“The use of derivatives to manage interest rate risk in commercial banks”

AUTHORS	Soretha Beets
ARTICLE INFO	Soretha Beets (2004). The use of derivatives to manage interest rate risk in commercial banks. *Investment Management and Financial Innovations*, *1*(2)
RELEASED ON	Tuesday, 14 December 2004
JOURNAL	"Investment Management and Financial Innovations"
FOUNDER	LLC “Consulting Publishing Company “Business Perspectives”

The Use of Derivatives to Manage Interest Rate Risk in Commercial Banks

Soretha Beets[1]

Abstract

Interest rate risk can be seen as one of the most important forms of risk, that banks face in their role as financial intermediaries. Innovation in financial theory, increased computerization, and changes in foreign exchange markets, credit markets and capital markets have contributed to the need to supplement traditional methods to measure and manage interest rate risk with more recent methods. Interest rate risk can thus be controlled optimally by using of derivatives along with traditional methods, in order for banks to experience less interest rate uncertainty, and to increase their lending activities, which can result in greater returns and higher overall profitability.

1. Introduction

A commercial bank can serve as a financial intermediary in two ways. First, it can serve as a broker, in which it channels funds from surplus units to deficit units without modifying the rate-sensitivities. Second, it can serve as an asset transformer, in which it modifies the rate sensitivities to appease the deficit units. The bank's choice will depend on the uncertainty of interest rates and the cost of funds (Madura & Zarruk, 1995).

Interest rate risk is one of the most important forms of risk that banks face in their role as financial intermediaries (Hirtle, 1996). Nowadays, apart from traditional ways to measure and manage interest rate risk, derivatives are also used. Banks participate in derivative markets especially because their traditional lending and borrowing activities expose them to financial market risk and doing so can help them to hedge or reduce risk and to achieve acceptable financial performance (Brewer & Moser, 2001).

In section 2, the importance, the definition and the most important sources of interest rate risk will be discussed. Section 3 deals with the traditional approaches to interest rate risk management. Section 4 handles general information on derivatives as well as the management of interest rate risk by means of derivatives, and section 5 provides a conclusion.

2. Interest Rate Risk and Its Sources

Fundamental changes in the regulatory and market environment have made interest rate risk a vital issue (Schaffer, 1991). Interest rate risk is the potential for changes in interest rates to reduce bank's earnings and lower its net worth (Feldman & Smith, 2000).

Banks encounter interest rate risk in several ways. The primary and most often discussed source of interest rate risk stems from timing differences in the repricing of bank assets, liabilities and off-balance-sheet instruments. These repricing mismatches generally occur from either borrowing short-term to fund long-term assets or borrowing long-term to fund short-term assets (Wright & Houpt, 1996).

Another important source of interest rate risk arises from imperfect correlation in the adjustment of the rates earned and paid on different instruments with otherwise similar repricing characteristics. When interest rates change, these differences can give rise to unexpected changes in the cash flows and earnings spread among assets, liabilities and off-balance-sheet instruments of similar maturities or repricing frequencies (Wright & Houpt, 1996).

An additional and increasingly important source of interest rate risk is the presence of options in many bank asset, liability and off-balance-sheet portfolios. Options may exist as standalone contracts that are traded on exchanges or arranged between two parties or they may be embedded within loan or investment products. Instruments with embedded options include various

[1] Department of Economics, University of the Free State Bloemfontein, South Africa.

types of bonds and notes with call or put provisions, loans such as residential mortgages that give borrowers the right to prepay balances without penalty, and various types of deposit products that give depositors the right to withdraw funds at any time without penalty. If not adequately managed options can pose significant risk to a banking institution because the options held by bank customers, both explicit and embedded, are generally exercised at the advantage of the holder and to the disadvantage of the bank. Moreover, an increasing array of options can involve significant leverage, which can magnify the influences of option positions on the financial condition of a bank (Wright & Houpt, 1996).

It is essential that banks accept some degree of interest rate risk. However for a bank to profit consistently from changes in interest rates requires the ability to forecast interest rates better than the rest of the market (Schaffer, 1991). The challenge for banks is thus not only to forecast interest rate risk, but also to measure and manage it in such a way that the compensation they receive is adequate for the risks they incur (Feldman & Schmidt, 2000). To measure and manage interest rate risk, various instruments, from gap management to derivative, can be used.

3. Traditional Ways to Measure and Manage Interest Rate Risk

3.1. Gap analysis

Regulators and banks employ a wide variety of techniques to measure and manage interest rate risk (Feldman & Schmidt, 2000). A traditional measure of interest rate risk is the maturity gap between assets and liabilities, which is based on the repricing interval of each component of the balance sheet. To compute the maturity gap, the assets and liabilities must be grouped according to their repricing intervals. Within each category, the gap is then expressed as the rand amount of assets minus those of liabilities. Although the maturity gap suggests how a bank's condition will respond to a given change in interest rates (Schaffer, 1991), and thus permits the analyst to get a quick and simple overview of the profile of exposure (Hudson, 1992), the downside of this approach is that it doesn't offer a single summary statistic that expresses the bank's interest rate risk. It also omits some important factors, for example, cash flows, unequal interest rates on assets and liabilities, and initial net worth (Schaffer, 1991).

3.2. Duration analysis

Duration can also be used and is usually presented as an account's weighted average time to repricing, where the weights are discounted components of cash flow. A bank will be perfectly hedged when the duration of its assets, weighted by rands of assets, equals to the duration of its liabilities, weighted by rands of liabilities. The difference between these two durations is called the duration gap, and the larger the bank's duration gap is, the more sensitive a bank's net worth will be to a given change in interest rates (Schaffer, 1991). The advantages of duration analysis is that it provides a simple and accurate basis for hedging portfolios, it can be used as a standard of comparison for business development and funding strategies, and it provides the essential elements for the calculation of interest rate elasticity and price elasticity (Cade, 1997). Several technical factors however, make it difficult to apply duration analysis correctly. First, the detailed information on cash flows required for duration analysis presents a computational and accounting burden. Second, the true cash flow patterns are not well known for certain types of accounts, such as demand deposits, and they are likely to vary with the size or timing of a change in market interest rates, making it harder to quantify the associated interest rate risk. Finally, a more complex version of duration is needed to reflect the fact that, long-term interest rates are not always equal to short-term interest rates and may move independently from each other (Schaffer, 1991).

3.3. Simulation analysis

Some banks simulate the impact of various risk scenarios on their portfolios (Schaffer, 1991). In other words, simulation analysis involves the modelling of changes in the bank's profitability and value under alternative interest rate scenarios (Payne et al., 1999). The advantages of this technique are that it permits an easy examination of a bank's interest rate sensitivities and strategies (Cade, 1997), and it replicates the same bottom line as duration theory while bypassing the more sophisticated mathematical deviations. The drawback of this approach is that the need for detailed cash flow data for assets and liabilities are not satisfied and computers alone cannot solve the problem of forecasting cash-flow patterns for some assets and liabilities (Shaffer, 1991).

3.4. Scenario analysis

Another approach is to choose interest rate scenarios within which to explore portfolio effects (Schaffer, 1991). Different scenarios must thus be set out and it must be investigated what the bank stand to loose or gain under each of them. Advantages of this approach are that it can be applied to most kinds of risks and that it is less limited by data availability. Schaffer (1991) states that this approach is thus more flexible and it requires less effort.

Unfortunately traditional measures of interest rate risk, while convenient, provide only rough approximations at best (Shaffer, 1991) and derivatives must be used in addition.

4. More Recent Ways to Measure and Manage Interest Rate Risk

Innovation in financial theory and increased computerization, along with changes in the foreign exchange markets, the credit markets and the capital markets over time, have contributed to the growth of financial derivatives (Sangha, 1992).

Financial derivatives are instruments whose value is derived from one or more underlying financial assets. The underlying instruments can be a financial security, a securities index, or some combination of securities, indices and commodities (Sangha, 1992).

Derivatives in their simplest form include forwards, futures, options and swaps and they can be defined as follows (Wilson & Holmann, 1996):

- Forward contract: This is a legal agreement between two parties to purchase or sell a specific quantity of a commodity, government security or foreign currency or other financial instrument at a price specified now, with delivery and settlement at a specified future date.
- Futures contract: This is an agreement to buy and sell a standard quantity and quality of a commodity, financial instrument, or index at a specified future date and price.
- Interest rate swap: This is an agreement between two parties to exchange interest payments on a specified principal amount for a specified period.
- Option: This is a contract conveying the right, but not the obligation to buy or sell a specified item at a fixed price within a specified period. The buyer of the option pays a non-refundable fee, called a premium, to the writer of the option and the maximum loss is the premium paid for the option. Options can be divided into caps, collars and floors:
    - Cap: This gives the purchaser protection against rising interest rates and sets a limit on interest rates and amount of interest that will be paid.
    - Floor: This sets a minimum below which interest rates cannot drop.
    - Collar: By purchasing a cap and simultaneously selling a floor, a bank gives up some potential downside gain to protect against a potential upside loss.

Commercial banks have become market makers (intermediaries) in interest rate risk management products, such as, futures contracts, forward rate agreements, interest rate swaps, and options such as caps, collars and floors. Banks will thus intermediate between long and short positions and they can assume the role of the clearinghouse, hedging residual exposure resulting from an imbalance between the opposing sides in the transaction (Brown & Smith, 1988). The bank thus transforms the nature of its sources and uses of funds. This transformation takes place on several dimensions: denomination, maturity, interest payment, and rate reset periodicity among others. The bank will also tailor the contracts to meet the needs of its depositors as well as its borrowers and it will design contracts that stand between those firms which seek to hedge against rising rates and those which seek to hedge against falling rates (Brown & Smith, 1988).

There are several hedging strategies that can be used to manage interest rate risk:

- Cash flow hedge: This is a hedge against forecasted transactions or the variability in the cash flow of a recognized asset or liability (Landsberg, 2002, p. 11). In this hedge, a variable rate loan can, for example, be converted to a fixed rate loan. It can also hedge the cash flows from returns on securities to be purchased in the future, the cash flow from the future sale of securities, or the cash flow of interest received on an existing loan (Rasch & Colquitt, 1998).
- Market value hedge: This is a hedge against exposure to changes in the value of a recognized asset or liability (Landsberg, 2002). In this type of hedge a fixed-rate can, for example, be converted to a variable rate (Rasch & Colquitt, 1998).
- Foreign currency hedge: A forward contract entered into to sell the foreign currency of the foreign operation would, for example, hedge the net investment. Therefore, if the exchange rate decreases, the net investment would also decrease. The forward contract would however increase in value because the currency could be purchased at a lesser amount than the locked-in selling price (Jones et al., 2000).

According to Sinkey (2002) the idea behind hedging interest rate risk with derivatives is to offset or reduce losses in cash or spot markets with gains in derivative markets and hedging can be applied to individual assets (a micro hedge) or to a bank's balance sheet (a macro hedge). An example of micro-hedging on the liability side of the balance sheet occurs when a financial institution attempting to lock in the cost of funds to protect itself against a possible rise in short-term interest rates, takes a short (sell) position in futures contracts on certificates of deposit or treasury bills. It will be best to pick a futures or forward contract whose underlying deliverable asset is closely matched to the asset (or liability) position being hedged, to prevent basis risk (uncorrelated prices). An example of a macro-hedge is when a balance-sheet exposure is fully hedged by constructing, for example, a futures position, such that if interest rates rise, the bank will make a gain (Saunders & Cornett, 2003).

Examples of hedging interest rate risk by means of forwards, futures, options and swaps will be further discussed.

4.1. Forwards

Suppose that a bank's money manager holds a 20-year, R 1 million face value bond on the balance sheet. At time 0, these bonds are valued by the market at R 97 per R 100 face value, or R 970 000 in total. Further assume that a manager receives a forecast that interest rates are expected to rise by 2% of the current level of 8 to 10% over the next three months. Rising rates mean that bond prices will fall and the manager thus stands to make a capital loss on the bond portfolio. The 20-year maturity bonds' duration is calculated to be exactly 9 years. A capital loss or change in bond values can be predicted with the following formula:

$$\Delta P / P = -D \times \Delta R / (1 + R), \tag{1}$$

where: ΔP = capital loss on bonds;
P = initital value of bond position;
Δ = duration of the bonds;
ΔR = change in forecast yield;
1 + R = 1 + the current yield on 20-year bonds.

Thus: ΔP / R 970 000 = - 9 x (0.02 / 1.08)

$\therefore\ \Delta P =$ - 161 667,67

As a result, the bank's manager expects to incur a capital loss on the bond portfolio of R 161 666,67 (or 16,67%) or as a drop in price from R 97 per R 100 face value to R 80.833 per R 100 face value. To offset this loss, the manager may hedge this position by taking an off-balance-sheet hedge, such as selling R I million face value of 20-year bonds delivered in three months' time. If the forecast of a 2% rise in interest rates is true, the portfolio manager's bond position has fallen in value by 16,67%, equal to a capital loss of R 161 666,67. After this rise in interest rates the manager can buy R 1 million face value of 20-year bonds in the spot market at R 80,33 per R 100 of face value, a total cost of R 808 333, and deliver these bonds to the forward contract buyer. The forward contract buyer agreed to pay R 97 per R 100 of face value for the R 1 million of face value bonds delivered or R 970 000. As a result the portfolio manager makes a profit on the forward transaction of R 970, 000 – R 808,33 = R 161,67. The on-balance-sheet loss of R 161 667 is thus exactly offset by the off-balance-sheet gain of R 161 667 from selling the forward contract. The hedge allows the bank's manager to protect against interest rate changes even if they are unpredictable. The bank's interest rate risk exposure is zero, and it can be said that they have immunized their assets against interest rate risk (Saunders & Cornett, 203).

4.2. Futures

The number of futures contracts that a financial institution should buy or sell depends on the size and direction of its interest rate risk exposure and the return-risk trade-off from hedging the risk. A financial institution's net worth exposure to interest rate shocks is directly related to its leverage adjusted duration gap as well as its asset size:

$$\Delta E = -[D_A - kD_L] \times A \times \Delta R / (1 + R), \qquad (2)$$

where: ΔE = change in a bank's net worth;
D_A = duration of the asset portfolio;
D_L = duration of the liability portfolio;
k = ratio of a bank's liabilities to assets;
A = size of a bank's asset portfolio;
ΔR / (1 + R) = shock to interest rates.

If D_A = 5 years and D_L = 3 years and it is supposed that a bank's manager receives information from an economic forecasting unit that interest rates are expected to rise from 10% to 11% over the next year, the financial institutions' initial balance sheet is:

Table 1

Financial institution's initial balance sheet

Assets (in millions)	Liabilities (in millions)
A = R 100	L = R 90
	E = R 10
R 100	R 100

and $k = L / A = 0.9$. The potential loss to the bank's net worth if the forecasts of rising rates are true will be:

$$\Delta E = -(D_A - D_L) \times A \times \Delta R / (1 + R), \qquad (3)$$

$$\therefore \Delta E = - (5 - (0.9 \text{ x } 3)) \text{ x } R\ 100 \text{ x } 0.01 / 1.1$$
$$= - R\ 2.091 \text{ million.}$$

The bank can thus expect to lose R 2.091 million in net worth if the interest rate forecast turns out to be correct. Since the bank started with a net worth of R 10 million, the loss of R 2.091 million is almost 21% of its initial net worth position. The bank manager's objective to fully hedge the balance sheet exposure would be fulfilled by constructing a futures position such that if interest rates do rise by 1% to 11%, the bank will make a gain on the futures position that just offsets the loss of balance sheet net worth of R 2.091 million. When interest rates rise, the price of a futures contract falls since its price reflects the value of the underlying bond that is deliverable against the contract. The amount by which a bond price falls when interest rates rise depends on its duration. Thus, the sensitivity of the price of a futures contract depends on the duration of the deliverable bond underlying the contract or:

$$\Delta F / F = -D_F \left(\Delta R / (1 + R)\right), \tag{4}$$

where: ΔF = change in rand value of futures contract;
F = rand value of the initial futures contracts;
D_F = duration of the bond to be delivered against the futures contracts;
ΔR = expected shocks to interest rates;
$1 + R$ = 1 + the current level of interest rates;
This can be rewritten as:

$$\Delta F = -D_F \text{ x } F \text{ x } (\Delta R / (1 + R)).$$

To see the rand loss or gain more clearly, the initial rand value position in futures contracts can be decomposed in two parts: $F = N_F \text{ x } P_F$. The rand value of the outstanding futures position depends on the number of contracts bought or sold (N_F) and on the price of each contract (P_F). N_F is positive when the futures contracts are bought and is assigned a negative value when contracts are sold. A short position in the futures contract will provide a profit when interest rates rise. Therefore a short position in the futures market is the appropriate hedge when the bank stands to loose on the balance sheet if interest rates are expected to rise (positive duration gap). A long position in the futures market produces a profit when interest rates fall. Therefore a long position is the appropriate hedge when the bank stands to loose on the balance sheet if interest rates are expected to fall (negative duration gap).

The number of futures contracts to buy or sell in a hedge can be given by:

$$N_F = (D_A - kD_L)A / D_F \times P_F\,. \tag{5}$$

If a bank, thus, for example, takes a short position in a futures contract when rates are expected to rise, it will seek to hedge the value of its net worth by selling an appropriate number of futures contracts (Saunders & Cornett, 2003).

4.3. Options

A financial institution's net worth exposure to an interest rate shock could be represented as:

$$\Delta E = -(D_A - kD_L) \times A \times \Delta R / (1 + R), \tag{6}$$

where: ΔE = change in the bank's net worth;
$(D_A - kD_L)$ = bank's duration gap;
A = size of the bank's assets;
$\Delta R / (1 + R)$ = Size of the interest rate shock;
k = bank's leverage ratio (L/A).

The bank's manager is supposed to wish to determine the optimal number of put options to buy to insulate the bank against rising interest rates, a bank with a positive duration gap would lose on-balance-sheet net worth when interest rates rise. In this case, the manager of the bank will buy put options. The manager thus wants to adopt a put option position to generate profits that just offset the loss in net worth due to an interest rate shock position. If ΔP is the total change in the value of a put option in T-bonds, it can be decomposed to:

$$\Delta P = \left(N_p \times \Delta p\right), \tag{7}$$

where: N_p = the number of R 100 000 put options on T-bond contracts to be purchased

Δp = the change in the rand value for each R 100 000 face value T-bond put option contract.

The change in the rand value of each contract (Δp) can be further decomposed into:

$$\Delta p = dp / dB \times dB / dR \times \Delta R . \tag{8}$$

The term, dp/dB, shows the change in the value of a put option for each R 1 rand change in the underlying bond. This is called the delta of an option and it lies between 0 and 1. For put options the delta has a negative sign since the value of the put option falls, when bond prices rise. The term, dB/dR, shows how the market value of the bond changes if interest rates rise by one basis point. This value of one basis point term can be linked to duration:

$$dB / B = -MD \times dR . \tag{9}$$

That is, the percentage change in the bond's price for a small change in the interest rate, is proportional to the bond's modified duration. The above equation can be rearranged as:

$$dB / dR = -MD \times B . \tag{10}$$

Thus, the term dB/dR is equal to minus the modified duration of the bond (MD), times the current market value of the T-bond (B) underlying the put option contract, and the equation, $\Delta p= dp/dB \text{x} dB /dR \text{x} \Delta R$ can be rewritten as:

$$\Delta p = \left[\left(-\delta\right) \times \left(-MD\right) \times B \times \Delta R\right], \tag{11}$$

where ΔR = the shock to interest rates.

Since $MD = D / (1 + R)$, the equation, $\Delta p = [(-\delta) \text{ x } (-MD) \text{ x } B \text{ x } \Delta R$, can be rewritten as:

$$\Delta p = \left[\left(-\delta\right) \times \left(-D\right) \times B \times \left(\Delta R / 1 + R\right)\right]. \tag{12}$$

Thus the change in the total value of a put position (ΔP) is:

$$\Delta P = N_p \times \left[\delta \times D \times B \times \left(\Delta R / \left(1 + R\right)\right)\right]. \tag{13}$$

The term in brackets is the change in the value of one R 100 000 face value T-bond put option as rates change, and N_p is the number of put option contracts. To hedge net worth exposure, it is required that the profit on the balance sheet put options (Δp) must offset the loss of on-balance sheet net worth ($-\Delta E$) when interest rates rise and bond prices thus fall. That is:

$$\Delta P = -\Delta E , \tag{14}$$

$$\therefore N_p \text{ x } [\delta \text{ x } D \text{ x } B \text{ x } (\Delta R / (1 + R))] = [D_A - kD_L] \text{ x } A \text{ x } (\Delta R / (1 + R)). \tag{15}$$

Cancelling $\Delta R / (1 + R)$ on both sides:

$$N_p \times \left[\delta \times D \times B\right] = \left[D_A - kD_L\right] \times A . \tag{16}$$

Solving for N_p, the number of put options to buy will be:

$$N_p = \left[(D_A - kD_L) \times A\right] / \left[\delta \times D \times B\right]. \tag{17}$$

Suppose that a bank's balance sheet is such that $D_A = 5$, $D_L = 3$, $k = 0.9$ and $A = R$ 100 000 million and rates are expected to rise from 10% to 11% over the next six months. This would result in a *R* 2.09 million loss in net worth to the bank. Further it must also be supposed that the delta of the put option is 0.5. That indicates that the option is close to being in the money, $D = 8.82$ for the bond underlying the put option contract, and that the current market value of *R* 100 000 faces value of long-term treasury bonds underlying the option contract, *B*, equals *R* 97 000. Solving for N_p, the number of put option contracts to buy will be:

$$N_P = R\ 230\ 000\ 000 / [\ 0.5 \text{ x } 8.82 \text{ x } R\ 97\ 000]$$
$$= R\ 230\ 000\ 000 / R\ 427\ 770$$
$$= 537.672.$$

If the bank slightly under-hedges, this will be rounded down to 537 contracts. If rates increase from 10% to 11%, the value of the financial institution's put options will change by:

$$\Delta P = 537 \text{ x } [0.5 \text{ x } 8.82 \text{ x } R\ 97\ 000 \text{ x } (0.01 / 1.1)]$$
$$= R\ 2{,}09 \text{ million.}$$

It thus just offsets the loss in net worth on the balance sheet. The total premium cost to the bank of buying these puts is the price of each put times the number of puts:

$$\text{Cost} = N_p \text{ x Put premium per contract.} \tag{18}$$

If it is supposed that *T*-bond put option premiums are quoted at 2,5 per *R* 100 of face value for the nearby contract or *R* 2500 per *R* 100 000 put contract, then the cost of hedging the gap with put options will be:

$$\text{Cost} = 537 \text{ x } R\ 2500$$
$$= R\ 1\ 342\ 500 \text{ or just over } R\ 1.3 \text{ million.}$$

The total assets were assumed to be *R* 100 million. If rates increase as predicted, the bank's gap exposure results in a decrease in net worth of *R* 2.09 million. This decrease is offset with a *R* 2.09 million gain on the put options position held by the bank. The financial institution hedged the interest rate risk exposure perfectly because the basis risk is assumed to be zero. That is, the change in interest rates on the balance sheet is assumed to be equal to the change in the interest rate on the bond underlying the option contract. The introduction of basis risk means that the bank must adjust the number of option contracts it holds to account for the degree to which the rate on the option's underlying security moves relative to the spot rate on the asset or liability the bank is hedging. Allowing basis risk to exist, the equation used to determine the number of put options to buy to hedge interest rate risk becomes:

$$N_p = \left[(D_A - kD_L) \times A\right] / \delta \times D \times B \times br. \tag{19}$$

Where *br* is a measure of the volatility of interest rates (R_b) on the bond underlying the options contract relative to the interest rate that impacts the bond on the financial institution's balance sheet, *R*. That is:

$$br = (\Delta R_b / 1 + R_b) / (\Delta R / (1 + R)). \tag{20}$$

If it is supposed that the basis risk, *br*, is 0.92, the number of put option contracts needed for the hedge is:

$$N_p = 230\ 000\ 000 / (0.5 \text{ x } 8.82 \text{ years x } R\ 97\ 000 \text{ x } 0.92) = 584.4262.$$

Additional put option contracts are thus needed to hedge interest rate risk because interest rates on the bond underlying the option contract do not move as much as interest rates on the bond held as an asset on the balance sheet (Saunders & Cornett, 2003).

Option-based interest rate derivatives can also be used to put a cap on interest expenses, without foregoing the potential benefit of declining rates, to put a floor under interest rate revenues, without foregoing the upside potential of rising rates, or to lock in (hedge) a bank's spread, a collar (Sinkey, 2002).

- Cap: The most common use of an interest rate cap is by a bank that is trying to limit its exposure on a variable rate liability, such as a revolving credit or a floating-rate note. While paying a fixed rate on a swap agreement would also serve the same purpose, the advantage of the cap is that it limits the upside cost of funding without removing the benefit that would accrue to the firm on a particular settlement date.
- Floor: Since interest rate caps are typically used to hedge the exposure associated with a floating-rate liability, it is natural to think of interest rate floors as providing a hedge to the holder of a floating rate asset. An interest rate floor can thus be thought of as an insurance policy for the floating rate asset that becomes more expensive as the guaranteed level of return increases.
- Collar: The natural concern of a bank with a variable rate liability is to limit the extent of its exposure to rising costs. This concern can be managed by purchasing an interest rate cap. In addition, it is possible for the bank to sell a floor in order to obtain some or all of the funds necessary to buy the cap. Since the cap provides the desired protection, the notional principal on the cap is set equal to the level of the funding liability. Also for any particular ceiling rate, market conditions will dictate the price of the cap, and so the net cost of the hedge will depend upon the characteristics of the floor being sold. The bank will have to decide on two variables when selecting the floor agreement, the floor rate and the notional principal. Depending on the variable it first sets, the firm can create an interest rate collar or an interest rate participation agreement. Interest rate collars are thus based on the concept that the bank selects the notional principal on the floor to be equal to that of the cap. Having done so, any desired level of net expense can be achieved by selecting a floor rate sufficient to yield the necessary price.

4.4. Swaps

Two financial institutions must be considered. The first is a money center bank that has raised $ 100 million of its funds by issuing four-year, medium-term notes with 10% annual fixed coupons rather than relying on short-term deposits to raise funds. On the asset side of its portfolio, the bank makes commercial and industrial loans where rates are indexed to annual changes in the London Interbank Offered Rate (LIBOR). As a result of having floating-rate loans and fixed-rate liabilities in its asset-liability structure, the money center bank has a negative duration gap, that is, the duration of its assets is shorter than the duration of its liabilities. One way for the bank to hedge this exposure is to shorten the duration or the interest rate sensitivity of its liabilities by transforming them into short-term floating rate liabilities that better match the duration characteristics of its asset portfolio.

The bank can make changes either on or off the balance sheet. On the balance sheet the bank could attract an additional $ 100 million in short-term deposits that are indexed to the LIBOR rate (say, LIBOR, plus 2.5%) in a manner similar to its loans. The proceeds of these deposits can be used to pay of the medium-term notes. This reduces the duration gap between the assets and liabilities. Alternatively the bank can go off the balance sheet, and sell an interest rate swap, that is, enter into a swap agreement to make the floating-rate payment side of a swap agreement.

The second party in the swap is a thrift institution (savings bank) that has invested $ 100 million in fixed-rate residential mortgages of long duration. To finance this residential mortgage portfolio, the savings bank has had to rely on short-term certificates of deposit (CDs) with an average duration of one year. On maturity, these CDs have to be rolled over at the current market rate. Consequently, the savings bank's asset-liability balance sheet structure is the reverse of the money center banks'. The savings bank could hedge its interest rate risk exposure by transforming the short-term floating-rate nature of its liabilities into fixed-rate liabilities that better match the long-term maturity/duration structure of its assets. On the balance sheet, the thrift could issue long-term notes with a maturity equal or close to that of the mortgages. The proceeds of the sales of the notes can be used to pay of the CDs and reduce the duration gap. Alternatively the thrift can buy a swap and take the fixed payment side of a swap agreement. The opposing balance sheet and interest rate risk exposure of the money center bank and the savings bank provide the necessary conditions for an interest rate swap between the two parties. This swap agreement can be arranged directly between the two parties. However, it is likely that a financial institution – another bank or an investment bank – would act as either a broker or an agent, receiving a fee for bringing the two parties together or to intermediate fully by accepting the credit risk exposure and guaranteeing the cash flows underlying the swap contract. By acting as a principal as well as an agent, the financial institution can add a credit risk premium to the fee. However, the credit risk exposure of a swap to a financial institution is somewhat less than that of a loan. Conceptually, when a third party fully intermediate the swap, that party is really entering into two separate swap agreements – one with the money center bank and one with the savings banks.

For simplicity, a plain vanilla fixed-floating rate swap, where a third party intermediary acts as a simple broker or an agent by bringing together two financial institutions with opposing interest rate risk exposure to enter into a swap agreement, will be considered. Suppose that the value of a swap is $ 100 million – equal to the assumed size of the money center medium term note issue – and the maturity of four years is equal to the maturity of the bank's note liabilities. The annual coupon cost of these note liabilities is 10%, and the money center bank's problem is that the variable rate on its assets may be insufficient to cover the cost of meeting coupon payments if market interest rates, and therefore asset returns, fall. By comparison, the fixed returns on the thrift's mortgage asset portfolio may be insufficient to cover the interest cost of its CDs if market rates rise. As a result, the swap agreement might dictate that the thrift send fixed payments of 10% per annum of the notional $ 100 million value of the swap to the money center bank to allow the bank to cover the coupon interest payments on its note issue fully. In return, the money center bank sends annual payments indexed to one-year LIBOR to help the thrift cover the cost of refinancing its one-year renewable CDs. Suppose further that the one-year LIBOR is currently 8% and the money center bank agrees to send annual payments at the end of each year equal to the one-year LIBOR plus 2% to the thrift. The expecting net financing costs are as follows:

Table 2

Expecting net financing costs

	Money center bank	Thrift
Cash outflows from balance sheet financing	- 10 % x $ 100	- (CD) x $ 100
Cash inflows from swap	10 % x $ 100	(LIBOR + 2 %) x $ 100
Cash outflows from swap	- (LIBOR + 2 %) x $ 100	-10 % x $ 100
Net cash flows	- (LIBOR + 2 %) x $ 100	- (8 % + CD Rate – LIBOR) x $ 100
Rate available on: Variable-rate debt Fixed-rate debt	LIBOR + 2,5 %	12 %

In the absence of default / credit risk, only the money center bank is really fully hedged. This happens because the annual 10% payments it receives from the savings bank at the end of each year, allows it to meet the promised 10% coupon rate payment to its note holders regardless of the return it receives on its variable rate assets. On the contrary, the savings bank receives variable rate payments based on LIBOR plus 2%. However, it is quite possible that the CD rate the savings bank has to pay on its deposit liabilities does not exactly track the LIBOR-indexed payments sent by the money center bank. That is, the savings bank is subject to basis risk exposure on the swap contract. There are two possible sources of this basis risk. First, CD rates do not exactly match the movements of the LIBOR rates over time, since the former are determined in the domestic money market and the latter in the Eurodollar market. Second, the credit / default risk premium on the savings bank's CDs may increase over time, thus the 2% add-on to LIBOR may be insufficient to hedge the savings bank's cost of funds. The savings bank might be better hedged by requiring the money center banks to send it floating payments based on the domestic CD rate rather than LIBOR. To do this the money center bank would probably require additional compensation since it would then be bearing basis risk. Its asset returns would be sensitive to LIBOR movements while its swap payments were indexed to local CD rates.

There must be distinguished between how the swap should be priced at time 0 (now), that is, how the exchange rate of fixed for floating is set when the swap agreement is initiated, and the actual realized cash flows of the swap. Assume that the realized or actual path of interest rates (LIBOR) over the four-year life of the contract will be:

Table 3

The realized path of interest rates

End of the year	LIBOR
1	9
2	9
3	7
4	6

The money center bank's variable payment to the thrift was indexed to these rates by the formula: (LIBOR + 2 %) x \$ 100 million. On the contrary, the fixed annual payment that the thrift made to the money center bank were the same each year: 10 % x \$ 100 million. The actual or realized cash flows among the two parties over the four years is indicated in the table below:

Table 4

The realized cash flows among two parties

End of year	One-year LIBOR (%)	One-year LIBOR + 2 % (%)	Cash payment by money center bank	Cash payment by savings bank	Net payment made by money center bank
1	9	11	\$ 11	\$ 10	\$ + 1
2	9	11	11	10	+ 1
3	7	9	9	10	- 1
4	6	8	8	10	- 2
Total			\$ 39	\$ 40	\$ - 1

The savings bank's net gains from the swap in years 1 and 2 are \$ 1 million per year. The enhanced cash flow offsets the increased cost of refinancing its CDs in a higher interest rate environment, that is, the savings bank is hedged against rising rates. By contrast, the money center bank makes net gains on the swap in years 3 and 4 when rates fall, thus, it is hedged against falling interest rates. The positive cash flow from the swap offsets the decline in the variable returns on the money center bank's asset portfolio. Overall, the money center bank makes a net dollar gain of $ 1 million in nominal dollars, and its true realized gain would be the present value of this amount (Saunders & Cornett, 2003).

4.5. Futures, forwards and swaps

The values of contracts based on futures, forwards, or swaps move proportionately to the value of the underlying asset. Because a LRBA (liabilities reprice before assets) bank is vulnerable to an unexpected increase in interest rate risk, if rates rise, it loses money in the cash market. By buying interest rate futures or forwards or by engaging in an interest rate swap in which the LRBA bank pays fixed and receives floating rate, positive cash flows are generated by the particular interest rate derivative when the interest rates rise. If the hedge is perfect, then the losses in the cash market will be offset exactly by the positive cash flows in the derivatives markets. If the hedge is less than perfect, then losses are not offset completely and the LRBA bank's net exposure shows a vulnerability to unexpected increases in interest rates (Sinkey, 2002).

An ARBL (assets reprice before liabilities) bank can also be vulnerable to an unexpected decrease in interest rates, and this means that the bank will lose money in the cash market if rates decline. By selling interest rate forwards, futures or by engaging in an interest rate swap in which the ARBL bank pays floating and receives fixed, positive cash flows can be generated by the particular interest rate derivative if the rates fall. If the hedge is perfect, then the losses on assets will be offset exactly by positive cash flows in the derivatives market. If the hedge is less than perfect, then losses are not offset completely and the ARBL bank's net exposure still reflects a vulnerability to unexpected decreases in interest rates (Sinkey 2002).

Interest rate swaps can thus reduce interest rate risk either by converting a fixed-rate income stream to a variable-rate stream or by converting a variable-rate stream to a fixed-rate stream. Used in the first way, a swap shortens the duration of assets, and used in the second way, it increases the duration of liabilities. Either or both approaches can help overcome the typical bank's mismatch between long-duration assets and short-duration liabilities. This has several shortcomings. First, if the commercial borrower defaults, then the variable rate income stream stops and the bank must turn elsewhere when it desires to continue trading fixed-rate or floating-rate payments. By that time, interest rates may have changed, making it difficult for the bank to find another counterparty at the original terms and the hedge is thus not perfect. Second, the arrangement seemingly requires the bank to find another institution with repricing needs exactly opposite to its own. Approximate matches can be accommodated by more complicated contracts involving more than two assets or parties. A related problem is that if all banks want to be on the same side of the deal, there may not be enough counterparties willing to take the other side. Futures contracts can be used to create cash flows that offset losses on the original portfolio (Schaffer, 1991).

4.6. Other uses, advantages and disadvantages of derivatives

Apart from using derivatives for interest rate risk management (hedging against interest rate risk), they can also be used to:

- Lower funding cost (Wilson & Hollman, 1996);
- Diversify sources of funding (Wilson & Hollman, 1996);
- Hedge debt (Wilson & Hollman, 1996);
- Hedge changes in foreign currency exchange rates (Wilson & Hollman, 1996);
- Manage the risk related to day-to-day operations (Anon, 1997);
- Manage the balance sheet and results (Anon, 1997); and
- Take open or speculative positions to benefit from anticipated market movements (Anon, 1997).

Using financial derivatives has the following advantages:

- Risk, which could not be easily avoided previously, can now be insured (Damant, 2000);
- Derivatives provide a relatively inexpensive means for banks to alter their interest rate risk exposure (Hirtle, 1996);
- Derivatives provide a means for banks to more easily separate interest rate risk management from their other business objectives (Hirtle, 1996);
- Banks that use derivatives can increase their business lending faster than banks that do not use derivatives and derivative usage thus fosters more loan making or financial intermediation (Brewer & Moser, 2001);
- Managing interest rate risk through derivatives may be preferable to balance-sheet adjustments using securities and loans because it lessens the need to hold expensive capital, implying that derivative usage allows banks to substitute inexpensive risk management for expensive capital (Brewer & Moser, 2001);
- Banks can use derivatives to transform almost any aspect of their business and of the structure of their financial statements. They can consider cutting out unprofitable activities and making up the gap with appropriate financial instruments, they can deal financially rather than physically with commodities and they can easily rearrange their financial activities in such a way as to apportion risks and returns exactly as they require;
- Derivatives have the potential to enhance profitability and reduce volatility when used properly (Wilson & Holmann, 1996), and can thus increase the potential for banks to move towards their desired level of interest rate risk exposure; and
- Derivatives have the potential to enhance the safety and soundness of banks and to produce a more efficient allocation of financial risks (BIS, 1994).

Using financial derivatives, unfortunately, also has disadvantages. They include the following:

- Derivatives transactions can affect the bank's overall risk exposure, and derivatives can thus be seen as a potential source of increased solvency exposure (Choi & Elyasiani, 1996);
- Knowing more about the derivatives position of a bank may not allow outside stakeholders to determine the overall riskiness of the bank. Banks invest in many non-derivative instruments that are illiquid and opaque. Thus even if the value of their derivatives positions were known, it would be hard to know how subject to interest rate and other risks the bank will be (Choi & Elyasiani, 1996); and
- There is a fixed cost associated with initially learning to use derivatives. Large banks are more willing to incur this fixed cost because they will be more likely to use a larger amount of derivatives and the fixed cost can thus be spread among opportunities (Brewer & Moser, 2001).

5. Conclusion

Banks encounter interest rate risk in several ways, with the most important being, the repricing differences between assets and liabilities. Banks must accept some form of interest rate risk, because banks profit from taking risks. It is therefore not only important for banks forecast interest rate risks but also to measure and manage it appropriately.

Traditional ways to measure and manage interest rate risk include gap analysis, duration analysis, simulation and scenario analysis. Nowadays derivatives are however used in addition to the traditional approaches, because of all the changes that have taken place in the financial marketplace recently and to make interest rate risk management more effective. Using derivatives can thus be considered as a part of any bank's interest rate risk management strategy and also its total risk management strategy to ensure optimal financial performance.

Apart from interest rate risk management by means of hedging, derivatives can also be used for other important purposes, for example, speculation. Despite the advantages of derivatives in the management of banks they unfortunately also have disadvantages, for which banks must be prepared, to ensure that the use of derivatives will be more beneficial than detrimental.

References

1. Anon. (1997) Derivatives in a corporate environment – a guide for auditors [Internet] Available from <http://www.iaecw.co.uk/viewer/index.cfm?AUB =TB21_2111> [Accessed 20 July, 2003]
2. Bank for international settlements (BIS). (1994) Risk management guidelines for derivatives [Internet] Available from: <http://www.bis.org/publ/bcbs211.pdf> [Accessed 20 July, 2003]
3. Brewer, E.J., Jackson, W.E. & Moser, J.T. (2001) The value of using interest rate derivatives to manage risk at U.S. banking organizations. Economic perspectives [Internet] 3rd quarter, 25(3):49 pp.49-55. Available from:<http://www.ebsco-sa. co.za> [Accessed August 22nd, 2003]
4. Brown, K.C. & Smith, D.J. (1988) Recent innovations in interest rate risk management and the re-intermediation of commercial banking. Financial management, 17(4) Winter, pp.45-58.
5. Cade, E.C. 1997. Managing banking risks. Cambridge, Gresham.
6. Choi, J.J. & Elyasiani, E. (1996) Derivative exposure and the interest rate and exchange rate risks of U.S. Banks [Internet] Available from:<http://www.fic. wharton.upenn.edu/fic/papers/96/9653.pdf> [Accessed 20 July, 2003]
7. Damant, D. (2000) Creating wealth from thin air. Balance sheet, 8(1), pp.37 – 39.
8. Feldman, R. & Schmidt, J. (2000) Interest rate risk – what is it, why banks would want it and how to evaluate it? Fedgazette [Internet] 12(3), pp.16-17. Available from:<http://www.ebsco-sa.co.za> [Accessed August 22nd, 2003]
9. Hirtle, B. (1996) Derivatives, portfolio composition and bank holding company interest rate risk exposure [Internet] Available from:<http://www.fic/wharton/ upenn/edu/fic/papers/96/961943.pdf> [Accessed 30 July, 2003]
10. Hudson, R. (1992) Practical aspects of measuring interest rate risk. In: Whitley, J. ed. Strategic issues in asset/liability management. New York, Stockton. Hundman, K. (1999) An analysis of the determinants of financial derivative use by commercial banks [Internet] Available from:<http://www.titan.iwu.edu/ ~econ/ppe/1999/katie.pdf> [Accessed 30 August, 2003]
11. Jones, J.P., Wilson, A.C., Dyson, R.A. & Steinberg, J. (2000) The effect of accounting for derivatives on other comprehensive income. CPA Journal [Internet] March , 70(3), pp.54-56. Available from:<http://www.ebsco-sa.co.za [Accessed August 22nd, 2003]
12. Landsberg, R.D. (2002) Going boldly where no nonqualified plans have gone before. Journal of deferred compensation, 7(2), pp.1-13.
13. Madura, J. & Zarruk, E. R. (1995) Bank exposure to interest rate risk – a global perspective. Journal of financial research, 18(1), pp.1-13.
14. Miller, G.J. (1987) Will governments hedge interest rate risks? Public Administrations Quarterly, 11(3), Fall, pp.297 – 313.
15. Payne, T.H., Finch, J. & Fulmer, J.G. (1999) Banks' use of derivatives to manage interest rate risk – a survey. Bank accounting and finance [Internet] Winter, 12(2), pp.58-62. Available from:<http://www.ebsco-sa.co.za> [Accessed August 22, 2003]
16. Peek, J. & Rosengren, E.S. (1997) Derivatives activity at troubled banks. Journal of financial services research, 12(2/3), pp.287 – 302.
17. Rasch, R.H., Colquitt, L.L. (1998) New accounting for derivatives. Journal of insurance regulation [Internet] Spring, 16(3), pp.327-342. Available from:<http://www.ebsco-sa.co.za> [Accessed August 22, 2003]
18. Sangha, B.S. (1995) Financial derivatives – applications and policy issues. Business Economics [Internet] January, 30(1), pp.46-52. Available from:<http://www.ebsco-sa.co.za> [Accessed August 24, 2003]

19. Saunders, A. & Cornett, M.M. (2003) Financial institutions management – a risk management approach. 4th ed. McGraw-Hill.
20. Shaffer, S. (1991) Interest rate risk – what's a bank to do. Business review [Internet] May/June, 17. Available from:<http://www.ebsco-sa.co.za> [Accessed August 24th, 2003]
21. Siems, T.F. (1997) Policy analysis – 10 myths about financial derivatives. [Internet] Available from:<http://www.ebsco-sa.co.za> [Available on Internet:] [Accessed 20 July, 2003]
22. Sinkey, J.F. (2002) Commercial bank financial management: in the financial services industry. 6th ed. Prentice-Hall, New Jersey.
23. Wilson, A.C. & Hollman, K.W. (1996) Proposed accounting for derivatives: implications for the insurance industry. Journal of insurance regulation, 14(2), pp. 251-268.
24. Wright, D.M. & Houpt, J.V. (1996) An analysis of commercial bank exposure to interest rate risk [Internet] Available from:<http://www.econpapers.hhs.se/ article/ fipfedgrb/y-3a1996-3a1_3afeb_3ap_3a115-128.htm> [Accessed 22 August, 2003]