast rate changes and the price impact on customer options embedded in bank assets and liabilities. Still, duration-based-sensitivity analysis represents a useful alternative to GAP and earnings-sensitivity analysis because it focuses on the present value of all cash flows over the entire range of maturities.

The chapter also examines the specific assumptions managers make when they try to actively manage a bank's interest rate risk exposure. By pursuing strategies to change asset or liability rate sensitivities or durations in line with rate forecasts, managers are explicitly speculating that forward rates implied by current interest rates will not be realized in the future. Whether the bank gains or loses is determined by whether actual rates vary favorably relative to forward rates.

QUESTIONS

- List the basic steps in duration gap analysis. What is the importance of different interest rate forecasts?
- Which has a longer Macaulay's duration: a zero coupon bond with a 2-year maturity, or a 2-year maturity coupon bond that pays 6 percent coupon interest if they both carry a 6 percent market yield? Explain your reasoning.
- You own a corporate bond that carries a 5.8 percent coupon rate and pays \$10,000 at maturity in exactly two years. The current market yield on the bond is 6.1 percent. Coupon interest is paid semiannually and the market price is \$9,944.32.
 - Calculate the bond's Macaulay's duration and modified duration.
 - If the market rate falls by 1 percent, what is the estimated impact on the bond's price?
- Assume that you own a \$1 million par value corporate bond that pays 7 percent in coupon interest (3.5 percent semiannually), has four years remaining to maturity, and is immediately callable at par. Its current market yield is 7 percent and it is priced at par. If rates on comparable securities fall by more than 40 basis points (0.2 percent semiannually), the bond will be called.
 - Calculate the bond's price if the market rate increases by 50 basis points (0.25 percent semiannually) using the present value formula from Chapter 4.
 - Calculate the bond's effective duration assuming a 50 basis point increase or decrease in market rates.
- A 5-year zero coupon bond and 15-year zero coupon bond both carry a price of \$7,500 and a market rate of 8 percent. Assuming that the market rates on both bonds fall to 7 percent, calculate the percentage change in each bond's price using equation 6.2.

6. Use duration gap analysis to determine if there is interest rate risk in the following transaction: A bank obtains \$25,000 in funds from a customer who makes a deposit with a 5-year maturity that pays 5 percent annual interest compounded daily. All interest and principal are paid at the end of five years. Simultaneously, the bank makes a \$25,000 loan to an individual to buy a car. The loan is at a fixed rate of 12 percent annual interest but is fully amortized with 60 monthly payments, such that the borrower pays the same dollar amount (principal plus interest) each month.
7. Compare the strengths and weaknesses of GAP and earnings-sensitivity analysis with DGAP and EVE-sensitivity analysis.
8. Is the following statement generally true or false? Provide your reasoning.
“A bank with a negative GAP through three years will have a positive duration gap.”
9. Conduct duration gap analysis using the following information:

Assets	Amount	Rate	Macaulay's Duration
Cash	\$ 23,000	0%	0
Bonds	\$102,000	7.2%	1.8 years
Commercial loans	\$375,000	11.0%	1.5 years
Liabilities & Equity			
Small time deposits	\$130,000	3.6%	4.0 years
Large CDs	\$ 70,000	6.3%	1.0 year
Transactions accounts	\$250,000	2.8%	3.3 years
Equity	\$ 50,000		

- a. Calculate the bank's duration gap if the ALCO targets the market value of stock holders' equity. Is this bank positioned to gain or lose if interest rates rise?
 - b. Estimate the change in market value of equity if all market interest rates fall by an average of 1.5 percent. Compare the results by applying Equation 6.2 to each balance sheet item and adding versus using Equation 6.9.
 - c. Provide a specific transaction that the bank could implement to immunize its interest rate risk. The transaction may be a new asset funded by a new liability or an asset sale and the simultaneous purchase of another asset.
10. Suppose that your bank currently operates with a duration gap of 2.2 years. Which of the following will serve to reduce the bank's interest rate risk?
 - a. Issue a 1-year zero coupon CD to a customer and use the proceeds to buy a 3-year zero coupon Treasury bond.
 - b. Sell \$5 million in 1-year bullet (single payment) loans and buy 3-month Treasury bills.
 - c. Obtain 2-year funding from the Federal Home Loan Bank and lend the proceeds overnight in the federal funds market.
 11. ALCO members are considering the following EVE-sensitivity estimates. The figures refer to the percentage change in market value of equity compared with the base rate forecast scenario. What does the information say about the bank's overall interest rate risk?

	Rate Change from Base Case					
	-3	-2%	-1%	+1%	+2%	+3%
% change in EVE	+38%	+47%	+19%	-5%	-14%	-18%

Problem

12. Discuss what impact each of the following will have, in general, on MVE sensitivity to a change in interest rates. Consider two cases where rates rise sharply and fall sharply.
- Bank owns a high percentage of assets in bonds that are callable anytime after three months.
 - Bank pays below market rates on time deposits and market interest rates move sharply higher.
 - A large percentage of the bank's assets are in 30-year fixed-rate mortgages.

PROBLEM

Review the most recent annual reports of the largest banks throughout the world. Collect information on their summary analysis of interest rate risk. Interpret whatever data are provided for earnings-at-risk and market value of equity at risk. Note that in some instances EVE sensitivity is labeled as value-at-risk for the bank's equity.