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Risk Management of Swaps and Capital Adequacy for Swap Market Makers

1. Introduction

Swaps are bilateral contracts between two economic agents usually facilitated by intermediaries. Typically, interest rate swaps are contracts in which one party agrees to exchange with another party, a sequence of floating rate cash flows for a sequence of fixed rate cash flows (computed on a notional principal amount), all denominated usually in the same currency. In foreign currency swaps, the principal amounts (denominated in different currencies) are also exchanged at a prespecified future date.
The swap market currently spans the corporate sector, bank sector, domestic money market sector and the Eurodollar markets. Swaps are structured across prime rates, London Interbank Offered Rates (LIBOR), Treasury bill yields, Index of Commercial Paper rates, etc. The status of swaps in companies' financial statements is currently under review: there are proposals to require some information disclosures in corporate financial statements concerning swaps that are outstanding. In addition, the capital adequacy requirements of market makers in the swap market (primarily commercial banks and investment banks) have come under closer scrutiny. Viewed from these perspectives, a discussion of valuation and risk management of swaps appears to be especially timely.

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1.1 Swaps as Portfolio of Forward Contracts

Conceptually, interest rate swaps have been regarded as forward contracts on interest rates. For example, a swap transaction in which a counterparty A agrees to receive 90 day LIBOR on January 1st of every year from another counterparty B in exchange for 8% for next 5 years may be thought of as a portfolio of 5 forward contracts on 90 day LIBOR at a forward rate of 8%. This view, while essentially correct, overlooks some of the complexities of swaps:

- A swap in which floating payments are exchanged for fixed payments may be regarded as a portfolio of forward contracts on the floating index, only if the reset dates and payment dates coincide. When there is a lag between the reset date and the payment date, swap is a portfolio of a random number of forward contracts, where the randomness arises from the uncertainty in future discount functions. For instance, in the previous example if the LIBOR set on January 1st is paid every

March 1st, then the payoff of each forward contract on March is the LIBOR set on January compounded at a rate of interest that prevailed between January and March which is unknown as of January.

- Moreover, these forward contracts are on interest rates and not on prices. Much of the received theory in the valuation of forward contracts has focussed on pricing forward contracts on asset prices as opposed to yields implied by asset values: since the price to yield transformation is non-linear, the task of valuing forward contracts on yields is significantly different from that of valuing forward contracts on asset values. See SUNDARESAN (1990b).
- Most swap contracts provide counterparties with options such as the ability to cancel the contract, ability to extend the contract, etc.
- An important dimension of swaps is that there is a positive probability of default since the contracting parties and the intermediaries typically have credit ratings varying anywhere from A or less (poor credit) to AAA (excellent credit).

To account explicitly for these factors, we define interest rate swaps as portfolios of forward contracts on interest rates of stated maturities set on stated dates and paid on prespecified dates. They are entered into by two parties who are subject to credit risk. In addition, swaps may provide contracting parties with some options.

1.2 Size of Swap Markets

In a recent study, swap market was estimated at about 1 US-trillion dollars [1]. The size of the market reported above is based on the notional principal of the swaps outstanding. In a recent survey, ISDA (International Swap Dealers Association) has provided some indication of the distribution of the size of currency and interest rate swap markets. A summary is provided in table 1. The figures pertain to the period ending December 1987. Figures are quoted in millions of dollars as well as in percentages.

Table 1: Outstanding Swap Transactions.

Currency	Interest Rate Swap	Currency Swap
US-$	$703'154	$98'015
	79.05%	44.72%
Yen	$59'988	$37'025
	6.74%	16.89%
Sterling	$40'142	$6'327
	4.51%	2.89%
Deutsche Mark	$39'583	$12'281
	4.45%	5.60%
Others	$46'662	$65'542
	5.25%	29.90%
Totals	$889'529	$219'190
	80.23%	19.77%

As table 1 indicates, the total outstanding volume is close to 1.1 US-trillion with roughly 80% of the transactions accounted for by the notional principal of interest rate swaps and the remaining by currency swaps. U.S. dollar denominated swaps dominate the market place.

1.3 Diversity of Swap Contracts

In addition to the sheer size of the swap markets, the diversity of contracts that are structured in the market bears some attention. Swaps are structured on different underlying instruments with different maturity dates. To gain a perspective on the diversity of this market, we turn to table 2.

There are 5 basic types of swaps. Fixed to floating in the same currency, floating to floating in the same currency, their counterparts across two currencies and currency swaps that are fixed to fixed.

In addition, there are two markets which are closely related to swap markets. They are:

- Interest Rate Caps: This agreement "caps" the interest obligations at a predetermined rate for a prespecified period of time. For example, firm A may agree to sell a cap on 3-month LIBOR at 6.5% for every quarter for the next

Table 2: Diversity of Swaps Market.

Type of Swap	Term of Swap	Remarks
Interest Rate Swaps	2 to 10 years	Same currency, one party pays fixed and the other pays floating.
Basis Swaps	2 to 7 years	Same currency, both parties pay floating cashflows keyed to different indices.
Currency Swaps fixed-to-floating	2 to 10 years	Different currencies, both pay fixed interest payments.
Currency Swaps fixed-to-floating	2 to 10 years	Different currencies, one pays fixed and the other floating.
Currency Swaps floating-to-floating	2 to 10 years	Different currencies, both pay floating interest payments.

two years. In return, firm B may pay firm A an agreed upon compensation.

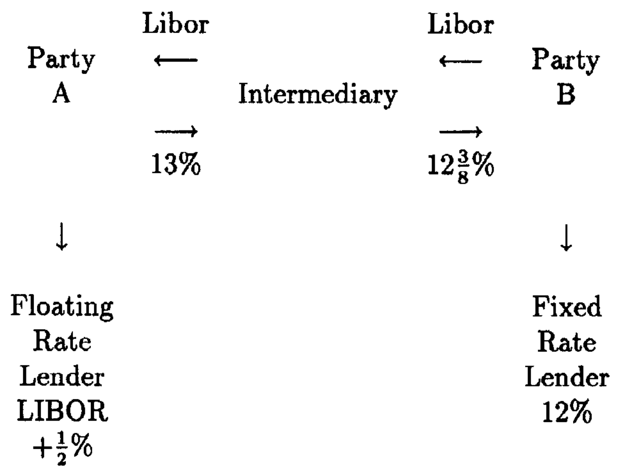
- Swaptions: Bank A, may sell an option to bank B whereby bank B will have the option to enter into a swap any time before a predetermined date at predetermined terms of exchange.

2. Risk Characteristics of Swaps

In general, swaps are subject to three distinct sources of risk: (i) interest rate risk, (ii) default risk and (iii) foreign currency risk. These components of risk interplay in subtle ways which must be understood to manage the total risk of swaps. To put these risk characteristics of swaps into proper perspective, it is useful first to review some broad risk questions in the context of figure 1 which presents a matched swap transaction.

In a matched swap transaction, the intermediary has brokered the swap. In this case, the intermediary faces no interest rate risk in the absence of default by either of the two parties. The floating rate borrower ends up with a fixed rate obligation, which

Figure 1: Matched Swap Transaction.



implies that his risk is that of a fixed rate note with a coupon of 13.5% with the same term and liquidity features, so long as there is no default. In a similar way, the fixed rate borrower ends up via the swap with floating obligations at a cost of LIBOR minus 3/8%. His risk is that of a floating rate borrower with the reset dates and payment dates as specified in the swap contract, so long as there is no default.

The impact of default is drastically different for the three players specified in figure 1. For the intermediary, default by one counterparty moves him from a matched book into a forward contract. To see this, let us assume that the floating rate borrower defaults. Then the intermediary will have to pay 12 3/8% and accept a payment of LIBOR from the solvent counterparty. This is obviously a forward purchase of LIBOR which may either have a positive or negative value at the time of default.

For the counterparty that defaulted, the effect of default is to move him from a forward contracting position into a straight floating rate debt situation. Of course, the precise outcome will depend on the contingency provisions that were written into the swap contract. For the solvent counterparty, the effect should have no consequence, as the financial intermediary performs the role of a clearing house. The integrity of the clearing process is a function of the capital adequacy of the intermediary and its credit worthiness. It is in this context that the rules pertaining to the capital adequacy of swap market makers proposed by Federal reserve and the Bank for International Settlements (BIS) have some important implications. We examine them later in our paper.

Figure 2: Foreign Currency Swap.

In a foreign currency swap situation, represented in figure 2, there is a foreign currency exposure as well. In the absence of default, the intermediary has a matched position. When there is default, he moves into an open forward contract position on foreign currency, in addition to assuming the interest rate risk. For the solvent counterparty, there is no change in the situation when there is default. The U.S. company pays 1 million British sterling and receives 2 million U.S. dollars at an exchange rate of 2 dollars per British pound. This transaction will be reversed at a later date which is prespecified now. The risk characteristics associated with reset dates, payment dates, index maturity and cashflows are less easy to characterize without formal arguments. If the floating leg of the swap resets frequently and does not have many option-like features, then the risk of the swap may be shown to be essentially that of the fixed side plus the face amount outstanding under some simplifying assumptions. We show that this is the case later in the paper in a more formal setting.

3. Valuation and Execution of Swaps

There are two special cases in which it is possible to value swaps without a specific model. The first case is one in which (i) the reset dates coincide with payment dates, (ii) both these dates coincide with Eurodollar futures maturity dates and (iii) the index maturity is 90 days LIBOR. The second case is one in which (i) the reset dates precede the payment date and (ii) the delay between reset and payment is exactly equal to the index maturity. We will describe these two special cases first.

3.1 Case 1

In this section, we will show how to use Eurodollar futures contracts to convert floating payments into fixed payments. Eurodollar futures contracts are currently traded on the International Monetary Market (IMM) of Chicago Mercantile Exchange and at the Singapore International Monetary Exchange. The Eurodollar futures at IMM extend up to 4 years. To simplify exposition, it will be assumed that Eurodollar futures are not marked-to-market. For the sake of simplicity, the reset dates are assumed to be the payment dates. Furthermore, Eurodollar futures are assumed to mature on reset dates.

We will illustrate the use of Eurodollar futures in synthesizing LIBOR-based swaps through a simple example. The key observation is that the Eurodollar futures price settles to 90-day LIBOR, $l_s(90)$, at maturity date s, by the following rule:

The Eurodollar futures price, $H_s(s)$, at maturity date s is

$$H_s(s) \equiv 100 \cdot [1 - l_s(90)]. \qquad (1)$$

To illustrate this point, let us consider the case of December 1987 Eurodollar futures contract. This contract matured on December 14th 1987 at a settlement price of 91.62. The 90 day LIBOR on that day stood at 8.38%. The maturity price was arrived at by the calculation 100-8.38 = 91.62. This settlement feature of Eurodollar futures is rather unique and is known as the "add on" settlement feature. This is to be contrasted with the discount settlement feature that is used in the Treasury bill futures market [2].

The Eurodollar futures prices is in percentages of one million face amount of a 90 day time deposit.

The market resolution is a basis point which is worth $1'000'000 \bullet \frac{1}{100} \bullet \frac{1}{100} \bullet \frac{90}{360} = \$25$. Thus if the Eurodollar futures price moved from 92.58 to 92.62 in one day, the dollar value of that move of 4 basis points will be 4 • 25 = $100 per contract.
Consider a firm that has floating rate liabilities indexed off 90 day LIBOR on a face amount of $100 million. The firm would like to swap these into a stream of fixed rate liabilities. Assume that the liability schedule facing the firm as of January 2nd 1987 is as shown in table 3.

Table 3: Schedule of Floating Liabilities.

t	s_1	s_2	s_3	s_4
Jan 2 1987	Mar 16 1987	Jun 15 1987	Sep 14 1987	Dec 14 1987

Liabilities are assumed to fall due each quarter on the maturity dates of Eurodollar futures contracts. As of January 2nd 1987, the schedule of Eurodollar futures prices looked as shown in table 4.

Table 4: Schedule of Eurodollar Futures Prices on January 2nd 1987.

$H_t(s_1)$	$H_t(s_2)$	$H_t(s_3)$	$H_t(s_4)$
93.95	93.95	93.86	93.68
6.05%	6.05%	6.14%	6.32%

The ex-post settlement prices of these futures contracts on their respective maturity dates is shown in table 5.

Table 5: Eurodollar Futures Prices on Maturity Dates.

$H_{s1}(s_1)$	$H_{s2}(s_2)$	$H_{s3}(s_3)$	$H_{s4}(s_4)$
93.50	92.87	92.50	91.62
6.50%	7.13%	7.50%	8.38%

The implied rate of interest $r_t(s_i) = 100 - H_t(s_i)$, is also indicated for each futures contract. Note that the implied rate of interest for each contract is known as of date t which is Jan 2nd 1987. Essentially, by selling a portfolio of futures contracts (called a strip of futures) on date t, it is possible for the firm to convert its floating liabilities into a stream of currently known liabilities as given by the implied rates of interest. To see this clearly, let us review table 6 in which the firm has sold a strip of 100 futures contracts.

Table 6: Swap Execution.

t	s_1	s_2	s_3	s_4
Jan 2 1987	Mar 16 1987	Jun 15 1987	Sep 14 1987	Dec 14 1987
Sell 100 of each future	0	0	0	0
Cashflows from futures	(6.50 - 6.05) • 250'000 = 112'500	(7.13 - 6.05) • 250'000 = 270'000	(7.50 - 6.14) • 250'000 = 340'000	(8.38- 6.32) • 250'000 = 515'000
Liabilities	-6.50 • 250'000 =-1'625'000	-7.13 • 250'000 =-1'782'500	-7.50 • 250'000 =-1'875'000	-8.38 • 250'000 =-2'095'000
Total	-6.05 • 250'000 =-1'512'500	-6.05 • 250'000 =-1'512'500	-6.14 • 250'000 =-1'535'000	-6.32 • 250'000 =-1'580'000

The firm at date t, sells a strip of Eurodollar futures contracts maturing on dates $s_i, i = 1,...,4$. The payoffs from futures contracts (ignoring marking to market) will be the date t futures price minus the settlement futures price. For example, the payoff from March 87 contract on date s_1 will be $[H_t(s_1) - H_{s1}(s_1)] \bullet 2500 \bullet 100$. On 16 March 87, Eurodollar futures price settled at 93.50. Therefore the payoff is (93.95 - 93.50) • 2500 • 100 = $112,500. From table 5, it is clear that the LIBOR increased during this period and as a result the futures prices fell. The profits from futures prices enabled the firm to lock in the rates that were determined at date t. The Eurodollar futures market permitted the firm to lock in at date t the known rates as shown in the bottom cell of table 6. The effective rate that is locked in by the firm is the swap rate and is computed as follows. Intuitively, swap rate is that fixed rate which is paid on the same dates as the floating payments with a present value equal to that of the floating payments.

Let $b_t(j), j = 1,..., 4$ be the discount functions quoted at date f for various future dates j. Then the swap rate x payable at each date s_i must satisfy the equality which is shown next.

$$x\,[b_t(s_1) + b_t(s_2) + b_t(s_3) + b_t(s_4)] = r_t(s_1)b_t(s_1) + r_t(s_2)b_t(s_2) + r_t(s_3)b_t(s_3) + r_t(s_4)b_t(s_4) \quad (2)$$

The swap rate x may be found as,

$$x = \frac{r_t(s_1)b_t(s_1) + r_t(s_2)b_t(s_2) + r_t(s_3)b_t(s_3) + r_t(s_4)b_t(s_4)}{[b_t(s_1) + b_t(s_2) + b_t(s_3) + b_t(s_4)]} \quad (3)$$

Equation (2) simply requires that in a swap the fixed rate x must have the same present value (as shown on the left hand side) as the floating payments (which by virtue of Eurodollar futures settlement feature is given by the right hand side). In the context of our example, the swap rate is easily calculated: on January 2nd 1987, LIBOR of different maturities are shown in table 7. The discount factors are calculated using the formula:

$$b_t(j) = \frac{1}{1 + \text{LIBOR} \cdot y/360} \quad (4)$$

where y is the maturity in days of libor. Using these discount functions, in equation (3), we get:

$$x = \frac{6.05\% \cdot 0.9845 + 6.05\% \cdot 0.9698 + 6.14\% \cdot 0.9552 + 6.32\% \cdot 0.9412}{0.9845 + 0.9698 + 0.9552 + 0.9412}$$

$$= 6.1383\% \quad (5)$$

The swap rate, x, is 6.1383% based on the discount functions and the implied rates of interest at date t.

Table 7: Schedule of LIBOR and Discount Functions on January 2nd 1987.

Variable	3 month	6 month	9 month	12 month
LIBOR	6.3125%	6.25%	6.25%	6.25%
Discount	0.9845	0.9698	0.9552	0.9412

While Eurodollar futures contracts may be used to execute swaps and they contain information about swap rates, institutions find it much easier to execute swaps by contacting swap intermediaries. There are good reasons as to why this is the case. With Eurodollar futures, the convergence to LIBOR is on the maturity date: this is ideal if the reset date and payment date coincide with the maturity date. For other swap structures, Eurodollar futures may not be used in so direct a manner. On the other hand, the swap market is well organized and the transactions are easily arranged. The credit risks are more easily factored into the contract. It is also easy to customize the swap contract to suit the needs of contracting parties: arbitrary indices, reset frequencies, payment dates, etc. may be easily fitted into the swap contract. However, the existence of Eurodollar futures markets and the swap rates implicit in Eurodollar futures force a tight link between swap rates and Eurodollar rates. The arbitrage possibilities between the two markets ensures greater efficiency in the swap market. Since most swap intermediaries hedge their risks in the Eurodollar market, the rates in these markets are linked closely.

3.2 Case 2

Consider now a situation in which the reset date precedes the payment date by 180 days and the index maturity is also 180 days (table 8). We will assume that the index maturity is also equal to the delay, s_{i+1} - s_i, $\forall i$ = 1, 2, 3. Then consider the following strategy: buy a discount paper at date t maturing on the first reset date s_1. On the first reset date, take the \$1 from the maturing discount paper and invest it in 180 days LIBOR.

Table 8: Schedule of Resets and Payments.

t	s_1	s_2	s_3	s_4
Today	First Reset	Second Reset First Payment	Final Reset Second Payment	Final Payment

This will produce a total cashflow of \$(1+LIBOR) on date s_2. Out of this cashflow, remove the LIBOR and reinvest \$1 at the then prevailing LIBOR. This will produce at date s_3 an amount equal to \$(1+LIBOR) and so on. Thus, the value at date t of receiving LIBOR on all payment dates (as set in preceding reset dates) plus \$1 on the final payment date is simply equal to the discount bond price, $b_t(s_1)$. Hence the value of just receiving the LIBOR on payment dates without the \$1 payment on the final payment date is $b_t(s_1)$ - $b_t(s_4)$. Thus, we have now valued the floating leg of the swap. What is the fixed payment c which will have the same value as the floating leg? It is easy to verify that c must satisfy the following relationship.

$$c \bullet (b_t(s_2) + b_t(s_3) + b_t(s_4)) = b_t(s_1) - b_t(s_4) \qquad (6)$$

Note that the swap rate is fully determined by the pure discount functions. We have presumed here that the credit risk is handled via contractual provisions such as marking to market, collateral requirements, etc. (More about this later.)
The value of swap on any date j before the first reset date s_1 is the value of fixed leg minus the value of floating leg as shown in the next equation below.

$$S_j = c \bullet (b_j(s_2) + b_j(s_3) + b_j(s_4)) - (b_j(s_1) - b_j(s_4)) \quad (7)$$

On the reset date s_1, the floating leg has no interest rate risk (it should tend to par) and hence the risk of the swap is that of a fixed rate note (including the face amount) with a maturity date s_4. This is seen by setting $j = s_1$ in the previous equation.

$$S_{s1} = c \bullet (b_{s1}(s_2) + b_{s1}(s_3) + b_{s1}(s_4)) + b_{s1}(s_4)) - 1. (8)$$

This suggests that swaps may be hedged by taking an offsetting position in either Treasury notes or Treasury note futures whose duration characteristics are identical to that of the fixed leg of swaps.
The most general case where reset dates, payment dates and index maturities are quite distinct from each other is treated only in the context of a specific model of the term structure. This is carried out in SUNDARESAN (1990a) which also treats situations where the floating leg pays averages of yields as well as options on swaps.

4. Risk Management of Swaps - Some Issues

Commercial banks and investment banks act as intermediaries in many swap transactions. The swap books of intermediaries present unique risk management problems. Until a suitable counterparty may be found, an intermediary "warehouses" the swap without having arranged an offsetting swap and thereby assumes the position of a counterparty. In addition to acting as an intermediary to match two counterparties, intermediaries usually assume the credit risks of both counterparties. It is the credit risks of counterparties that make the swaps somewhat idiosyncratic and that makes it difficult to organize a liquid secondary market.
The size of the swap book in many cases runs into hundreds or perhaps even thousands of millions of dollars. The diversity of indices used and such contractual features such as options to extend, cancel, caps, floors, etc. make the risk measurement and management a difficult task. The guidelines issued recently in this regard impart a sense of urgency to the task of risk measurement and risk management. We provide some highlights of the

guidelines next to provide a perspective on the issue of risk management of swaps.

4.1 Federal Reserve - BIS Guidelines for Swaps

The Federal Reserve and the Bank for International Settlements have proposed sweeping guidelines on the question of risk measurement of swaps (CANNING/PITMAN/WILLIAMS, 1988, FEDERAL RESERVE SYSTEM, 1987). These guidelines require the calculation of the "marked-to-market" value of all interest rate swaps. In order to perform this task, it is necessary to have theoretically sound models of swap valuation. A key ingredient in the proposed guidelines is the concept of replacement cost of swaps. This is computed by adding only the positive marked-to-market values. To this replacement cost is added a measure of future potential increases in credit exposure. This future potential exposure measure is calculated by multiplying the total notional value of contracts by one of the following credit conversion factors shown in table 9.

Table 9: Credit Risk Measurement for Swaps.

Remaining Maturity	Interest Rate Swaps	Foreign Currency Swaps
One year or less	0.0%	1.0%
Over one year	0.5%	5.0%

No potential exposure is calculated for single currency interest rate swaps in which payments are made based upon two floating rate indices, that is, so called floating/floating or basis swaps. The credit exposure on these contracts is evaluated solely on the basis of their marked-to-market value. Exchange rate contracts with an original maturity of 14 days or less are excluded. Instruments traded on exchanges that require daily payment of variation margin are also excluded. The only form of netting recognized is netting by novation. Netting by novation is a contract between two counterparties under which any obligation to each other to deliver a given currency on a given date is automatically amalgamated with all other obligations for the same currency and value date, legally substituting one single net amount for the previous gross obligations.

It is useful to note that the key to the guidelines is the ability to mark to market swap positions so as to compute their replacement cost. In a market which is liquid, bid-offer spreads are small and the task of marking to market is simplicity itself. But swap contracts that are illiquid may not always have a liquid secondary market and the determination of their value requires two important considerations: first, an appropriately tested swap valuation model is necessary to perform the task of valuation. Second, the valuation should be done by an agent who has no vested interest to either overstate or understate the value of the swap positions. If the swap desk finds that marking to market could result in substantial charge to its profits, it may not report it fearing adverse senior management action.

With these observations, we proceed to analyze the risk of swaps.

4.2 Swap Risk Analysis

As a counterparty to interest rate swap transactions, an intermediary faces (i) interest rate risk, (ii) spread risk, (iii) credit risk and (iv) foreign exchange risk. We analyze each component in detail next.

(i) Interest Rate Risk

When a swap transaction is entered into by an intermediary, no cash exchanges hands (except perhaps a fee for matching buyers and sellers) but the intermediary establishes an exposure to interest rate risk, credit risk and possibly foreign currency risk. To analyze the risk, let us consider a 5 year interest rate swap on a notional principal of $100 million in which the intermediary pays 8% fixed semi-annually and receives 3 month London Interbank Offered Rate (LIBOR) semi-annually from XYZ Bank. Let us assume that the intermediary is AAA rated and XYZ Bank is (say) a BB credit. Although no principal exchanges hands, it is useful to think of the swap in following terms: the intermediary is short $100 million par of a 5 year AAA rated corporate with a coupon of 8% and long in $100 million face amount, a floating rate note with a maturity of 5 years which is reset every 3 months to LIBOR. The interest risk of this hypothetical floating rate note is roughly that of a BB rated time deposit of 3 months maturity: this is due to the fact that the floating rate note may be thought of as rolling into a sequence of 3 month time deposits for next 5 years. On the expiration date of the swap, the principal amounts on fixed and floating sides will produce a wash. In such a setting, the swap risk to intermediary is clear: the intermediary is short in a 5 year Corporate which is AAA rated and long in a 3 month time deposit ignoring spread risks between corporate and LIBOR markets, intermediary is net short. The swap value will increase as the rates go up and vice versa. This risk is easily quantified in terms of duration, and other measures that are commonly used in these markets. In a similar way, were the intermediary be the receiver of fixed payment and payer of floating, then the swap risk to the intermediary will be that of a net long position. Since the floating leg is typically keyed to LIBOR and the fixed keyed to Treasuries, it is best to aggregate the risks of these two legs separately for management reporting purposes. This keeps the distinct nature of these two markets and the possible spread risks between them separate.

(ii) Spread Risk
We considered an example in which the intermediary agreed to pay 8% in exchange for 3 month LIBOR. Let us say that after 3 months, the going rate for 8% fixed is 3 month LIBOR plus 40 basis points, if the floating payer is a BB credit. The original swap will have lost some of its value and on a marked-to-market basis some loss will have to be recognized. This is termed as the "current replacement cost" of the swap in the Federal Reserve Guidelines to Banks and Bank holding companies. We call this risk the spread risk.

(iii) Default and Credit Risk
We began our analysis by assuming that the intermediary is AAA rated. Let us assume that the XYZ Bank in the swap transaction suffers an unexpected deterioration in its credit standing and defaults. This could have either a positive or negative effect on the swap risk. If the credit deterioration and default took place when the swap had a positive value to the intermediary, then it will hurt the intermediary. On the other hand, if the credit deterioration and default took place when the swap had a positive value to XYZ, Inc., then intermediary will actually benefit from the default of its counterparty. The economic impact due to default on the intermediary will depend on the replacement cost of finding an alternate counterparty to assume the liabilities of the defaulting party. If in the example, XYZ Inc. becomes a BBB credit then the replacement cost of the swap to the intermediary would have been adversely impacted. Much of the outcome will also depend on the termination provisions that were written into the swap contract at the time the swap was initiated.

(iv) Foreign Currency Risk
Referring back to table 2, it should be clear that all swaps that are structured across two currencies are subject to foreign currency risk. This is especially severe for swaps which are fixed to fixed across two currencies. To examine the exposure in a swap of this nature, it is necessary to explicitly recognize that the agreement to exchange principal is a forward contract on the currency and is easily hedged in the foreign currency futures market for short maturity swaps. The recent introduction of the DIFF futures contract at the International Monetary Market at the Chicago Mercantile Exchange

enables one to lock in the interest rate differential between actively traded foreign currencies for short maturities.

4.3 Management of Interest Rate Risk of Swaps

To further quantify the interest rate risk of interest rate swaps, the following assumptions will be made:

- Swap transactions are heavily collateralized and the counterparties are screened so that the impact of credit risk and default risk may be ignored. In the next section, we will explicitly treat the effect of credit and default risk and its management.
- The floating leg of the swap transaction is structured such that the payment date follows the reset date by exactly the reset frequency. In addition, the index maturity is assumed to be equal to the reset frequency.

Under the assumptions listed above, it was shown that the value of the swap may be represented in terms of zero coupon instruments representing the floating and fixed sectors of the swap. See equation (5). Thus, we examine the risk management issues under the same assumptions as in section 3.2, case 2.

Thus for an interest rate swap with a 5 years life, in which the intermediary pays a fixed amount of 8% and receives 3 month LIBOR every 3 months, the swap value when it has τ years to maturity may be specified as follows:

$$S(\tau) = Discount(\text{next reset}) - Corporate(\tau, 8\%) \quad (9)$$

The swap's risk resembles that of a portfolio in which intermediary is long a discount paper with a maturity equal to the next reset date and denoted by *Discount*(next reset) and a short position in a corporate AAA rated paper with a coupon of 8% and a maturity equal to that of the swap and denoted by *Corporate*(τ, 8%). Note that on a reset date the swap's risk is identical to that of the short position in the corporate paper itself, for the discount paper matures and carries no risk. Hedge policies may then be stated in terms of U.S.Treasuries, provided we assume that the spread between corporate and Treasury sectors is not too variable. In the context of the example above, the intermediary can establish a long position in U.S.Treasury to hedge the swap risk. Intuitively, in so doing, the intermediary will have reduced the duration of the fixed side to that of the floating side.

Eurodollar futures contracts is another alternative which is often used for hedging. Eurodollar futures contracts are traded at IMM of CME and display extensive depth. Currently, ED futures are available out to next 3 years in quarterly cycles. In this hedge strategy, the payer of fixed rate buys a strip of Eurodollar futures contracts to increase the duration of the floating leg to match the duration of fixed leg. The depth in the Eurodollar futures coupled with their availability out to three years provides a relatively low cost of hedging. Many swaps pay without any arrears. The cash settlement feature of Eurodollar futures which settle to LIBOR without arrears on the settlement date is yet another attractive reason for using ED futures contracts.

4.4 Management of Credit Risk of Swaps

The credit risks associated with swaps is an important component of the overall risk of swaps. The management of credit risk proceeds along two distinct lines:

1. Contractual provisions, contingencies, documentation and collaterals.
2. Diversification of the swap book across industry segments and market segments.

Much of the credit risk management rests with the structuring of swap agreements, contingency provisions, termination provisions and collateral requirements. Usually, collateral in the form of readily marketable securities may be demanded from the weaker credit to guard against potential credit risk. In setting aside the capital that is needed to support swap activities, it is first necessary to mark the swaps to market so as to correctly determine the replacement cost of swaps. This requires a properly calibrated model for valuing swaps in general. Once this is done and the interest rate exposure is properly hedged as indicated in the previous section, credit risk of the book has to be aggregated. It is useful in this context to subdivide the swaps into two groups: one in which the intermediary is paying fixed and the other in which the intermediary is paying floating. In each of these groups, swaps must be further classified across different credit risk categories and marked to market and aggregated within those credit risk classifications. This will enable the management of the swap book to identify which of the swap agreements have significant replacement costs due to deteriorating credit risk and to what extent the swap book is reasonably matched. Marking to market will effectively indicate the health of the swap book upon the termination of each swap agreement (voluntary or involuntary) in the book. If there is a net loss then the capital that is set aside should be sufficient to meet those losses. The credit risk and interest rate risk may interact in subtle ways. In order to examine this further, it is useful to examine the mark-to-market value of the swap book for different term structure scenarios and credit risk assumptions. Monte Carlo simulation techniques and two state variables (credit risk and interest rate risk) approach grounded in contingent claims pricing framework may be used to accomplish this task.

Footnotes

[1] See International Financial Review, Issue 734, July 23, 1988.

[2] The settlement prices of futures are quoted as 100 minus the discount rate in percent which applies to bills delivered on the settlement date. Thus a futures price of 93.50 implies a discount rate of 6.50%. An investor who is short as of the delivery date in a Treasury bill futures contract may deliver either a 90-days T-bill, or a 91-days T-bill or a 92-days T-bill. The short will receive upon delivery of a 90-day T-bill an amount which will be computed using in (1) as follows:

$$1'000'000 \cdot [1 - \frac{0.065}{\frac{90}{360}}] = 983'750.$$

Thus the "discount" convention in the cash market is also followed in the futures market.

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