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CHAPTER

5

Managing Interest Rate Risk: GAP and Earnings Sensitivity

Sensitivity to market risk (S) is one of the basic components of a bank's CAMELS rating. For most banks, interest rate risk is the primary contributor to market risk because they don't have trading accounts. Given the recent volatility of interest rates and related potential swings in profitability, banks and regulators have paid increased attention to measuring and monitoring how rate changes affect performance. Senior managers and analysts continuously monitor what interest rate "bet" the bank is making.

Interest rate risk arises largely from traditional banking activities associated with accepting deposits and making loans. When liabilities and assets do not reprice coincidentally, the interest yield and market value of the loans can vary over time much differently than the interest cost and market value of liabilities. The result is a change in net interest income and value of stockholders' equity. When the repricing is dramatically different, the swings in earnings can potentially produce a net loss to the bank.

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 net interest income in the first year of:	
100 basis point increase in rates	−0.50%
100 basis point decrease in rates	−0.90%
Effect on net interest income in the second year of:	
100 basis point increase in rates	1.10%
100 basis point decrease in rates	−7.60%

What does this mean? Does a rate increase help or hurt the bank? 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.

This chapter examines the management of a bank's interest rate risk position in terms of GAP and earnings-sensitivity analysis. In this context, interest rate risk refers to the volatility in net interest income and, ultimately, net income attributable to changes in the level of interest rates and shifts in the composition and volume of bank assets and liabilities. A bank that takes substantial risk will see its net interest margin vary widely from that expected when rates increase or decrease. A bank that assumes little interest rate risk will observe little change in its performance due to rate changes. Chapter 6 extends the analysis by relating interest rate risk to the volatility in a bank's market value of stockholders' equity and risk measures associated with the difference in average durations of a bank's assets and liabilities.

The analysis initially introduces traditional measures of interest rate risk associated with static GAP models. These models focus on GAP as a static measure of risk and net interest income as the target measure of bank performance. Sensitivity analysis extends GAP analysis to focus on the variation in bank earnings across different

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interest rate environments. This net interest income simulation, or "What if?" forecasting, provides information regarding how much net interest income changes when rates are alternatively assumed to rise and fall by various amounts. It takes into account shifts in asset and liability composition and embedded options in a bank's assets and liabilities and off-balance sheet activities. It provides a better understanding of potential changes in earnings than simple static models. As such, it is labeled **earnings-sensitivity analysis.** Throughout, we provide numerous examples that clarify how changes in interest rates and other factors affect potential earnings.

Prior to the deregulation of interest rates in the mid-1980s, banks and savings and loans were effectively guaranteed a positive spread between what they earned in interest on loans and securities and what they paid in interest on liabilities. Virtually all institutions charged the maximum rates allowed on assets and paid the maximum rates allowed on liabilities. They were not allowed by regulation to compete on the basis of interest rates. Thus, charging 6 percent on loans and paying 2 percent on deposits ensured a 4 percent spread if loans didn't default. Since interest rate deregulation, banks are no longer guaranteed a profitable spread between asset yields and funding costs. Interest rate fluctuations alter bank earnings and the value of stockholders' claims unless management implements strategies to reduce their impact. Interest rate risk management is extremely important because no one can consistently forecast interest rates accurately. A bank's asset and liability management committee (ALCO), or alternatively its risk management committee, is responsible for measuring and monitoring interest rate risk. It also recommends pricing, investment, funding, and marketing strategies to achieve the desired trade-off between risk and expected return.

Bank managers generally have greater expertise in managing credit risk than interest rate risk, especially at smaller institutions. This reflects the perception that earnings problems and possible bank failure are more closely tied to bad loans than mismatched pricing of assets and liabilities. They often rely on brokers to recommend specific investment securities for purchase and sale and outsource interest rate risk analytics to consulting companies. During the late 1990s through 2004, many banks invested heavily in callable federal agency securities and mortgage-backed securities with little or no default risk, but with extensive call and prepayment risk. With the decline in interest rates, they saw their interest income drop as borrowers refinanced high-rate mortgages so that mortgage-backed securities were paid off early and issuers called high-rate agency bonds and refinanced them at lower rates.

The fundamental issue is whether bank managers understand the magnitude of interest rate risk that they assume and whether earnings will fall sharply when interest rates change adversely. The basic questions are: "Do banks understand the nature of their interest rate bet?" and "Do banks understand how big the bet is?"

Banks use two basic models to assess interest rate risk. The first, GAP and earnings-sensitivity analysis, emphasizes income statement effects by focusing on how changes in interest rates and the bank's balance sheet affect net interest income and net income. The second, duration gap and economic value of equity analysis, emphasizes the market value of stockholders' equity by focusing on how these same types of changes affect the market value of assets versus the market value of liabilities. This chapter examines the first model.

MEASURING INTEREST RATE RISK WITH GAP

Unexpected changes in interest rates can significantly alter a bank's profitability. GAP and earnings-sensitivity analysis targets the volatility in net interest income associated with changing interest rates and balance sheet composition. Depending on the cash flow characteristics of a bank's assets and liabilities and the existence of embedded options, interest rate changes may raise or lower net interest income.

Consider a bank that makes 30-year, fixed-rate mortgage loans financed primarily with 3-month to 1-year deposits. Why would management choose this portfolio? The bank receives interest and principal payments on the mortgages monthly and pays monthly interest on deposits. With an upward sloping yield curve, the mortgage rate will exceed the short-term deposit rates by a large spread. For example, if the mortgage rate is 7 percent and the deposit rates are 2 percent, the initial spread is 5 percent. This initial spread should be large enough to cover the cost of doing business, cover the expected change in rates over the investment horizon, and provide for a reasonable profit.

What happens if interest rates change? Because the mortgages have a 30-year maturity, these rates are fixed as long as the mortgages are outstanding. Rate changes thus affect the deposit rates and not the mortgage rates directly. If the deposit rates rise, the spread will fall below 5 percent. Similarly, if deposit rates fall, the spread will rise above 5 percent. The bank's choice of long-term, fixed-rate assets financed by short-term deposits evidences a specific interest rate bet. Rising rates lower net interest income while falling rates increase net interest income.

Of course, it's not quite that simple. For one, the balance sheet is dynamic and thus changing constantly over time. Rate changes are only one factor that affects earnings. Similarly, an upward sloping yield curve indicates a consensus view that short-term rates are going to increase over time. For a bank to take the position described, management is essentially betting that rates will not rise above expectations. Finally, there are embedded options in the mortgages that will likely alter the cash flows and eventual interest payments and receipts if rates change. In the case of falling rates, some mortgage borrowers will refinance and the bank will lose some interest income because it must reinvest the proceeds at lower rates.

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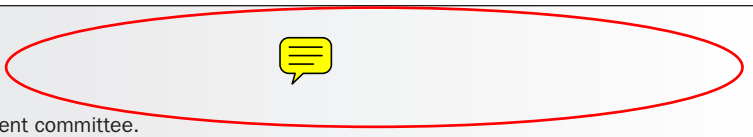
EXHIBIT 5.1 Important Terminology



ALCO: Acronym for asset and liability management committee.

ALM: Acronym for asset and liability management.

Base rate: Any interest rate used as an index to price loans or deposits; quoted interest rates are typically set at some markup, such as 0.25 percent or 1 percent, over the base rate and thus change whenever the base rate changes.

Cost of funds: Interest expense divided by the dollar volume of interest-bearing liabilities.

Duration: A measure of the approximate price sensitivity of an asset or portfolio to a change in interest rates.

Earnings change ratio: A percentage measure that indicates how much of each type of a bank's assets or liabilities will reprice when some index rate changes. An earnings change ratio of 1 indicates that the underlying asset or liability changes in yield or cost 1-to-1 with changes in the index rate.

Earning ratio: The dollar volume of a bank's earning assets divided by the dollar volume of total assets.

Earnings-sensitivity analysis: Conducting "what if" analysis by varying factors that affect interest income and expense to determine how changes in key factors affect a bank's net interest income and net interest margin. The output indicates how much net interest income will change under different interest rate scenarios in dollars and in percentage terms.

Effective GAP: The "true" measure of GAP that takes into account a specific interest rate forecast and when embedded options will either be exercised or will affect the actual repricing of an asset or liability.

Embedded option: A specific feature of a bank's asset, liability, or off-balance sheet contract that potentially changes the cash flows of the item when interest rates vary. Examples include early prepayment of principal on loans, issuers calling outstanding bonds, and depositors withdrawing funds prior to maturity.

Floating rate: Assets or liabilities that carry rates tied to the prime rate or other base rates. The instrument is repriced whenever the base rate changes.

GAP: The dollar volume of rate-sensitive assets minus the dollar volume of rate-sensitive liabilities.

GAP ratio: The dollar volume of rate-sensitive assets divided by the dollar volume of rate-sensitive liabilities.

Gradual rate shock: An assumed change in interest rates that occurs over time; a 1 percent annual increase in rates may translate into a monthly increase of 8.3 basis points.

Hedging: Taking a position or implementing a transaction to reduce overall risk associated with an existing position.

Instantaneous rate shock: An immediate increase or decrease in all interest rates by the same amount; a parallel shift in the yield curve.

Net interest margin (NIM): Tax-equivalent net interest income divided by earning assets.

Net overhead: Noninterest income minus noninterest expense.

Nonrate GAP: Noninterest-bearing liabilities plus equity minus nonearning assets as a ratio of earning assets.

Rate-sensitive assets (RSAs): The dollar value of assets that either mature or can be repriced within a selected time period, such as 90 days.

Rate-sensitive liabilities (RSLs): The dollar value of liabilities that either mature or can be repriced within a selected time period, such as 90 days.

Risk Management Committee: Central committee charged with enterprise-wide risk management measurement, monitoring and policies. Members typically set strategy regarding market risk within the organization.

Simulation: An analysis of possible outcomes for net interest margin resulting from selecting hypothetical values for key variables that influence the repricing of assets, liabilities, and off-balance sheet items, and conducting forecasts to determine the effects of changes in these variables on a bank's net interest income.

Speculation: Taking a position or implementing a transaction that increases risk in hopes of earning above average returns.

Spread: The interest yield on earning assets minus the interest cost of interest-bearing funds.

Variable rate: Assets or liabilities that are automatically repriced at regular intervals.

Efforts at managing interest rate risk force a bank's ALCO to establish specific targets for net interest income, measure overall risk exposure, and formulate strategies to attain the targets. Specific targets and strategies presumably reflect management's view of actions that will lead to maximizing the value of the bank.

The following sections describe the traditional static GAP model and explain its shortcomings, then describe how earnings-sensitivity analysis provides a meaningful extension. Exhibit 5.1 summarizes important terminology.

TRADITIONAL STATIC GAP ANALYSIS

Traditional static GAP models attempt to measure how much interest rate risk a bank evidences at a fixed point in time by comparing the rate sensitivity of assets with the rate sensitivity of liabilities. Static GAP focuses on manag-

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ing net interest income in the short run. The objective is typically to measure expected net interest income and then identify strategies to stabilize or improve it. Interest rate risk is measured by calculating GAPs over different time intervals based on aggregate balance sheet data at a fixed point in time—hence, the term static GAP. These GAP values are then examined to infer how much net interest income will change if rates change.

There are several basic steps to static GAP analysis.

1. Develop an interest rate forecast.
2. Select a series of sequential time intervals for determining what amount of assets and liabilities are rate sensitive within each time interval.
3. Group assets and liabilities into these time intervals, or "buckets," according to the time until the first repricing. The principal portion of the asset or liability that management expects to reprice is classified as rate sensitive. The effects of any off-balance sheet positions, such as those associated with interest rate swaps, futures, and so on, are also added to the balance sheet position according to whether the item effectively represents a rate-sensitive asset or rate-sensitive liability.
4. Calculate GAP. A bank's static GAP equals the dollar amount of rate-sensitive assets (RSAs) minus the dollar amount of rate-sensitive liabilities (RSLs) for each time interval.
5. Forecast net interest income given the assumed interest rate environment and assumed repricing characteristics of the underlying instruments.

Note that GAP measures balance sheet values. It represents the principal amounts of cash flows that are reflected in the measures. Expected interest income and interest expense components of cash flows are ignored in the GAP measure. Formally,

$$\text{GAP} = \text{RSAs} - \text{RSLs}$$

where rate-sensitive assets and liabilities are those identified within each time bucket. As such, there is a periodic GAP and a cumulative GAP for each time bucket. The periodic GAP compares RSAs with RSLs across each single time bucket. The cumulative GAP compares RSAs with RSLs over all time buckets from the present through the last day in each successive time bucket. For example, the cumulative GAP through 90 days (0–90 days) equals the sum of the periodic GAPs for the two time buckets, 0–30 days and 31–90 days.

This information is used to identify the bank's interest rate risk and to develop strategies to manage this risk. Management can alter the size of the GAP to either hedge net interest income against changing interest rates or speculatively try to increase net interest income. Hedging involves reducing the volatility of net interest income either by directly adjusting the dollar amounts of rate-sensitive assets and liabilities, or by taking an off-balance sheet position such as with forwards, futures, option contracts, and interest rate swaps.[1] Changing the size of GAP to take advantage of perceived rate changes is speculative because it assumes that management can forecast interest rates better than the market.

What Determines Rate Sensitivity?

The first three steps in GAP analysis require the classification of the principal portions of specific assets and liabilities that are rate sensitive within specific time intervals. Other balance sheet items either carry fixed rates or do not earn or pay interest. Interest payments are not included directly because GAP is a balance sheet (plus off-balance sheet) measure of risk. Management typically selects a variety of time buckets that provide useful information, as outlined later. The initial issue is to determine what features make an asset or liability rate sensitive.

CONSIDER A 0–90 DAY TIME INTERVAL. The key issue is to identify what assets and liabilities listed on a bank's balance sheet will be repriced within 90 days given the specific interest forecast. Note that the GAP definition and steps in the analysis require that the person determining rate sensitivity forecast when something will be repriced. The question typically arises as to whether the contractual date or expected date of repricing is the correct one. The answer depends on the purpose of the analysis. If the purpose is to simply inform the interpreter, knowing when items contractually reprice is helpful. For example, knowing how many loans are priced off of the bank's prime rate is good information. However, it is generally more valuable to assess the impact of repricing variations on earnings. Thus, the impact of having loans priced off of prime will vary if prime changes in three months versus nine months. The model can help estimate the different impacts only if prime loans are categorized according to when prime is expected to change. In practice, analysts use expected repricing dates under the relevant interest rate scenario to assess risk.

In general, an asset or liability is normally classified as rate sensitive within a time interval if:

1. It matures.
2. It represents an interim or partial principal payment.

[1]The use of interest rate swaps, caps, floors, collars, forwards, futures, and options is explained and demonstrated in Chapter 6.

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3. The interest rate applied to the outstanding principal balance changes contractually during the interval.
4. The interest rate applied to the outstanding principal balance changes when some base rate or index changes and management expects the base rate/index to change during the time interval.

MATURITY. If any asset or liability matures within a time interval, the principal amount will be repriced. If an asset matures, the bank must reinvest the proceeds. If a liability matures, the bank must replace the liability with new funding. Both hold true regardless of whether interest rates change or not. The question is what principal amount is *expected to* reprice? Step *two* in GAP analysis determines the *time frame for* which proceeds will be reinvested or liabilities refinanced.[2] In the case of a 0–90 day time interval, any investment security, loan, deposit, or purchased liability that matures within ninety days is rate sensitive.

INTERIM OR PARTIAL PRINCIPAL PAYMENT. More generally, any principal payment on a loan is rate sensitive if management expects to receive it within the time interval. This includes final principal payments as well as interim principal payments. Consider a bank that makes a 1-year $100,000 loan with principal payments of $25,000 due every three months (every 90 days). When making the initial assessment of rate sensitivity, $25,000 would be classified as a rate-sensitive asset within 90 days because the bank expects to receive and reinvest this portion of the total principal on the loan. Thus, banks that make car loans and residential mortgages, which typically include set fixed-dollar payments that include both principal and interest, record the principal component of each regular monthly payment on the loans as rate-sensitive assets.

CONTRACTUAL CHANGE IN RATE. Some assets and deposit liabilities earn or pay rates that vary contractually with some index. These instruments are repriced whenever the index changes. If management knows that the index will contractually change within 90 days, the underlying asset or liability is rate sensitive.

Consider an adjustable rate mortgage with a 15-year maturity and principal balance of $250,000. The rate equals the prevailing 10-year Treasury rate plus 1 pecent and adjusts annually on the anniversary date of when the loan was originated according to changes in the 10-year Treasury rate. When the loan is first booked, it is not rate sensitive within 90 days because the principal will not reprice until the Treasury rate changes. After 9 months, the rate automatically adjusts within the 90 day window according to what the 10-year Treasury rate equals at the end of the first year. The full outstanding principal balance is classified as rate sensitive once the known repricing (re-set date for the 10-year Treasury rate) is within 90 days.

CHANGE IN BASE RATE OR INDEX. Some loans and deposits carry rates tied to indexes where the bank has no control or definite knowledge of when the index will change. For example, a commercial loan priced at 1 percent over some other bank's prime rate carries a floating rate, but may or may not be repriced with any known frequency. Such prime rate loans typically state that the bank can change prime daily. The loan is rate sensitive in the sense that its yield can change at any time but its effective rate sensitivity depends on how frequently the prime rate actually changes. For the GAP figures to be most meaningful, management must forecast when the prime rate or other index will change. The full amount of principal should be allocated to the time interval that coincides with when the index or base rate is expected to change. The GAP and effect on net interest income will vary accordingly. This is why the first step, having an interest rate forecast, is important. The classification will differ across different economic environments.

Many asset and liability management models used by banks classify prime-based loans and other floating-rate instruments as immediately repriceable. Although this is true, assuming that the indexes and base rates can contractually change at any time, the resulting GAP figure is not very meaningful because such rates do not change simultaneously or in many cases all that frequently. For example, although Wall Street prime changed more than 50 times in 1980, there are years when it never changed. In 2004, prime increased by 25 basis points at four different times and the pattern continued in 2005. How a bank classifies these base rate loans and other accounts, such as NOWs and MMDAs, can dramatically alter the GAP measures reported and the effective (or actual) GAP measures if the underlying indexes do not change as assumed.

Factors Affecting Net Interest Income

Although GAP presumably provides information about a bank's interest rate risk exposure, many factors affect net interest income. In addition to changes in the *level* of interest rates, changes in the *composition* of assets and liabilities, changes in the *volume* of assets and liabilities outstanding, and changes in the *relationship* between the yields on earning assets and rates paid on interest-bearing liabilities will alter net interest income from that expected. Some factors are at least partially controllable, while others are not. Asset and liability management examines the impact of all factors on net interest income. The following analysis documents circumstances when net interest income increases and decreases by comparing it at a hypothetical bank before and after each influence.

[2]In this context, an instrument will still be repriced if rates do not change because new contract terms will be determined. As discussed later, this is important because not all rates change by the same amount at the same time.

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EXHIBIT 5.2 Expected Balance Sheet Composition and Average Interest Rates for a Hypothetical Bank

	Assets	Yield Rates	Liabilities	Interest Costs
Rate-sensitive	$ 500	6%	$ 600	2%
Fixed-rate	350	9	220	4
Nonearning/Nonpaying	150		100	
Total			$ 920	
			Equity	
			$ 80	
Total	$1,000		$1,000	

Net interest income = 0.06($500) + 0.09($350) − 0.02($600) − 0.04($220)
= $61.50 − $20.80
= $40.70
Net interest margin = $40.70/$850 = 4.79%
GAP = RSAs − RSLs = $500 − $600 = −$100

NOTE: RSAs are rate-sensitive assets; RSLs are rate-sensitive liabilities. The assumed time frame for classifying RSAs and RSLs is 1 year. Yield rates are computed on a tax-equivalent basis. All rates are expected to remain constant at current levels.

Consider a bank with the general balance sheet accounts listed in Exhibit 5.2. For ease of example, the RSAs and RSLs represent principal amounts that are expected to be repriced within a 1-year time interval when interest rates are assumed to remain constant at current levels. Thus, the RSAs and RSLs either mature within one year, represent partial principal payments made during the next year, are variable-rate contracts that are automatically repriced within one year, or carry floating-rate yields that management forecasts will change during the year. The RSAs include short-term securities, federal funds sold, expected principal payments on loans, and the outstanding principal on all repriced variable-rate and floating-rate loans. The RSLs include small time deposits and jumbo CDs maturing within one year, federal funds purchased, some interest-bearing transactions accounts, and money market deposit accounts. The crucial feature is that cash flows associated with rate-sensitive contracts vary with changes in interest rates. Fixed-rate assets and liabilities carry rates that are constant throughout the one-year time interval. Cash flows do not change unless there is a default, early withdrawal, or prepayment that is not forecasted accurately. Nonearning assets generate no explicit income, and nonpaying liabilities pay no interest. Both of these are classified as fixed-rate (at zero) in this static analysis. Note that all embedded options are ignored.

Expected average earning asset yield rates and interest costs for the year appear beside each account and represent expected values. If these balance sheet and interest rate figures reflect average performance during the year, the bank's tax-equivalent net interest income is expected to equal $40.70 per $850 in earning assets for a net interest margin (NIM) of 4.79 percent. These figures represent benchmark estimates. During the year, the level of interest rates normally changes from that initially projected, as do the composition and volume of assets and liabilities. This bank's one-year cumulative GAP equals −$100. The sign and magnitude of GAP presumably provide information regarding interest-rate risk.

CHANGES IN THE LEVEL OF INTEREST RATES

The sign of GAP (positive or negative) indicates the nature of the bank's interest rate bet. The GAP measure compares the dollar value of a bank's assets that reprice within an interval to the dollar value of liabilities that reprice within the same time frame. A negative GAP, such as that shown in Exhibit 5.2, indicates that the bank has more RSLs than RSAs. When interest rates rise during the time interval, the bank pays higher rates on all repriceable liabilities and earns higher yields on all repriceable assets. If all rates rise by equal amounts at the same time, both interest income and interest expense rise, but interest expense rises more because more liabilities are repriced. Net interest income thus declines, as does the bank's net interest margin. When interest rates fall during the interval, more liabilities than assets are repriced at the lower rates such that interest expense falls more than interest income falls. In this case, both net interest income and net interest margin increase. The sign of a bank's GAP thus indicates whether interest income or interest expense will likely change more when interest rates change. A bank with a negative GAP is said to be *liability sensitive* because more liabilities are expected to reprice versus assets and interest expense is expected to change more than interest income.

A positive GAP indicates that a bank has more RSAs than RSLs across some time interval. When rates rise, interest income increases more than interest expense because more assets are repriced such that net interest income similarly increases. Rate decreases have the opposite effect. Because interest income falls more than interest

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expense, net interest income falls. Such a bank is said to be *asset sensitive.* More assets than liabilities are expected to reprice and interest income changes more than interest expense.

If a bank has a zero GAP, RSAs equal RSLs and equal interest rate changes do not alter net interest income because changes in interest income equal changes in interest expense. It is virtually impossible for a bank to have a zero GAP given the complexity and size of bank balance sheets. These relationships are summarized as follows:

GAP Summary

GAP	Change in Interest Rates	Change in Interest Income		Change in Interest Expense	Change in Net Interest Income
Positive	Increase	Increase	>	Increase	Increase
Positive	Decrease	Decrease	>	Decrease	Decrease
Negative	Increase	Increase	<	Increase	Decrease
Negative	Decrease	Decrease	<	Decrease	Increase
Zero	Increase	Increase	=	Increase	None
Zero	Decrease	Decrease	=	Decrease	None

Section A of Exhibit 5.3 shows the relationship between an increase in the level of rates and a negative GAP for the hypothetical bank in Exhibit 5.2. All rates are assumed to increase by an average of 1 percent during the year, with the bank's portfolio composition and size unchanged.[3] This is characterized as assuming a parallel shift in the yield curve by +1 percent. With these assumptions, the only items that change are the yield rates and interest costs on rate-sensitive assets and liabilities. Interest income increases by $5 to $66.50, but interest expense increases by $6 to $26.80, such that net interest income declines by $1 relative to that initially projected in Exhibit 5.2. NIM subsequently falls by 12 basis points to 4.67 percent.

Suppose instead that rates decrease by 1 percent relative to the base case. The average yield earned on rate-sensitive assets declines to 5 percent while the interest cost of rate-sensitive liabilities declines to 1 percent. By assumption, fixed rates do not change. Interest income falls by $5 while interest expense falls by $6 such that net interest income increases by $1. This occurs because the bank now pays lower rates on a greater amount of liabilities ($600) than assets ($500) that are now earning lower yields. NIM subsequently widens.

The change in net interest income arises because the amount of rate-sensitive assets differs from the amount of rate-sensitive liabilities and all rates are assumed to change by the same amount in the same direction. The larger the GAP difference, the greater the impact. If RSAs equaled RSLs, the change in interest income would be matched by the change in interest expense regardless of whether rates rise or fall, so that net interest income would be unchanged. In this framework, whether NIM rises or falls depends on whether the GAP is positive or negative and how much the level of interest rates changes. The following relationship summarizes this framework.

$$\Delta NII_{exp} = GAP \times \Delta i_{exp} \tag{5.1}$$

where

ΔNII_{exp} = the expected change in net interest income over a period of time from some base amount,

GAP = cumulative GAP over the interval through the end of the period of time, and

Δi_{exp} = the expected permanent change in the level of interest rates.

Again, this applies only in the case of a parallel shift in the yield curve, which rarely occurs. Specifically, if the 1-year GAP is any positive value, net interest income increases when rates are assumed to rise and decreases when rates fall. Suppose, for example, that the above bank's initial position consists of $650 in rate-sensitive assets and $200 in fixed-rate assets with all other factors the same. The 1-year GAP equals $50. At the rates listed, interest income is expected to equal $58 while interest expense is still $20.80, producing $38.80 in net interest income. If rates rise by 1 percent, interest income rises by $6.50 while interest expense rises by just $6. With this smaller positive GAP, net interest income now increases by $0.50. It declines when rates fall.[4]

In this context, the sign and size of GAP provide information regarding a bank's interest rate risk position. The sign indicates the bank's interest rate bet. If GAP is positive, the bank wins (net interest income should rise) when rates rise and loses when rates fall. If GAP is negative, the bank wins when rates fall and loses when rates rise. The size of GAP indicates how much risk a bank assumes. Specifically, a zero GAP indicates the lowest risk. The farther GAP is from zero (lowest risk), the greater is the potential variation in net interest income and thus, the greater the assumed risk.

[3]Earnings-sensitivity analysis recognizes that the amount of rate-sensitive assets and rate-sensitive liabilities changes when interest rates change, and that various rates change by different amounts at different times. This discussion ignores this possibility, which is why static GAP is not very meaningful as a risk measure.

[4]The reader should verify that interest income changes by the same amount as interest expense in these examples when the GAP equals zero.

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EXHIBIT 5.3 Expected Changes in Net Interest Income from Changes in the Level of Rates, Spread Volume and Balance Sheet Mix

A. 1% Increase in Level of All Short-Term Rates

	Assets	Yield Rates	Liabilities	Interest Costs
Rate-sensitive	$ 500	7%	$ 600	3%
Fixed-rate	350	9%	220	4
Nonearning/Nonpaying	150		100	
			Equity	
			80	
Total	$1,000		$1,000	

Net interest income = 0.07($500) + 0.09($350) − 0.03($600) − 0.04($220)
= $66.50 − $26.80
= $39.70
Net interest margin = $39.70/$850 = 4.67%
GAP = $500 − $600 = −$100

B. 1% Decrease in Spread between Asset Yields and Interest Costs

	Assets	Yield Rates	Liabilities	Interest Costs
Rate-sensitive	$ 500	6.5%	$ 600	3.5%
Fixed-rate	350	9.0	220	6.0
Nonearning/Nonpaying	150		100	
			Equity	
			80	
Total	$1,000		$1,000	

Net interest income = 0.065($500) + 0.09($350) − 0.035($600) − 0.04($220)
= $64.00 − $29.80
= $34.20
Net interest margin = $34.20/$850 = 4.02%
GAP = $500 − $600 = −$100

C. Proportionate Doubling in Size

	Assets	Yield Rates	Liabilities	Interest Costs
Rate-sensitive	$1,000	6%	$1,200	2%
Fixed-rate	700	9	440	4
Nonearning/Nonpaying	300		200	
			Equity	
			160	
Total	$2,000		$2,000	

Net interest income = 0.06($1,000) + 0091($700) − 0.02($1,200) − 0.04($440) = $81.40
Net interest margin = $81.40/$1,700 = 4.79%
GAP = $1,000 − $1,200 = −$200

D. Increase in RSAs and Decrease in RSLs

	Assets	Yield Rates	Liabilities	Interest Costs
Rate-sensitive	$ 540	6%	$ 560	2%
Fixed-rate	310	9	260	4
Nonearning/Nonpaying	150		100	
			Equity	
			80	
Total	$1,000		$1,000	

Net interest income = 0.06($540) + 0.09($310) − 0.02($560) − 0.04($260)
= $60.30 − $21.60
= $38.70
Net interest margin = $38.70/$850 = 4.55%
GAP = $540 − $560 = −$20

NOTE: RSAs are rate-sensitive assets; RSLs are rate-sensitive liabilities.

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Changes in the Relationship Between Short-Term Asset Yields and Liability Costs

Net interest income may similarly differ from that expected if the spread between earning asset yields and the interest cost of interest-bearing liabilities changes. There is no reason that all rates should change by the same amount over time. Asset yields may vary relative to interest costs because of an unexpected shift in the yield curve (unequal changes in the level of different maturity interest rates are labeled a nonparallel shift in the yield curve), an increase or decrease in risk premiums, and nonsynchronous changes in indexes on floating-rate assets or liabilities. If, for instance, liabilities are short-term and assets are long-term, the spread will narrow when the yield curve inverts and will widen when the yield curve increases in slope. Similarly, asset yields may be tied to base rates that change monthly while liability costs change weekly with money market rates.

Section B of Exhibit 5.3 examines the impact of a 1 percent decrease in the spread (from 4 percent to 3 percent) on rate-sensitive assets and liabilities for the year. With the portfolio composition unchanged, net interest income declines to $34.20. Of course, net interest income increases whenever the spread increases. Changes in net interest income associated with changes in the difference between different interest rates, say prime minus 3-month LIBOR, are a reflection of *basis risk*.

Changes in Volume

Net interest income varies directly with changes in the volume of earning assets and interest-bearing liabilities, regardless of the level of interest rates. Consider Section C in Exhibit 5.3 where the bank doubles in size. The portfolio composition and interest rates are unchanged. Net interest income doubles because the bank earns the same interest spread on twice the volume of earning assets such that NIM is unchanged. GAP now doubles to −$200 but is the same fraction of total assets. The net effect is that growth, by itself, leads to an increase in the dollar amount of earnings but does not alter profitability measures or the relative size of GAP to assets. A bank that alternatively contracts in size experiences a decrease in net interest income with no change in profitability measures or the relative size of GAP to assets.

Changes in Portfolio Composition

Any variation in portfolio mix potentially alters net interest income. A manager who wants to reduce risk for the sample bank in Exhibit 5.3 might attempt to increase asset rate sensitivity by pricing more loans on a floating-rate basis or shortening maturities of investment securities. Alternatively, the manager might decrease liability rate sensitivity by substituting longer-term CDs for overnight federal funds purchased. These transactions change both the GAP and the bank's interest rate risk position. They also change net interest income from that initially expected. Section D of Exhibit 5.3 summarizes the impact of a $40 shift of fixed-rate assets to RSAs and a corresponding $40 shift from RSLs to fixed-rate liabilities. In this case, the level of rates is unchanged and net interest income falls by $2 from the initial estimate of $40.70. This decline is caused by a decline in the average yield on earning assets which produces a $1.20 drop in interest income, and an increase in the average interest cost of liabilities that produces a $0.80 increase in interest expense. In addition to changing expected net interest income, this change in composition alters the GAP to −$20 and thus reduces the bank's interest rate risk profile.

There is no fixed relationship between changes in portfolio mix and net interest income. The impact varies with the relationships between interest rates on rate-sensitive and fixed-rate instruments and with the magnitude of funds shifts. If, for example, the change in mix was reversed in the above case, net interest income would increase. Net interest income would drop if the $40 shift in liabilities was the only change in portfolio composition. In many cases, banks change mix as part of initiatives to offset anticipated adverse changes in net interest margin. Generally, any shift to loans from securities will increase net interest income near-term because loan yields exceed most security yields on a pretax and prerisk (default loss) basis. Similarly, any shift from core deposits to noncore liabilities reduces net interest income because noncore liabilities generally carry higher interest rates.

Changes in the magnitudes of nonearning assets and nonpaying liabilities also influence net interest income and NIM. If a bank can reduce its nonearning assets, net interest income increases automatically, with the magnitude determined by how the funds are invested. For example, net interest income rises by $3 [.06($50) − 0] with a $50 shift to RSAs. A $50 shift to fixed-rate assets increases net interest income by $4.50 [.09($50) − 0]. In both cases, NIM rises because the bank's funding costs are unchanged with higher interest income.

Rate, Volume, and Mix Analysis

Many banks publish a summary in their annual report of how net interest income has changed over time. They separate changes attributable to shifts in asset and liability composition and volume from changes associated with movements in interest rates. Exhibit 5.4 represents such a report for Synovus, headquartered in Columbus, Georgia, for 2004 versus 2003, and 2003 versus 2002.

Consider the data for 2004 compared with 2003. The figures refer to the change in either interest income, interest expense, or net interest income attributable to changes in the volume of earning assets and interest-bearing liabilities—under the volume heading—or that attributable to changes in earning asset yields or rates

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EXHIBIT 5.4 Substitute Data for 2004 Versus 2003

	2004 Compared to 2003 Change Due to *			2003 Compared to 2002 Change Due to *		
	Volume	Yield/ Rate	Net Change	Volume	Yield/ Rate	Net Change
Interest earned on:						
Taxable loans, net	$149,423	(117,147)	32,276	161,222	36,390	197,612
Tax-exempt loans, net†	1,373	(586)	787	1,108	(450)	658
Taxable investment securities	(5,313)	(916)	(6,229)	4,507	2,570	7,077
Tax-exempt investment securities†	2,548	74	2,622	2,026	(206)	1,820
Interest earning deposits with banks	223	(176)	47	28	48	76
Federal funds sold and securities purchased under resale agreements	406	(1,745)	(1,339)	1,447	1,410	2,857
Mortgage loans held for sale	7,801	(1,680)	6,121	(113)	549	436
Total interest income	156,461	(122,176)	34,285	170,225	40,311	210,536
Interest paid on:						
Interest bearing demand deposits	6,074	(12,517)	(6,443)	1,537	5,433	6,970
Money market accounts	21,380	(36,244)	(14,864)	4,654	13,888	18,542
Savings deposits	(369)	(3,307)	(3,676)	(660)	(67)	(727)
Time deposits	32,015	(22,545)	9,470	38,824	32,812	71,636
Federal funds purchased and securities sold under repurchase agreements	(6,165)	(29,744)	(35,909)	23,148	15,870	39,018
Other borrowed funds	21,318	(4,272)	17,046	21,960	3,361	25,321
Total interest expense	74,253	(108,629)	(34,376)	89,463	71,297	160,760
Net interest income	$82,208	(13,547)	68,661	$80,762	(30,986)	49,776

NOTE: Figures are in thousands of dollars.

*The change in interest due to both rate and volume has been allocated to the rate component.

†Reflects taxable-equivalent adjustments using the statutory federal income tax rate of 35 percent in adjusting interest on tax-exempt loans and investment securities to a taxable-equivalent basis.

SOURCE: Synovus 2004 Annual Report.

paid on liabilities—under the yield/rate heading. The Net Change column represents the sum of these two figures.

The purpose is to assess what factors influence shifts in net interest income over time. Data in the column headed Volume indicate how much interest income and interest expense would have changed if rates were held constant at 2002 levels and the only impact was balance sheet changes in the amounts of earning assets and interest-bearing liabilities. In 2004, volume effects for Synovus exceeded interest rate effects for interest income, with yield/rate effects greater than volume for interest expense. From 2003 to 2004, net interest income increased by $xxxxxx, of which $xxxxx was attributed to the growth in earning assets versus interest-bearing liabilities with all interest rates held constant at 2002 levels. As such, Synovus grew its loans and securities holdings relative to its funding, which added significantly to earnings given the prior year's spread. Data in the column headed Yield/Rate assumes that volumes of the balance sheet items are held constant at 2003 levels and the effects reflect primarily changes in earning asset yields and liability costs (rates). From 2003 to 2004, Synovus saw its interest income fall by $xxxxx associated with declines on earning assets while its interest expense fell by just $xxxxx. The net was a loss of $xxxxxx, which reduced net interest income. While interest rates increased modestly in 2004, those on earning assets rose less than those on interest-bearing liabilities.

This view of GAP and net interest income is simplistic. Obviously, asset yields and interest costs do not change coincidentally or by equal amounts. Even within distinct time intervals, assets and liabilities are repriced at varied intervals, producing cash flows that may differ substantially from those implied by the GAP. For example, if all RSAs from Exhibit 5.2 matured in one month while all RSLs matured in six months, projected cash flows would reflect interest rate and portfolio changes occurring five months apart such that the forecast change in net interest income could be substantially wrong.

For more meaningful comparisons, managers should calculate the GAP over relatively short periods and allow for a wide range of interest rates and repricings. The next section introduces a rate-sensitivity report, a framework that is commonly used to evaluate a bank's interest rate risk position. It essentially calculates GAPs across different time buckets. Data for Security Bank, a $100 million organization, are used to demonstrate the framework.

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RATE-SENSITIVITY REPORTS

Many managers monitor their bank's risk position and potential changes in net interest income using a framework like that in Exhibit 5.5. This report classifies Security Bank's assets and liabilities as rate sensitive in selected time buckets through one year. Underlying each report should be an assumed interest rate environment. The last column lists the totals for all balance sheet items as of year-end. Note that Security Bank reports $85.3 million in earning assets and $14.7 million in nonearning assets, $78.5 million in interest-bearing liabilities and $21.5 million in liabilities and equity not subject to interest payments. Each earlier column of data reflects the dollar volume of repriceable items within a distinct but sequential time period. For example, of the $9.5 million in Treasury and agency securities owned, $700,000 will be repriced in 8 to 30 days, $3.6 million is repriceable in 31 to 90 days, and so forth. All floating-rate commercial loans tied to a base rate are designated as rate sensitive from 8 to 30 days out. This classification reflects Security Bank's experience in changing base rates monthly on average during the past year. The column labeled Non Rate-Sensitive indicates amounts that do not earn or pay interest.

Figures for rate-sensitive liabilities similarly indicate when the items are expected to be repriced. Thus, NOW accounts will presumably be repriced within 91 to 180 days while a portion of money market deposit accounts will be repriced in 8 to 30 days and the bulk in 31 to 90 days. Note that savings accounts are assumed not to reprice for at least one year even though the rates can be changed more frequently. This classification differentiates

EXHIBIT 5.5 Rate-Sensitivity Analysis for Security Bank, December 31, 2005

	Time Frame for Rate Sensitivity							
	1–7 Days	8–30 Days	31–90 Days	91–180 Days	181–365 Days	Over 1 Year	Non Rate-Sensitive	Total
Assets								
U.S. Treasury and agency securities		$ 0.7	$ 3.6	$ 1.2	$ 0.3	$ 3.7		$ 9.5
Money market investments			1.2	1.8				3.0
Municipal securities			0.7	1.0	2.2	7.6		11.5
Federal funds sold and repurchase agreements	$ 5.0							5.0
Commercial loans*	1.0	13.8	2.9	4.7	4.6	15.5		42.5
Installment loans	0.3	0.5	1.6	1.3	1.9	8.2		13.8
Earning assets								$ 85.3
Cash and due from banks							$ 9.0	9.0
Other assets							5.7	5.7
Nonearning assets								$ 14.7
Total assets	$ 6.3	$15.0	$10.0	$10.0	$ 9.0	$35.0	$14.7	$100.0
Liabilities and Equity								
Money market deposit accounts		$ 5.0	$12.3					$ 17.3
Time deposits < $100,000	$ 0.9	2.0	5.1	$ 6.9	$ 1.8	$ 2.9		19.6
CDs ≥ $100,000	4.1	4.0	12.9	7.9	1.2			30.1
Federal funds purchased and repurchase agreements								
NOW accounts				9.6				9.6
Savings accounts						1.9		1.9
Market-rate liabilities								$ 78.5
Demand deposits							$13.5	13.5
Other liabilities							1.0	1.0
Equity							7.0	7.0
Nonpaying liabilities and equity							21.5	$ 21.5
Total liabilities and equity	$ 5.0	$11.0	$30.3	$24.4	$3.0	$ 4.8	$21.5	$100.0
Periodic GAP	$ 1.3	$ 4.0	−$20.3	−$14.4	$6.0	$30.2		
Cumulative GAP	$ 1.3	$ 5.3	−$15.0	−$29.4	−$23.4	$ 6.8		

NOTE: Figures are in millions of dollars.

*Floating-rate loans total $10 million and are classified as repriceable in 8 to 30 days. There is no guarantee that base rates will change in this time period.

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between when an asset or liability can be repriced and when management believes it will be repriced. Prime-based loans can reprice daily if prime changes daily. The prime rate typically changes much less frequently. Banks can change MMDA rates daily, but unless they actually do, these deposits will only be as rate sensitive as their actual repricing schedule. A comparison of RSAs and RSLs that can change immediately would indicate differences in **contractual** repricing, but is likely not meaningful unless rates are highly volatile and these items are actually repriced as frequently as contracts allow.

Two types of GAP measures are reported at the bottom of the report. The **periodic GAP** compares RSAs with RSLs across each of the different time buckets. RSAs exceed RSLs in each interval through 30 days and for 181 days through one year, while RSLs exceed RSAs in the 31–90 day and 91–180 day intervals. The **cumulative GAP,** in contrast, measures the sum of the periodic GAPs through the longest time frame considered. Thus, the cumulative GAP at 31–90 days of −$15 million equals the sum of the periodic GAPs for 1–7 days ($1.3 million), 8–30 days ($4 million), and 31–90 days (−$20.3 million).

Each periodic GAP figure simply indicates whether more assets or liabilities can be repriced within a specific time interval. Because it ignores whether assets and liabilities in other periods can be repriced, it is not all that meaningful. Cumulative GAP figures are the most important because they directly measure a bank's net interest sensitivity through the last day of the time bucket by comparing how many assets and liabilities reprice through that last day. Thus, the cumulative GAP of −$15 million indicates that Security Bank can reprice $15 million more of rate-sensitive liabilities than rate-sensitive assets during the next 90 days. The 1-year cumulative GAP indicates that $23.4 million more in liabilities than assets are expected to be repriced over this longer period. It is important to note that GAP figures for the interval over one year provide no new information about a bank's interest rate risk position. The periodic GAP of $30.2 simply reflects the fact that the bank has $35 million in earning assets that reprice beyond one year, while it pays interest on $4.8 million in similar long-term liabilities. The subsequent $6.8 million cumulative GAP simply measures the difference between $85.3 million in earning assets and $78.5 million in interest-bearing liabilities.

Note that the cumulative GAPs are positive for the first two periods with the remainder negative through one year. According to the previous discussion, Security Bank has positioned itself to gain if rates fall over the next year. Specifically, if rates decrease uniformly during the year, the bank's net interest income would increase unless offset by changes in portfolio mix or bank size because interest income should fall less than interest expense. If rates increase, net interest income should decline. Furthermore, the size of the GAP indicates that the bank's performance may vary substantially as the cumulative GAP through one year is almost 25 percent of total assets. Many community banks have policy statements that presumably limit interest rate risk by specifying that selected GAPs, as a fraction of earning assets, cannot fall outside of ±15 percent.

The rate-sensitivity report provides a view of a bank's interest rate risk profile at a single point in time. It reflects a point estimate of risk implied by the basic concept of a static GAP. Most banks employ earnings-sensitivity analysis to address weaknesses in the static GAP concept. They also evaluate interest rate risk using duration-based measures of relative asset and liability price sensitivity.

Strengths and Weaknesses: Static GAP Analysis

The principal attraction of static GAP analysis is that it is easy to understand. Periodic GAPs indicate the relevant amount and timing of interest rate risk over distinct maturities and clearly suggest magnitudes of portfolio changes to alter risk. They indicate the specific balance sheet items that are responsible for the risk. GAP measures can also be easily calculated once the cash flow characteristics of each instrument are identified.

Unfortunately, the static GAP procedure also contains numerous weaknesses. First, there are serious *ex post* measurement errors. Consider, for example, loans whose rates are tied to base rates or indexes. The frequency of changes in base rates or indexes cannot be accurately forecast because management does not know when market interest rates will change. In 1980, the prime rate listed in the *Wall Street Journal,* a popular base rate for commercial loans, changed 52 times. In 1983, it changed only three times and, in 2000, it changed twice. Prime-based loans were considerably more rate sensitive in 1980, and in 2001 when it changed 11 times. During the first 9 months of 2004 prime increased 3 times as the Federal Reserve increased the targeted federal funds rate 3 times. GAP figures do not directly reflect this historical frequency of base rate changes. When there is uncertainty over the frequency of base rate changes, GAP measures reflect any errors in allocating loans differently than actual rate changes would require. To overcome this problem, a bank should evaluate the statistical rate sensitivity of all base rates to selected market indexes. To avoid mismeasuring risk, funds should be allocated to time buckets according to their effective (expected) rate sensitivity, which is often linked to the historical frequency of rate changes. With GAP analysis, rate sensitivity for these loans is not known.

Second, GAP analysis ignores the time value of money. The construction of maturity buckets does not differentiate between cash flows that arise at the beginning of the period versus those at the end. If a bank buys a 1-month T-bill financed by overnight borrowing in the federal funds market, the 1-month GAP is zero. This suggests no interest rate risk when, in fact, this transaction exposes the bank to losses when the federal funds rate rises. Whether a bank gains with rising or falling interest rates depends on the actual timing of repricings within each

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interval. Thus, a bank with a zero GAP will still see net interest income change when rates change. Similarly, GAP ignores interest flows. One attraction of duration-based measures of interest rate risk is that they incorporate the present value of all cash flows.

Third, the procedure essentially ignores the cumulative impact of interest rate changes on a bank's risk position. GAP measures should be calculated over the entire range of repricings, yet they often focus only on near-term changes in net interest income. As such, many banks evaluate GAP measures and variation in net interest income only through the upcoming year. Interest rate changes also affect the value of fixed-rate assets and liabilities and total risk beyond one year. These changes are ignored.

Fourth, liabilities that pay no interest are often ignored in rate-sensitivity comparisons because many banks allocate demand deposits as non-rate-sensitive liabilities. As such, GAP analysis does not recognize any rate risk associated with demand deposit flows, even though a bank typically loses deposits when interest rates rise. This occurs because the opportunity cost of demand deposits increases for the owners and the benefits of better cash management rise. Many compensating balance agreements, in turn, allow the owners of demand deposits to reduce the dollar amount of compensating balances when rates rise because the bank can earn a higher yield from investing these funds. To be useful, GAP analysis must allocate the rate-sensitive portion of demand deposits to the appropriate time buckets depending on their actual rate sensitivity. When rates are expected to increase, more demand deposits will be rate sensitive. It is extremely difficult, however, to know the exact rate sensitivity of these deposits.

Finally, static GAP does not capture risk associated with options embedded in the loans, securities, and deposits that banks deal with. Examples include the prepayment option that mortgage borrowers have and often exercise when interest rates fall, and the early withdrawal option that depositors have and often exercise when interest rates rise. These options have different values and a different probability of being exercised when interest rates are at different levels and rate volatility changes. The impact of these options is to alter the effective size of GAP over different time intervals when interest rates are rising versus falling and when rates are at high levels versus low levels. Earnings-sensitivity analysis addresses these concerns.

GAP RATIO. Some asset and liability management (ALM) programs focus on the GAP ratio when evaluating interest rate risk. The GAP ratio equals RSAs divided by RSLs with the typical focus on a 1-year cumulative GAP ratio. When

$$\text{GAP Ratio} = \text{RSAs/RSLs}$$

GAP is positive, the GAP ratio is greater than one. A negative GAP, in turn, is consistent with a GAP ratio less than one.

Neither the GAP nor GAP ratio provides direct information on the potential variability in earnings when rates change. The GAP ratio is further deficient because it ignores size. Consider two banks that have $500 million in total assets. The first bank has $3 million in RSAs and $2 million in RSLs so that its GAP equals $1 million and its GAP ratio equals 1.5. The second bank has $300 million in RSAs and $200 million in RSLs. Its GAP equals $100 million, yet it reports the same 1.5 GAP ratio. Clearly, the second bank assumes greater interest rate risk because its net interest income will change more when interest rates change.

Link Between Gap and Net Interest Margin

A better risk measure relates the absolute value of a bank's GAP to earning assets. The greater is this ratio, the greater is the interest rate risk.[5] Many banks actually specify a target GAP to earning asset ratio in their ALCO policy statements. Consider a bank with the policy target that the 1-year cumulative GAP as a fraction of earning assets should be greater than −15 percent and not more than +15 percent. This target allows management to position the bank to be either asset sensitive or liability sensitive, depending on the outlook for interest rates. Yet, the policy limits the size of the GAP and implicitly how much risk management can take.

The ratio of GAP to earning assets has the additional advantage in that it can be directly linked to variations in NIM. In particular, management can determine a target value for GAP in light of specific risk objectives stated in terms of a bank's target NIM.[6] Consider a bank with $50 million in earning assets that expects to generate a 5 percent NIM. As part of its management strategy, the bank has decided it will risk changes in NIM equal ±20 percent during the year. Thus, NIM should fall between 4 and 6 percent. This risk assessment, in conjunction with expected interest rates, imposes policy limits on an acceptable GAP. The general relationship is:

$$\frac{\text{Target GAP}}{\text{Earning assets}} = \frac{(\text{Allowable \% change in NIM})\,(\text{Expected NIM})}{\text{Expected \% change in interest rates}} \tag{5.2}$$

[5]Remember that risk in this context is associated with the volatility in net interest income. The use of absolute value demonstrates that the sign of GAP does not influence the volatility of net interest income, only whether net interest income rises or falls when rates change in a specific direction.

[6]Binder and Lindquist (1982) elaborate on this and provide a matrix that outlines potential GAP variances for different levels of NIM risk.

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For example, suppose that management expects interest rates to vary up to 4 percent during the upcoming year. According to Equation 5.2, the bank's ratio of its 1-year cumulative GAP (absolute value) to earning assets should not exceed 25 percent.

$$\text{Target GAP/Earning assets} = (.20)(.05)/.04 = .25$$

Equation 5.2 and management's willingness to allow only a 20 percent variation in NIM sets limits on the GAP which would be allowed to vary from −$12.5 million to $12.5 million, based on $50 million in earning assets.

Using the data from Exhibit 5.5, suppose that Security Bank's management establishes the same 20 percent variance in NIM as a risk objective but expects its NIM to equal 4.5 percent over the next year. If it expects interest rates to rise by 2 percent, it would target the GAP to earning asset ratio at no more than 45 percent. Exhibit 5.5 indicates that the bank's 1-year cumulative GAP is −$23.4 million, or 27.5 percent of earning assets. Thus, management could increase its negative GAP to as much as −$38 million and remain within its target risk profile.

The important point is that a bank's effective GAP and net interest margin are closely linked. Ideally, banks should identify the amount of net interest income at risk if interest rates change. Rather than do this directly via earnings-sensitivity analysis, many banks limit the size of GAP as a fraction of assets, which indirectly limits the variation in net interest income.

EARNINGS-SENSITIVITY ANALYSIS

In recent years, many bank managers have used an earnings-sensitivity framework to measure and monitor interest rate risk. This framework extends static GAP analysis by making it dynamic. It does this by model simulation or "what if" analysis of all the factors that affect net interest income across a wide range of potential interest rate environments. The analysis essentially repeats static GAP analysis assuming different interest rate environments and compares expected net interest income between the different environments. The steps include:

1. Forecast interest rates.
2. Forecast balance sheet size and composition given the assumed interest rate environment.
3. Forecast when embedded options in assets and liabilities will be in the money and, hence, exercised such that prepayments change, securities are called or put, deposits are withdrawn early, or rate caps and rate floors are exceeded under the assumed interest rate environment.
4. Identify which assets and liabilities will reprice over different time horizons, and by how much, under the assumed interest rate environment. Identify off-balance sheet items that have cash flow implications under the assumed rate environment.
5. Calculate (estimated) net interest income under the assumed rate environment.
6. Select a new interest rate environment and compare the forecast of net interest income across different rate environments versus the base case.

The primary value of this framework is that it allows managers to assess how much net interest income might vary across a wide range of interest rates. The typical comparison looks at seven different interest rate environments beginning with a base case, or most likely, scenario. This may be based on current rates, forward rates implied by the yield curve, or management's specific forecast of rates. Each of the other scenarios then assumes that rates move systematically higher by +1 percent, +2 percent, and +3 percent or systematically lower by −1 percent, −2 percent, and −3 percent. An important part of these forecast environments is the recognition that different customer options may go "in the money" such that they are exercised at different times. In addition, management can specify different interest rate changes for different instruments such that the spread between asset yields and liability costs varies. For example, if a bank's prime rate is assumed to increase by 1 percent, retail time deposit rates might be assumed to increase by just 0.5 percent. The difference in rate changes will have the impact of increasing a bank's net interest income.

In each environment, management determines different amounts of assets, liabilities, and off-balance sheet positions that are effectively rate sensitive, and implicitly calculates a different effective GAP for each scenario. The output then is the change in net interest income or change in NIM from the base case. Policy or risk limits are commonly set relative to allowable changes in net interest income and NIM from the base case. A more extensive framework has managers forecast the change in noninterest income and noninterest expense across different rate environments with the final output being the change in net income versus the base case. Finally, the assumed rate changes may reflect instantaneous, or immediate shocks, or gradual rate changes over time.

Exercise of Embedded Options in Assets and Liabilities

To fully understand the risk inherent in a bank's operations, it is necessary to understand the different types of options that bank customers have. The most obvious include a customer's option to refinance a loan. Although the

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option is not generally explicit in a loan contract, any borrower can repay a loan early. A more obvious option is the call option on a federal agency bond that a bank might own. For example, the Federal Home Loan Bank (FHLB) might issue a bond with a 3-year maturity that is callable at face value after 30 days. This means that the FHLB, at its option, can pay the bank the principal any time after 30 days. Thus, the bank might expect to own the bond for three years, but end up owning it just 30 days or a fraction of the time until maturity. An option embedded in bank liabilities is a depositor's option to withdraw funds prior to final maturity. Such an early withdrawal might also surprise a bank by forcing it to pay the depositor back far in advance of final maturity.

Whenever options are embedded in bank assets and liabilities, managers should address three issues. The first is whether the bank is the buyer or seller of the option. This is the same as asking "Does the bank or its customer determine when the option is exercised?" The buyer is the party that controls when the option is exercised while the seller presumably receives some compensation for selling (or writing) the option. In each of the above examples, the bank is the seller of the option and the customer is the buyer. Borrowers decide when to refinance, the FHLB decides when to call (repay) the bond, and the depositor decides when to withdraw the deposit. The second issue is how, and by what amount, is the bank being compensated for selling the option, or how much it must pay if it buys the option. In the three previous cases, there may be explicit prepayment penalties on a loan and deposit (for early withdrawal) that represent fees (if they are not waived), and the bank receives a higher promised yield on a callable bond compared with the yield on an otherwise similar noncallable bond. Finally, the bank should forecast when the option will be exercised. In the above examples, this involves forecasting when a loan will be prepaid, when the agency bond will be called, and when the depositor will withdraw funds early. These forecasts, in turn, will depend on the assumed rate environment. Loan refinancing (prepayments) typically rise sharply when interest rates fall. Bonds are called when interest rates fall. Deposits are withdrawn early when deposit rates rise sufficiently.

Market participants cannot generally forecast interest rates accurately for long periods of time. The focus on embedded options is important, however, because it forces management to recognize the risks inherent in their portfolios. These risks exist even if rates do not change because there is always the possibility that rates might change. It also allows management to identify a worst-case scenario and have a better sense of maximum loss potential.

When doing earnings-sensitivity analysis, it is important to recognize that banks often enter into off-balance sheet contracts with futures, forward rate agreements, swaps and options that also affect aggregate interest flows. Chapter 7 introduces these derivatives including caps and floors on interest rates that are used to manage interest rate risk. Each type of contract may have different cash flow effects in different rate environments that potentially alter a bank's interest income and/or interest expense. The effects of these must also be included in any forecast of net interest income volatility.

Different Interest Rates Change by Different Amounts at Different Times

Earnings-sensitivity analysis allows management to incorporate the impact of different competitive markets for various balance sheet accounts with alternative pricing strategies. This enables managers to forecast different spreads between asset yields and liability interest costs when rates change by different amounts. It is widely recognized, for example, that banks are quick to increase base loan rates, such as their prime rate, when interest rates increase in general, but are slow to lower base loan rates when interest rates fall. The implication is that floating rate loans are more rate sensitive in rising rate environments versus falling rate environments. In like manner, banks typically increase loan rates more than they increase deposit rates in a rising rate environment such that the spread widens. During a falling rate environment, the opposite often occurs as deposit rates lag in being lowered relative to other money market rates and certain loan rates such that the spread narrows. The implication is that although the rate sensitivity of different instruments might be nominally the same, the impact is different due to different timing of rate changes and different magnitudes of rate changes.

This impact is even more apparent when examining callable bonds that banks own as part of their investment portfolios. Consider the 3-year FHLB bond that is callable after 30 days, described earlier. If rates fall enough, the entire bond will likely be called because the FHLB can refinance at lower rates and save on interest expense. In a falling rate environment, this bond is very rate sensitive and might be classified as such in the 31- to 90-day time interval. In a rising rate environment, the bank might end up owning the bond for three years because it will not be called. As such, it is not rate sensitive because it will not be repriced for three years. It is clear that the bank's effective (actual) GAP will be different in a rising versus falling rate environment because the bond is only rate sensitive when rates fall.

The net effect is that when conducting the "what if" analysis, managers can examine the impact of these nonparallel shifts in interest rates and the differing degrees or effective rate sensitivity. Not surprisingly, the impact of interest rate changes is not as straightforward as that suggested by Equation 5.1 or simple GAP.

Earnings-Sensitivity Analysis: an Example

Consider the Rate-Sensitivity Report for First Savings Bank (FSB) as of year-end 2005 presented in Exhibit 5.6. This report is based on the most likely interest rate scenario summarized in Charts A and B of Exhibit 5.7. FSB is a $1 billion bank that bases its analysis on forecasts of the federal funds rate (Chart A) and ties other rates to this

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EXHIBIT 5.6 ABC Rate-Sensitivity Report for Most Likely (Base Case) Interest Rate Scenario: December 31, 2005

	Total	3 Months or Less	>3–6 Months	>6–12 Months	>1–3 Years	>3–5 Years	>5–10 Years	>10–20 Years	>20 Years
Loans									
Prime Based	100,000	100,000							
Equity Credit Lines	25,000	25,000							
Fixed Rate >1 Yr		170,000	18,000	18,000	36,000	96,000	2,000		
Var Rate Mtg 1 Yr	55,000	13,750	13,750	27,500					
30-Yr Fix Mortgage	250,000	5,127	5,129	9,329	32,792	28,916	116,789	51,918	
Consumer	100,000	6,000	6,000	12,000	48,000	28,000			
Credit Card	25,000	3,000	3,000	6,000	13,000				
Investments									
Eurodollars	80,000	80,000							
CMOs FixRate	35,000	2,871	2,872	5,224	13,790	5,284	4,959		
U.S. Treasury	75,000		5,000	5,000	25,000	40,000			
Fed Funds Sold	25,000	25,000							
Cash & Due From Banks	15,000								15,000
Loan Loss Reserve	(15,000)								(15,000)
Non-Earning Assets	60,000								60,000
Total Assets	1,000,000	278,748	53,751	101,053	228,582	104,200	121,748	51,918	60,000
Deposits									
MMDAs	240,000	240,000							
Retail CDs	400,000	60,000	60,000	90,000	160,000	30,000			
Savings	35,000								35,000
NOW	40,000								40,000
DDA Personal	55,000								55,000
Comm'l DDA	60,000	24,000							36,000
Borrowings									
Treasury Tax & Loan	25,000	25,000							
L-T Notes Fixed Rate	50,000						50,000		
Fed Funds Purchased									
Non-Int. Bearing Liabilities	30,000								30,000
Capital	65,000								65,000
Tot Liab & Equity	1,000,000	349,000	60,000	90,000	160,000	30,000	50,000		261,000
Swap: Pay Fixed/ Receive Float		50,000			(25,000)	(25,000)			
Periodic GAP		(20,252)	(6,249)	11,053	43,582	49,200	71,748	51,918	(201,000)
Cumulative GAP		(20,252)	(26,501)	(15,448)	28,134	77,334	149,082	201,000	0

overnight rate. As such, the federal funds rate serves as the bank's benchmark interest rate. Chart A also presents implied forward rates from the market for federal funds futures contracts (market implied rates), which provide a consensus forecast of expected rates. FSB conducts earnings-sensitivity analysis across seven different rate environments (rate shocks) with the specific forecasts for federal funds in three rising (+1 percent, +2 percent, +3 percent) rate environments and three falling (−1 percent, −2 percent, −3 percent), as noted in Chart B. Rates are assumed to change gradually in each case. A 200 basis point (2 percent) rate change is calculated by cumulatively adding or subtracting approximately 17 basis points per month for one year from the most likely scenario and maintaining these levels during a second year of forecasts.

Importantly, FSB uses a base case interest rate forecast that is drawn from market-implied forecast rates. Examine Chart A in Exhibit 5.7. Note the dashed line that represents federal funds futures rates. Because the futures rate increase continuously the farther from the present, the market is expecting an increase in the federal funds rate. FSB uses the data appearing as the solid line as its base case interest rate environment. As such, it is a most likely scenario if rates track those expected in the marketplace. After 12 months the federal funds rate is expected to level off around 4 percent for most of the second year. Importantly, this framework is quite different from using constant (rates remain at current levels) rates as the base case.

Ignore for now the explanation of the data for interest rate swaps (third row of data from the bottom of Exhibit 5.6) except that the swaps effectively represent a rate-sensitive asset in the three months or less time bucket.[7]

[7]Note that the $50,000 reported for swaps in under three months effectively increases the periodic GAP without swaps of −$70,252 to a periodic GAP after swaps of −$20,252.

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EXHIBIT 5.7 Base Case Interest Rate Scenario and Rate Ramps

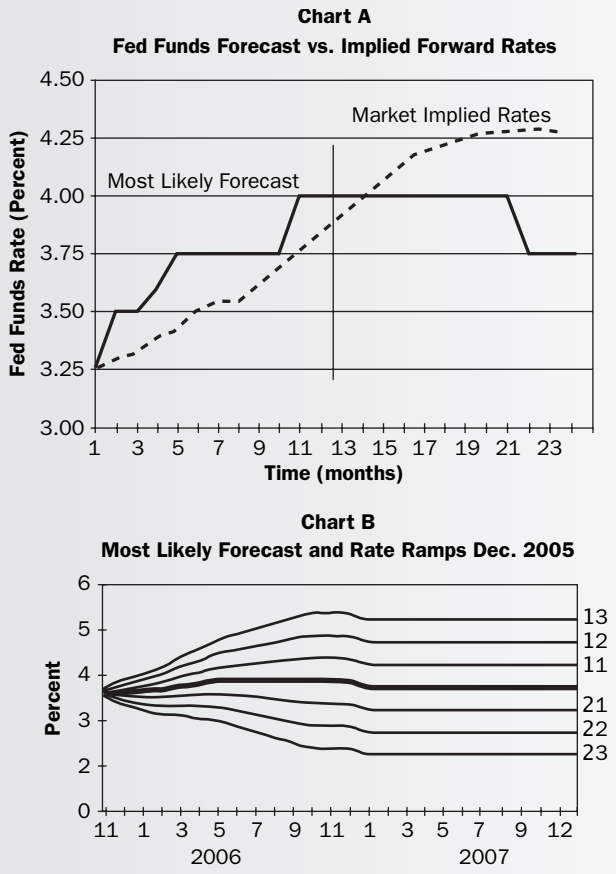

Exhibit 5.6 reports data for eight different time buckets from three months or less to more than 20 years. The majority of assets are in 30-year fixed-rate mortgages, fixed-rate loans with maturities over one year, prime-based loans, and consumer loans. In fact, the assets have a very long average contractual maturity as 25 percent are 30-year mortgages. The majority of deposits are retail CDs and MMDAs representing 64 percent of the total funding. According to this static GAP report, FSB's 1-year cumulative GAP equals −$15,448,000, or −1.64 percent of the $940 million in earning assets. Under static GAP analysis, the bank has little rate risk, but is positioned to lose modestly if interest rates increase through one year. Of course, this ignores the significant embedded options in the bank's mortgage holdings as well as other factors.

Exhibit 5.8 presents the results of earnings-sensitivity analysis. The top figure is for the year 2006—one year out, while the bottom figure is for the year 2007—two years out. The seven different interest rate environments are noted on the horizontal axis with the base case scenario in the middle.

The +100, +200, and +300 listings refer to the environments where the federal funds rate is assumed to be 1 percent, 2 percent, and 3 percent higher, respectively, than the base case (most likely) scenario. The three assumed lower-rate environments are identified to the left of the most likely case. The vertical axis lists the change in net interest income (NII) from the most likely scenario under each interest rate scenario. Note the zero value for the base case because it is the reference point for comparing forecasts from the other rate environments. Each forecast of net interest income incorporates assumed shifts in volume and composition of assets and liabilities, changes in spreads recognizing that asset yields and liability interest costs do not change coincidentally by the same amount, and different exercises of embedded customer options.

As indicated in Exhibit 5.8, net interest income will fall slightly if rates increase by 1 to 2 percent during the first year relative to the most likely scenario. However, if rates increase by 3 percent, NII will actually increase, contrary to that suggested by a negative GAP. If rates fall by 1 percent relative to the most likely case, net interest income increases

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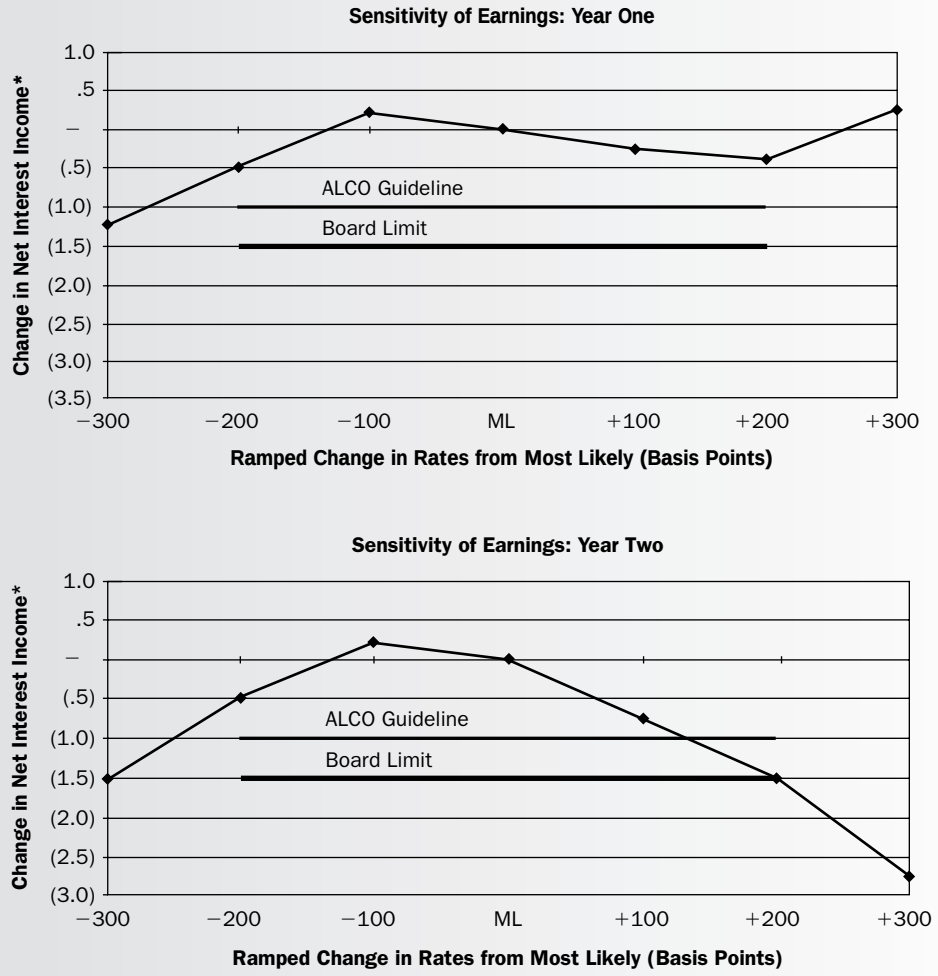
EXHIBIT 5.8 Earnings Sensitivity over One Year and Two Years versus Base Case Rate Scenario



*Millions of Dollars

slightly, but if rates fall 2 or 3 percent, NII also falls. This again contradicts the implications of the negative GAP from Exhibit 5.6. This is possible because the data in Exhibit 5.6 apply only to the most likely case. In each of the other rate scenarios, different amounts of assets and liabilities are rate sensitive based on the exercise of embedded options. Similarly, rates on each balance sheet item are assumed to change by different amounts when rates change.

EXPLANATION OF SENSITIVITY RESULTS. FSB's earnings-sensitivity results reflect two typical impacts of rate changes. The first is that embedded options potentially alter cash flows when the options go in the money. The second is that rates change by different amounts at different times. When rates increase in the analysis, asset yields are assumed to increase more than liability costs and sooner such that spreads widen. The opposite occurs when rates fall. Such differences are common because banks have some pricing power over loans tied to base rates and with their core deposits. Consider the times when the Federal Reserve increases the target federal funds rate. Banks typically increase their quoted prime rates immediately by the same amount as the increase in the federal funds rate. In turn, they lag any increases in their deposit rates. Spreads thus initially widen.

Regarding embedded options, FSB owns many fixed-rate mortgages subject to prepayment risk. As rates decline, borrowers will refinance these mortgages so that they are effectively called away from FSB. Generally, fixed-rate loans are refinanced and callable bonds are called such that more assets become rate sensitive. When rates rise, these loans and securities are not nearly as rate sensitive to where mortgage prepayments and other loan

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refinancings drop sharply and there are fewer rate-sensitive assets. Deposits are more rate sensitive when rates rise with more early withdrawals (RSLs increase). This shift may at least partially offset the impact of spreads widening. These same deposits are less rate sensitive (RSLs decrease) when rates fall, but the spread between earning asset yields and the cost of interest-bearing liabilities falls.

Under this structure, there is a different effective GAP for each rate scenario. If rates fall sharply by 2 or 3 percent, net interest income will fall because the effective GAP is positive as many assets with embedded options must be repriced. If rates rise sharply, loan prepayment options are not exercised but early withdrawal options are. For FSB, an assumed reduction in rates of 1 percent is actually consistent with rates being virtually constant as the federal funds rate would change from 3.25 percent initially to 3 percent, or 1 percent below that forecast at the end of 12 months. Net interest income is thus forecast to remain fairly stable. Still, if rates fall by 2 or 3 percent, FSB sees NII decline as the long-term mortgages prepay and the funds are invested at lower rates. Net interest income falls in the +1 percent and +2 percent cases because more liabilities reprice than assets as loan refinancings drop sharply. Net interest income rises in the +3 percent case because the spread widens and offsets the impact of a small GAP. These factors explain why net interest income might fall when rates fall and not change significantly when rates rise.

The bottom part of Exhibit 5.8 reveals the comparative forecasts under each scenario in the year 2007, or two years from the date of the report. Over this time frame, the bank loses in both sharply rising and falling rate environments. FSB no longer gains with a +3 percent rate move because the interest cost of liabilities catches up with the increased asset yields as banks cannot lag rate increases forever. Thus, the spread is no longer as large. This again reflects the fact that FSB's effective GAP becomes more negative in an increasing rate environment and positive in a declining rate environment. The key point is that this analysis clearly reveals potential volatility in net interest income over sharply different rate environments. Also, FSB sets ALCO guidelines and risk policy limits according to allowable earnings sensitivity as noted in Exhibit 5.8. The bank has a board of directors' limit of a maximum $1.5 million reduction in net interest income for any 2 percent rate move up or down over two years. The bank violates its risk guidelines according to forecasts of year two in a +3 percent environment. Steps would have to be taken to reduce the bank's risk exposure to meet these limits. In general, the greater is the variation in forecast net interest income across rate environments, the greater is interest rate risk.

Some banks and bank analysts refer to the summary results of a bank's earnings sensitivity as **earnings-at-risk** or **net interest margin simulation.** Most banks measure interest rate risk using this framework because it is easy to understand and because it focuses on earnings, which drive bank performance in the near term. Review the introduction to the chapter, which presents sensitivity data for PNC. As indicated, PNC's simulation at year-end 2004 produced an expected 0.5 percent reduction in net interest income if rates gradually increased by 1 percent in 2005. Net interest income would fall by xxx percent with a 1 percent gradual decrease in rates during 2005. The following year, net interest income would increase by xxx percent in a + 1 percent rate environment and decrease by 7.6 percent in a −1 percent rate environment. PNC loses the most in a falling rate environment (asset sensitive) two years out. The bank's rate risk appears to be small for 2005.

INCOME STATEMENT GAP

Many managers of community banks interpret their bank's interest rate risk using a simplified framework compared with comprehensive earnings-sensitivity analysis. They feel comfortable with this because the complexity and size of assets and liabilities does not change dramatically over short periods of time. They similarly do not have significant risk exposure with off-balance sheet transactions that significantly affects the bank's net interest income. The models do, however, recognize the existence of embedded options and the different speeds and amounts of repricing specific assets and liabilities when rates change.

One common practice is to calculate an **income statement GAP,** or **Beta GAP,** that takes some of these factors into account. Consider the rate-sensitivity report presented in Exhibit 5.9 for a bank with just under $30 million in total assets. This particular report uses the prime rate as the benchmark rate and contains two forecasts of the change in net interest income: one for an environment where the bank's prime rate is assumed to fall by 100 basis points and another when prime is assumed to increase by 100 basis points over the next year. The first three columns of data relate to the case where the prime rate falls. The **balance sheet GAP** is a 1-year cumulative GAP that reflects contractual repricing and indicates that the bank is liability sensitive in the amount of −$7,466,000, or almost 25 percent of assets. The second column of data provides information about each asset's or liability's **earnings change ratio (ECR).** As the footnote suggests, this figure indicates how the yield on each asset, and rate paid on each liability, is assumed to change relative to a 1 percent drop in the prime rate. Thus, the effective yield on federal agency securities is assumed to fall by 71 basis points (0.71 percent), while the effective yield on federal funds sold will fall by 96 basis points (0.96 percent) if prime falls by 1 percent. Not surprisingly, deposit rates lag such that they generally fall by smaller amounts relative to the 1 percent drop in prime. Note that MMDA rates are assumed to fall by 60 basis points. The third column of data reports the amount of each balance sheet item that

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EXHIBIT 5.9 Income Statement GAP and Earnings Variability

Amounts in Thousands Report Data as of September 30, 2002 Rate-Sensitive Assets	**Prime Down 100bp** **Balance Sheet GAP[a]**	**ECR[b]**	**Income Statement GAP**	**Prime Up 100bp** **Balance Sheet GAP***	**ECR[b]**	**Income Statement GAP**
	A	B	A × B	C	D	C × D
Loans						
Fixed Rate	$ 5,661	100%	$5,661	$5,661	100%	$5,661
Floating Rate	3,678	100%	3,678	3,678	100%	3,678
Securities						
Principal Cash Flows						
Agencies	200	71%	142	200	71%	142
Agy Callables	2,940	71%	2,087	300	60%	180
CMO Fixed	315	58%	183	41	51%	20
Fed Funds Sold	2,700	96%	2,592	2,700	96%	2,592
Floating Rate						
Total Rate-Sensitive Assets	$15,494		$14,343	$12,580		$12,273
Rate-Sensitive Liabilities						
Savings	$ 1,925	75%	$1,444	$ 1,925	5%	$ 96
Money Mkt Accts	11,001	60%	6,600	11,001	40%	4,400
NOW	2,196	80%	1,757	2,196	20%	439
Fed Funds Purch/Repo	0	96%	0	0	96%	0
CDs $ 100M	3,468	85%	2,948	3,468	85%	2,948
CDs , 100M	4,370	84%	3,671	4,370	84%	3,671
Total Rate-Sensitive Liabilities	$22,960		$16,420	$22,960		$11,554
Rate Sensitivity Gap (Assets-Liab)	($7,466)		$2,077	($10,380)		$719
Total Assets	$29,909		$29,909	$29,909		$29,909
GAP as a Percent of Total Assets	−24.96%		−6.94%	−34.71%		2.40%
Change in Net Interest Income			$20.8			$7.2
Change in Net Interest Margin			0.07%			0.02%
Net Interest Margin			5.20%			5.20%
Percentage Change in Net Interest Margin			1.34%			0.46%

[a]One year balance sheet GAP includes all balances that may change in rate in the next 12 months.

[b]The Earnings Change Ratio (ECR) is an estimate of the change in rate of a rate-sensitive instrument per 100 basis point move in prime.

will effectively be repriced at a 1 percent lower rate and equals the ECR times the balance sheet amount. These figures represent how much of the balance sheet amount will be effectively repriced by 1 percent less if the prime rate falls by 1 percent. The objective is to obtain an income statement GAP figure that indicates the net amount of assets or liabilities that effectively reprices 1 percent lower.

The bank's income statement GAP is listed at −$2,077,000, as the difference between $14,343,000 in effective RSAs that will reprice 1 percent lower and $16,420,000 in effective RSLs that will reprice 1 percent lower. This is an effective GAP estimate. As such, we can apply Equation 5.1 to interpret the impact on net interest income. Here, a 1 percent reduction in the prime rate will lead to an estimated $20,770 increase in net interest income and a corresponding 7 basis point increase in net interest margin.

$$\Delta\text{Net interest income} = -\$2{,}077{,}000(-0.01) = +\$20{,}770$$

The three columns of data at the right of Exhibit 5.9 refer to the estimated impact of a 1 percent increase in the prime rate over the next year. Note that in a rising rate environment, a smaller amount of callable agency

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securities is assumed to be rate sensitive because fewer securities will likely be called. Also, the ECRs for some of the assets and core deposit liabilities are different, reflecting the fact that effective reinvestment rates on agency callables and CMOs will not rise as much with slower prepayments, and the bank will not increase its deposit rates in line with increases in prime or by the same amount as they would be lowered in a falling rate environment. The net impact is that the bank's effective income statement GAP is smaller at $719,000. A 1 percent increase in prime will increase net interest income by an estimated $7,190. Importantly, different assumed changes in prime will produce different estimated changes in net interest income depending on the same factors that alter a bank's effective rate sensitivity of assets and liabilities.

MANAGING THE GAP AND EARNINGS-SENSITIVITY RISK

Effective GAP measures and the potential variation in net interest income indicate the general interest rate risk a bank faces. Equation 5.1 applies in the income statement GAP framework but not the general earnings-sensitivity framework. It generally suggests that if interest rates are expected to increase during the GAP period, a positive cumulative GAP will lead to an increase in net interest income. If rates are expected to fall, a negative GAP will lead to an increase in net interest income. The actual change in net interest income will meet expectations only if interest rates change in the direction and amount anticipated and if RSAs and RSLs are accurately forecast. Importantly, the size of the effective GAP, or the range of variation in net interest income, signifies how much risk a bank is taking. The larger is the absolute value of GAP, the greater is the change in net interest income for a given change in rates. The greater is the potential variation in net interest income from the base case, the greater is the risk.

The GAP model suggests that a bank that chooses not to speculate on future interest rates can reduce interest rate risk by obtaining a zero effective GAP or no variability in net interest income. The bank is fully hedged because its interest rate risk is negligible. Of course, this zero-risk position is rarely achieved and is rarely desired. Alternatively, a bank may choose to speculate on future interest rates and actively manage the GAP. Equation 5.1 suggests that a bank can systematically increase net interest income if it can accurately forecast rates and vary its effective GAP accordingly. If management expects rates to increase, it should become more asset sensitive. If it expects rates to decrease, it should become more liability sensitive.

Listed below are steps that banks can take to reduce risk in the context of effective GAP management.

1. Calculate periodic GAPs over short time intervals.
2. Match fund repriceable assets with similar repriceable liabilities so that periodic GAPs approach zero.
3. Match fund long-term assets with non-interest-bearing liabilities.
4. Use off-balance sheet transactions, such as interest rate swaps and financial futures, to hedge.

Management may alternatively choose to alter the rate sensitivity of assets and liabilities to take greater risk. Chapter 6 discusses the specific bets that management makes when it speculatively adjusts its effective GAP or earnings-sensitivity profile. Listed below are various ways to adjust the effective rate sensitivity of a bank's assets and liabilities on-balance sheet.

Objective	Approach
Reduce asset sensitivity	Buy longer-term securities. Lengthen the maturities of loans. Move from floating-rate loans to term loans.
Increase asset sensitivity	Buy short-term securities. Shorten loan maturities. Make more loans on a floating-rate basis.
Reduce liability sensitivity	Pay premiums to attract longer-term deposit instruments. Issue long-term subordinated debt.
Increase liability sensitivity	Pay premiums to attract short-term deposit instruments. Borrow more via non-core purchased liabilities.

The benefits and costs of these approaches are discussed at the end of Chapter 6.

SUMMARY

A bank's asset and liability management committee is responsible for monitoring and managing a bank's interest rate risk profile. This chapter initially introduces the traditional static GAP model as a means of measuring interest rate risk. It then extends the discussion to focus on earnings-sensitivity analysis, which essentially

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represents net income simulation under different assumed interest rate environments. It allows management to assess the sensitivity of net interest income to changes in balance sheet volume and composition, shifts in the relationship between asset yields and the costs of interest-bearing liabilities, and general shifts in the level of interest rates.

The earnings sensitivity framework is helpful in measuring the earnings impact when options embedded in bank loans, securities, and deposits are exercised. The analysis is critical in today's environment in which many banks have sold options on both sides of the balance sheet. Borrowers have the option to refinance loans and depositors have the option to withdraw funds prior to deposit maturity. As such, interest income and interest expense may vary sharply from that expected when interest rates change. Earnings sensitivity analysis provides a methodology for analyzing the range of potential outcomes from interest rate changes, shifts in balance sheet composition and the exercise of embedded options. The net result is an understanding of the relationship between how much net interest income might rise or fall over the next one to two years relative to potential interest rate changes and, thus, how much risk is assumed. It provides information regarding how management might position itself to gain if it wants to take on additional risk or how it might hedge if it wants to reduce overall risk.

Questions

1. List the basic steps in static GAP analysis. What is the objective of each?
2. Are the following assets rate sensitive within a 6-month time frame? Explain.
   a. 3-month T-bill
   b. Federal funds sold (daily repricing)
   c. 2-year Treasury bond with semiannual coupon payments
   d. 4-year fully amortized car loan with $450 monthly payments including both principal and interest (for the first 6 months, principal payments total $578)
   e. commercial loan priced at the bank's prime rate plus 2 percent
3. Consider the following bank balance sheet and associated average interest rates. The time frame for rate sensitivity is one year.

Assets	Amount	Rate	Liabilities & Equity	Amount	Rate
Rate sensitive	$3,300	7.3%	Rate sensitive	$2,900	3.8%
Fixed-rate	1,400	8.7%	Fixed-rate	1,650	6.1%
Nonearning	500		Nonpaying liabilities	650	
Total	$5,200		Total	$5,200	

   a. Calculate the bank's GAP, expected net interest income, and net interest margin if interest rates and portfolio composition remain constant during the year. This bank is positioned to profit if interest rates move in which direction?
   b. Calculate the change in expected net interest income and NIM if the entire yield curve shifts 2 percent higher during the year. Is this consistent with the bank's static GAP?
   c. Suppose that, instead of the parallel shift in the yield curve in part b, interest rates increase unevenly. Specifically, suppose that asset yields rise by 1 percent while liability rates rise by 1.75 percent. Calculate the change in net interest income and NIM. Is this uneven shift in rates more or less likely than a parallel shift?
   d. Suppose the bank converts $300 of rate-sensitive liabilities to fixed-rate liabilities during the year and interest rates remain constant. What would the bank's net interest income equal compared with the amount initially expected? Explain why there is a difference.
4. Suppose that your bank buys a T-bill that matures in 6 months and finances the purchase with a 3-month time deposit. The purchase price of the T-bill is $3 million financed with a $3 million deposit.
   a. Calculate the 6-month GAP associated with this transaction. What does this GAP measure indicate about interest rate risk in this transaction?
   b. Calculate the 3-month GAP associated with this transaction. Is this a better GAP measure of the bank's risk? Why or why not?
5. What is the fundamental weakness of the GAP ratio compared with GAP as a measure of interest rate risk?
6. Discuss the problems that loans tied to a bank's base rate present in measuring interest rate risk where the base rate is not tied directly to a specific market interest rate that changes on a systematic basis.

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7. Consider the following asset and liability structures:

County Bank

Asset: $10 million in a 1-year, fixed-rate commercial loan
Liability: $10 million in a 3-month CD

City Bank

Asset: $10 million in a 3-year, fixed-rate commercial loan
Liability: $10 million in a 6-month CD

   a. Calculate each bank's 3-month, 6-month, and 1-year cumulative GAP.
   b. Which bank has the greatest interest rate risk exposure as suggested by each GAP measure? Consider the risk position over the different intervals.

8. Consider the Rate-Sensitivity Report in Exhibit 5.6.
   a. Is First Savings Bank (FSB) positioned to profit or lose if interest rates rise over the next 90 days?
   b. Suppose that management has misstated the rate sensitivity of the bank's money market deposit accounts because the bank has not changed the rate it pays on these liabilities for six months and doesn't plan to change them in the near future. Will the bank profit if rates rise over the next 90 days?

9. Assume that you manage the interest rate risk position for your bank. Your bank currently has a positive cumulative GAP for all time intervals through one year. You expect that interest rates will fall sharply during the year and want to reduce your bank's risk position. The current yield curve is inverted with long-term rates below short-term rates.
   a. To reduce risk, would you recommend issuing a 3-month time deposit and investing the proceeds in 1-year T-bills? Will you profit if rates fall during the year?
   b. To reduce risk, would you recommend issuing a 3-month time deposit and making a 2-year commercial loan priced at prime plus 1 percent? Why?

10. Management at Bay Bank expects its net interest margin to equal 4.8 percent during the next year. It will allow variation in NIM of just 10 percent during the year and expects interest rates to either rise or fall by 2 percent. If management expects the bank to have $400 million in earning assets, determine how large its 1-year cumulative GAP can be to not exceed the allowable variation in NIM.

11. Each of the following potentially alters the rate sensitivity of the underlying instrument. Presumably there is an embedded option associated with each. Indicate when the option is typically exercised and how it affects rate sensitivity.
   a. Fixed-rate mortgage loan with a yield of 8 percent and 30-year final maturity.
   b. Time deposit with five years remaining to maturity; carries a fixed rate of 5 percent.
   c. Commercial loan with a 2-year maturity and a floating rate set at prime plus 2.5 percent. There is a cap of 9 percent representing the maximum rate that the bank can charge on the loan.

12. What information is available from earnings-sensitivity analysis that is not provided by static GAP analysis?

13. Exhibit 5.8 demonstrates that FSB loses in year two if rates either rise or fall sharply from the most likely scenario. Explain why in terms of when embedded options are expected to be exercised and what happens to spreads.

14. Interpret the following earnings-at-risk data. What does it suggest regarding the bank's risk exposure?

	Earnings-at-Risk	
Interest Rate Change (%)	**1 Year**	**2 Years**
+1% shock	+2.4%	+4.9%
−1% shock	−1.7%	−5.5%
−1% yield curve inversion	+1.1%	−2.6%

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15. Given the following information for E-Bank, calculate its income statement (effective) GAP. How much will net interest income change if the 1-year Treasury rate falls 1 percent?

Rate-Sensitive Assets	1-Year Balance Sheet GAP	ECR
Loans	$55,120,000	82%
Securities	$28,615,000	67%
Rate-Sensitive Liabilities		
MMDAs	$41,640,000	34%
NOWs	$37,260,000	90%
CDs ≥ 100,000	$20,975,000	85%

Problem

The following data are taken from the 2004 annual report for Synovus, which reported $xxx million in net interest income before provisions and $xxxx billion in assets at year-end. Review the information and determine the bank's risk exposure at the end of 2004 and 2003, respectively. The information for interest rate swaps represents the effect of off-balance sheet transactions used to hedge interest rate risk.

1. Interpret the periodic and cumulative interest-sensitivity gap information. Was the bank positioned to profit or lose if interest rates fell in 2005? Explain.
2. Interpret the GAP impact of interest rate swaps. Was the bank's net interest rate risk exposure greater or lower as a result of swap activity through 1 year? Explain. Did the bank use swaps to hedge or speculate when viewed in this context?
3. Examine GAP as a fraction of earning assets. Did the bank assume much risk at each year-end? Explain.

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