EDUCATIONAL NOTE

NATURE AND USES OF DERIVATIVES

CHAPTERS 6-9

COMMITTEE ON INVESTMENT PRACTICE

MARCH 1996

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Canadian Institute of Actuaries Institut Canadien des Actuaires

MEMORANDUM

To: All Members of the Canadian Institute of Actuaries

From: R.J. Sharkey, Chairperson
Committee on Investment Practice

Date: March 29, 1996

Subject: **Educational Note on the Nature and Uses of Derivatives**

This note provides a description of interest rate swaps, futures and forwards, options and a wide variety of other related derivatives. It discusses, with examples, how they can be used to manage portfolio risks, to hedge specific assets and liabilities, to hedge a rate crediting strategy, to broaden investment and marketing opportunities, to manage duration gaps, to create synthetic assets and in asset overlay strategies.

Questions regarding the note can be addressed to me at my *Yearbook* address.

RJS

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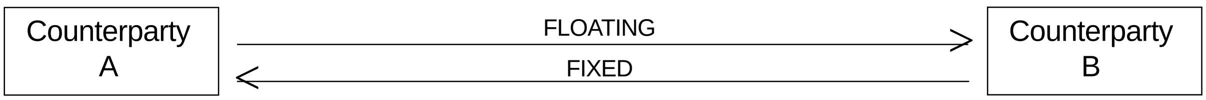
CHAPTER 6 – INTEREST RATE SWAPS

6.1 Interest Rate Swap Terms

An interest rate swap is an exchange of one or more payments between two counterparties, at specified times, for a specified period of time. The payments are calculated as a percentage of principal amount according to the swap agreement. The principal amount is not an obligation of either party. It is simply the basis on which payments are calculated. At the end of the swap term, payments simply cease. Since the principal amount is typically not exchanged, this amount is referred to as the notional principal amount.

The size of the notional principal amount can range from one million to billions of dollars and the term from one to 50 years. Swaps are highly liquid up to five years and increasingly illiquid and infrequent beyond 10 years. Swaps can be written for odd dates and uneven amounts relatively easily.

Interest Rate Swap



In a typical swap, counterparty A agrees to make periodic floating rate payments for the term of the swap to counterparty B in return for the receipt from B of periodic fixed rate payments. The floating rate is determined by a market index such as one-, three- or six-month LIBOR, 30-day commercial paper composite rate or three-month banker's acceptance rates. The floating rate is reset on each date that a floating rate payment is made.

Floating payments are made at the end of each period based on the floating rate at the beginning of the period. In an "in-arrears" swap, the floating payment is made at the end of the period based on the rate at the end of the period.

The floating rate is usually based on a short-term index, but this is not essential. In the case of a constant maturity swap, the floating rate could be paid every six months, say, based on the then current five-year Canada bond rate. Also, the floating rate could be based on more than one index (greater, average, lesser of two).

Fixed and floating payments need not be exchanged on the same dates. Fixed rate payments might be made semi-annually, and floating rate payments made quarterly, for example. Mismatched payment swaps are uncommon, since they involve greater credit risk and may have adverse tax consequences if the counterparty is foreign. In a zero-coupon swap, one counterparty might make periodic payments throughout the life of the swap but receive only a single payment predetermined at swap inception or maturity. In the extreme, a single payment is exchanged at maturity representing the net economic value of the fixed and floating cash flow streams.

In a semi-fixed swap, fixed payments are based on more than one fixed rate. The lower of the fixed rate might be paid if the floating rate is below a certain rate and the higher fixed rate is paid, otherwise.

In a basis swap, one counterparty pays one floating rate index in exchange for another floating rate index in the same currency. A yield-curve swap is a basis swap in which floating indices based on different points in the yield curve are exchanged. Counterparty A could agree to pay the two-year constant maturity Canada bond rate in return for the receipt from counterparty B of the five-year constant maturity Canada bond rate. Payments occur every six months for ten years, say. Counterparty A might believe the yield curve will steepen between two and five years and counterparty B that it will flatten. A "diff" swap involves the exchange of floating rate payments based on two different floating indexes denominated in different currencies.

An index amortizing swap has a notional principal amount that decreases with the level of the floating rate. Usually, the amortization schedule slows down (speeds up) as rates rise (fall). This makes their interest rate sensitivity similar to investments, such as mortgage-backed securities, that are sensitive to prepayment risk. An accreting (step-up) swap has a notional principal amount that increases according to a pre-set schedule or pre-defined formula. Certain currency swaps involve a pair of notional principal amounts.

A swap spread lock fixes a swap spread over government bonds at the outset or at some point during an initial period. A swap at that spread must be entered into at some point in the future, unless the replacement cost is paid between the counterparties to unwind the commitment.

An accrual interest rate swap involves the payment of a floating rate, such as LIBOR, in exchange for the floating rate plus a large spread. However, the latter interest payment only accrues on days in which the floating rate is between an upper and lower bound.

6.2 Classic Debt Management Uses of Interest Rate Swaps

Originally the swap market was used to arbitrage between different credit spreads available in different segments of the capital markets. The classic swap situation involves a strong (AAA) bank that is able to issue fixed rate debt in the public market at advantageous rates, but wishes to raise floating rate funds as part of its treasury funding operations. It also involves a weak (BBB) corporate entity that is unable to raise fixed rate term debt at an attractive cost, but is able to borrow on a committed basis through a banking facility at a relatively narrow margin over a floating rate index. These two parties have complementary requirements.

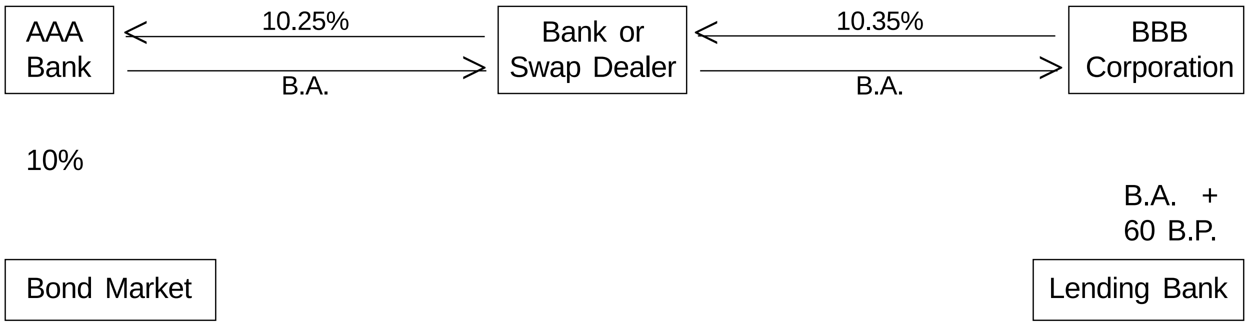
Through an interest rate swap, both parties may be able to borrow in their favoured debt markets at a cost that is cheaper than doing so directly. This is because typically fixed rate bond markets have tended to require a much wider quality spread between high and low quality borrowers than is typical of floating rate markets. If the strong and weak counterparties raise funds in the market in which they have a relative advantage, the resultant interest rate payments can be swapped to achieve cheaper funding for both.

The (AAA) bank might be able to issue a floating rate note at an all-in-cost of three-month banker acceptances (BAs) plus 25 basis points. Alternatively, it might be able to issue five-year fixed rate bank paper at 10.00% and to do a five-year swap in which it pays the BA rate and receives a fixed rate of 10.25%. The net fixed payments of plus 25 basis points reduces the floating swap payments. The net floating rate cost (reduced by the net 25 basis points) to the bank is BAs less 25 basis points.

The weak (BBB) corporation might be able to do a private placement at 11.25%. Alternatively, it might be able to borrow on a floating rate basis at BAs plus 60 basis points, and to do a five-year swap to pay 10.25% and receive the BA rate. The net floating payments of plus 60 basis points increases the fixed swap payments. The corporation's all-in fixed rate cost is 10.85% (10.25% plus .60%).

It could well be the case that the AAA bank would not commit to long-term lending to the BBB corporation at BAs plus 60. A bank with a lower credit rating might act as lending bank. The corporation might find another swap bank or dealer that would agree to receive a fixed pay swap at 10.35% from the BBB corporation. The swap bank or dealer would also agree to pay a fixed pay swap at 10.25% to the AAA bank. The swap bank or dealer would earn a spread of 10 basis points and the all-in-cost of the fixed rate debt to the BBB corporation would increase to 10.95%. The situation can be depicted as follows:

A Classic Interest Rate Swap



The AAA bank raises floating rate debt at 50 basis points (BAs +25 basis points versus BAs –25 basis points) less cost than its floating rate note alternative. The BBB corporation raises fixed rate debt at 30 basis points (11.25% versus 10.95%) less cost than its private placement alternative.

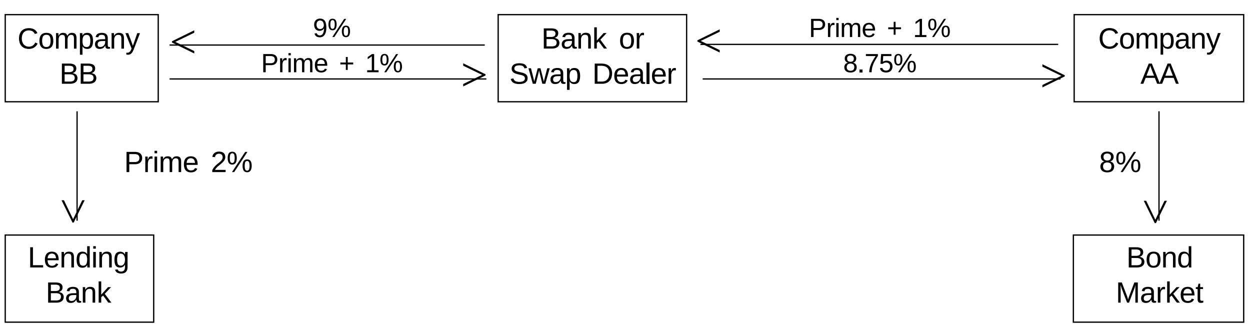
This classic interest rate swap alternative arises because there is 125 basis points difference in the fixed rate borrowing costs of the AAA bank and BBB corporation and only 35 basis points difference between their floating rate borrowing costs. The arbitrage potential of 90 basis points (125 basis points versus 35 basis points) is shared 50 basis points to the AAA bank, 30 basis points to the BBB corporation and 10 basis points to the swap bank or dealer. There is no change in the situation from the perspective of the bond market investors lending to the AAA bank and the lending bank lending to the BBB corporation.

Interest rate swaps can also be used to provide lower rated corporations with indirect access to the fixed rate bond markets. A BB company might not have access to the bond market because of its low credit. It might be able to borrow from a bank on a floating rate basis at prime +2%. It might also be able to enter into a five-year swap with a swap dealer to pay 9% fixed and receive prime +1%. In effect, the BB company has sourced five-year money at a fixed rate of 10%.

The swap dealer might be able to do a five-year swap with a AA company to pay fixed at 8.75% and receive prime +1%. Net of its swap with the BB company the swap dealer earns 25 basis points for five years in return for taking on the counterparty exposure to the BB and AA companies.

The AA company raises five-year money in the bond market at 8%. The swap to receive 8.75% locks in a net fixed positive spread of 75 basis points. It pays the swap dealer prime +1%, which is prime +25 basis points, net of the positive 75 basis point spread. If it usually borrows at prime +50 basis points, the AA company raises floating rate funds at 25 basis points under its normal costs.

A Classic Interest Rate Swap



See Appendix 1 on factors impacting the swap spread for more information on swaps.

6.3 Managing Portfolio Interest Rate Risk Using Interest Rate Swaps

Interest rate swaps can be used to manage portfolio duration. The simplest way of understanding the potential duration impact of an interest rate swap is by extension of the law of one price. According to this law, two portfolios that result in the same cash flows in each and every interest rate and economic scenario must have the same price. This law is the foundation for arbitrage-free pricing, since an arbitrage opportunity will exist between one portfolio and another, if they give rise to identical cash flows under all circumstances, but their prices differ. Risk-free profit can be made by shorting the more expensive portfolio and using the proceeds to buy the cheaper portfolio.

The floating rate side of an interest rate swap can be decomposed into a series of forward contracts on the floating rate index. The total price of the floating rate side of a swap is equal to the price of this series of forwards. This price must be the same as the price of the fixed rate side of the swap. In a similar fashion, two portfolios that give rise to the same cash flows under all circumstances must have the same duration. This could be termed the "law of one duration."

The net cash flows resulting from the sale of a five-year term fixed rate bond with a coupon of 8% and the purchase of a five-year floating rate bond to pay BAs with the same par value are identical to the net cash flows resulting from a five-year swap to pay 8% and receive BAs. While there are default situations where the net cash flows differ (as between different bond issuers or between different ranking financial obligations of the same issuer), this nicety will be ignored. Accordingly, the law of one duration dictates that the duration impact of the one portfolio consisting of a long and short bond position is equivalent to that of the interest rate swap.

The duration impact of a five-year term floating bond to pay three-month BAs, should be the same as that of a portfolio of three-month BAs, by a further application of the law of one duration. Once again, liquidity, supply/demand and credit subtleties that make these portfolios less than perfectly equivalent under all circumstances are ignored. Consequently then, the duration of a floating rate bond at the commencement of each floating rate period, based on three-month BAs, is simply .25 years (three months).

The duration impact of a five-year fixed pay swap to pay 8% can be incorporated into the asset portfolio by including a notional negative (short) five-year term bond position at 8% and a positive BA position with a duration of .25. The bond amounts are both equal to the swap notional principal amount and net out. The duration impact will change with the passage of time due to the shortening of the remaining term to swap maturity and the time to the next resetting of the BA rate on the swap. The duration impact of a five-year fixed receive swap to receive 8% can be handled in an analogous way.

There are several situations in which an interest rate swap might be entered into in preference to a repositioning of the bond portfolio done simply to reduce interest rate risk. The realization of capital gains or losses upon sale of bonds could have adverse tax or financial reporting implications. The required bond repositioning may interfere with the portfolio or trading strategies of the bond portfolio manager. It may not be possible to liquidate sufficient bonds in a cost-effective, expeditious manner. Opportunity costs in holding a large money market position may be prohibitive.

The wholesale swap market and the retail residential mortgage and GIC markets do not always move in tandem. The mortgage (GIC) spread may be wide (narrow or negative) relative to the fixed swap rate based on historical relations. Mortgages (GICs) can be aggressively sought (sold) in these situations without immediately acquiring offsetting GICs (mortgages). The offsetting GICs (mortgages) may not be immediately available or they may not be available at an attractive price. The mismatch risk from excess mortgages (GICs) is eliminated by entering into interest rate swap transactions to pay (receive) fixed. In effect, the swap locks in the abnormally wide (narrow) mortgage (GIC) spread, until such time as GICs (mortgages) can be found.

This use of interest rate swaps parallels the use of Canada bonds and money markets instruments to hedge mortgage and GIC inventories. The decision to use a swap or cash market solution will be primarily spread-driven. If the fixed rate swap spread relative to Canada bonds is relatively wide, based on historical relations, then agreeing to receive the fixed swap rate will be preferred to purchasing a Canada bond. If the fixed swap rate relative to Canada bonds is relatively narrow, based on historical relations, then agreeing to pay the fixed swap rate will be preferred to selling Canada bonds. Should the swap rate revert to historical norms by the time the swap needs to be unwound, swap spreads are likely to have moved in the insurer's favour.

The choice between Canada bond and interest rate swaps has considerable importance. No one strategy is always best. The five-year swap spread relative to five-year Canada bonds has ranged recently from a high of 120 basis points in 1990 to a low of 15 basis points in 1993-94.

Hedging a Rate Crediting Strategy

A universal life, single premium deferred annuity or other policy might require a rate crediting strategy linked to current five-year government bond rates. A portfolio of cash market investments designed to support such a rate in a stable or falling interest rate environment may fail to do so in a rising interest rate environment because the portfolio rate lags behind current new money five-year rates. Put options or a cap on five-year government bonds could be purchased to hedge against rising five-year rates. Alternatively, a five-year constant maturity swap could be used.

In a five-year constant maturity swap, the insurer agrees to pay a rate fixed for the life of the swap (which need not be five years) in exchange for a floating rate payment that resets every period based on the then current five-year rate. In a rising interest rate environment, such a swap will blend with the cash market portfolio rate to produce a combined rate that tracks new money five-year rates much more closely. Such a swap will be more cost-effective than put options or a cap, since with the swap, the insurer does not pay for protection from, and consequently bears, the downside risk in a declining interest rate environment.

Liquidity Risk

It is important to recognize that extensive use of swaps to manage interest rate risk can lead to major cash flow mismatches even in situations where portfolios are closely duration matched. While an interest rate swap to pay fixed and receive BAs is equivalent to selling five-year bonds and holding BAs from an interest rate perspective, it is not equivalent from a liquidity perspective. Reliance on swaps to manage interest rate risk requires additional vigilance with respect to liquidity.

A portfolio consisting of illiquid five-year bonds and mortgages combined with fixed pay swaps may have similar interest rate risk to a one-year GIC. However, should the one-year GIC be withdrawn at maturity, it may not be possible to liquidate the supporting portfolio in a cost-effective, expeditious manner. Ensuring adequate liquidity should be a priority.

6.4 Hedging Specific Liabilities With Interest Rate Swaps

Assume $50 million of five-year term monthly pay RRSP sales occur on February 28, at 7.5%. They are priced assuming a mortgage rate of 9.5%. However, no mortgages are available until May 28, when $50 million of five-year mortgages are funded at 9%. If the liabilities are not hedged, the actual profit will be 50 basis points less than assumed in the original pricing.

Suppose the $50 million of excess five-year term liabilities are hedged by doing a $50 million five-year term swap to receive fixed at 8.25% on February 28. The RRSP deposits will be invested in BAs to support the floating rate payments required by the swap. When the $50 million of five-year mortgages are funded on May 28, an offsetting $50 million five-year term swap to pay fixed would be done.

Then, if the fixed swap rate decreases by 50 basis points, as did the mortgage rate (9.50% – 9.00%), the offsetting swap will require fixed payments at 7.75% (8.25% – .50%). The floating side of the swaps are both BA rates and so they net to zero. The hedging and offsetting swaps combine to produce a net payment to the company of 50 basis points. When combined with the 9% mortgage rate, a fixed rate of 9.50% is achieved. This is the rate assumed in the pricing of the RRSP sales. In practise, the funding of the $50 million of mortgages may be spread over several weeks instead of all occurring on May 28. This is handled by entering into a series of offsetting swaps in amounts equal to the amount of mortgages funding at each point in time. The offsetting swaps would total $50 million.

There is a loss of spread between February 28 and May 28 between the mortgage rate of 9.50% and the fixed rate of 8.25% received on the swap. Spread over the five years, the spread loss amounts to approximately seven basis points. The loss would be less if a portion of the assets assumed in the pricing were lower yielding or if the mortgages funded before the full three months. This “hedging loss” should be reflected in pricing.

There is potential for loss (gain) in that the fixed rate on the hedging instrument need not move in lockstep with mortgage rates, the so-called basis risk. In particular, the fixed swap rate on May 28 may have decreased by 40 basis points to 7.85%. Now the company receives fixed of 8.25% and pays fixed of 7.85%, for a net received spread of 40 basis points. Since mortgage rates dropped by 50 basis points, there is a net loss of 10 basis points, because of the change in spreads between mortgages and swaps, while the hedge was in place. The example assumes that the mortgages funded on May 28 were duration-matched to the liabilities sold on February 28. The interest rate sensitivity of the five-year swap is similar to that of five-year mortgages, which is, in turn, similar to that of the five-year monthly pay GICs. Variations in the spreads between five-year GICs, five-year mortgages and five-year swaps mean that some interest rate risk remains.

A larger notional principal amount of five-year term swaps would be needed to hedge five-year compound GICs, since the five-year compound GIC duration is greater than that of a five-year bond and, hence, greater than that of a five-year swap. A simple calculation will determine what notional principal amount of five-year swaps will duration-match the five-year GICs sold.

A more serious complication arises if the mortgages funded do not “match” the GICs sold. If the mortgages are one year in term at a rate of 7% say, it would not be appropriate to do offsetting five-year swaps to pay fixed at 7.75%. Instead, a one-year swap to pay 6.75% might be entered into. This would lock-in a net positive spread of 150 basis points on the swaps for the first year (8.25% receive, 6.75% pay).

The achieved first year gross spread would be reduced from 150 basis points to 100 basis points, as a result of having to pay 7.50% on the five-year GIC and receiving only 7% on the one-year mortgage.

While the first year spread is narrow, it may represent a satisfactory spread in the light of forward rates. In particular, if the one-year mortgage matures and is reinvested in a four-year mortgage and a four-year swap entered into at the time, then a satisfactory spread may be achievable over the full five-years of the GICs. If the spread between the one-year forward four-year mortgage rate and the one-year forward four-year swap rate prevailing on May 28 equals the spread actually achieved one year hence, then the spread will be satisfactory. The potential for loss (gain) represents a basis risk.

6.5 Hedging Specific Assets With Interest Rate Swaps

Assume $50 million of five-year mortgages are funded on November 28, at 9.50%. Sales of RRSP GICs are priced at this time assuming this rate. However, no sales are made until February 28, when $50 million of five-year term, monthly pay GICs are sold. These sales are priced using the 10% rate on five-year mortgages applicable on February 28. If the assets are not hedged, the actual profit will be 50 basis points less than assumed in the pricing.

The $50 million of excess five-year assets can be hedged by doing a $50 million five-year swap to pay fixed at 8.25% on November 28. The fixed pay rate is supported by the 9.50% earned on the mortgages. When the $50 million of RRSP sales are completed on February 28, an offsetting $50 million swap to receive fixed is done.

If the fixed swap rate increases by 50 basis points, as did the mortgage rate (9.50% – 10.00%), then the offsetting swap will involve fixed receipt of payments at 8.75% (8.25% – 8.75%). The floating side of the swaps are both BA rates and so they net to zero. The hedging and offsetting swaps combine to produce a net payment to the company of 50 basis points. When combined with the 9.50% mortgage rate, a fixed rate of 10.00% is achieved. This is the rate assumed in the pricing of the RRSP sales.

In practise, the RRSP sales may be spread over several weeks, instead of all occurring on February 28. This is handled by entering into a series of offsetting swaps in amounts equal to the amount of sales occurring at each point in time. The offsetting swaps would total $50 million.

There is a pick-up in spread, between November 28 and February 28, between the mortgage rate of 9.50% and the rate of 8.25% paid on the swap. Spread over the five years, the spread profit amounts to approximately seven basis points. This “hedging gain” could be reflected in pricing.

There is potential for loss (gain) in that the fixed rate on the hedging instrument need not move in lockstep with mortgage rates, the so-called basis risk. In particular, the fixed swap rate of February 28 may have increased by 40 basis points to 8.65% (8.25% – 8.65%). Now the company receives fixed of 8.65% and pays fixed of 8.25% for a net received spread of 40 basis points. Since mortgage and GIC rates increased by 50 basis points, there is a net loss of 10 basis points, because of the change in spreads between mortgages and swaps, while the hedge was in place.

The example assumes that the GICs sold on February 28 were duration-matched to the assets funded on November 28 and were duration-matched to five-year swaps. The notional principal amount of the hedging swap could be adjusted to ensure that the product of the amount and the swap duration equalled that of the product of the asset market value and duration.

A more serious complication arises, if the GICs sold do not duration-match the assets funded. If the GICs are one year in term at a rate of 6%, say, then it would not be appropriate to do offsetting five-year swaps to receive fixed at 8.75%. Instead, a one-year swap to receive 6.50% might be entered into. This would lock-in a net negative spread of 175 basis points on the swaps for the first year (8.25% pay, 6.50% receive). The achieved first year gross spread would be increased from –175 basis points to +175 basis points, as a result of having to pay 6% on the one-year GIC and receiving 9.50% on the five-year mortgage.

If the one-year GIC matures and is rolled into a four-year GIC, a four-year swap can be entered into at the same time. If the spread between the one-year forward four-year GIC rates and the one-year forward four-year swap rates prevailing on February 28 equals the spread actually achieved one year hence, then the spread achieved over the five-year term of the assets should be satisfactory. The potential for loss (gain) represents the basis risk.

6.6 Use of Interest Rate Swaps to Broaden Investment and Marketing Opportunities

Interest rate swaps can be used to overcome unattractive features of an otherwise attractive asset or liability. They can thereby broaden investment and marketing opportunities.

Suppose a cheap five-year term, floating rate bond paying BAs plus 60 basis points could be bought, but all liabilities were five-year fixed rate. The investment is cheap and, therefore, desirable, but floating rate, and, therefore, inappropriate to support the fixed rate liabilities.

A five-year term interest rate swap to pay BAs and to receive a fixed rate of 8%, could be purchased along with the floating rate bond. In combination, the bond and swap result in a fixed rate of 8.60%. Since the floating rate bond is cheap, the rate of 8.60% may be quite attractive. This would be especially true if excess demand for five-year investments had caused five-year fixed rate spreads to narrow and an excess supply of floating rate investments had caused the floating rate spread to widen.

Suppose a five-year asset can be sold either directly or in an MBS issue at an attractive rate, but fixed rate assets are needed to support liabilities. The sale proceeds can be invested in BAs and a five-year swap to pay BAs entered into. The fixed swap rate received will provide protection against a drop in rates until the BAs are liquidated to fund new five-year investments. This might be an especially attractive process if the company can source more five-year assets than it can use in support of its liabilities.

Suppose a five-year asset is available at an attractive rate, but a three-year asset is needed to support liability sales. The company could enter into a five-year swap to pay fixed and a three-year swap to receive fixed, or equivalently, it could enter into a three-year forward two-year swap to pay fixed. The swaps convert the final two years of the five-year fixed rate asset into a floating rate, thereby eliminating the interest rate risk arising from the term mismatch. Swaps could also be used to handle the situation where the available assets have a term shorter than that needed to support liability sales.

The spread difference between the three- and five-year swaps need to be combined with the spread difference between the five-year asset and three-year liability to determine what rate is locked in for the three-year period.

In a positive yield curve environment, the rate paid on the five-year swap will exceed the rate received on the three-year swap. This loss of spread may or may not be offset by the excess spread on the five-year asset relative to that assumed in pricing the three-year liability.

There is also the risk that after three years, the spread locked in by the five-year asset and five-year swap may not be satisfactory. In particular, if a two-year swap to receive fixed is entered into in three years, a positive or negative spread will be earned between the fixed spread received and the fixed spread paid on the original five-year swap. If this spread, combined with the rate on the five-year asset is less than that which could be earned on a new comparable two-year asset, then the rate locked in over the final two years will not be satisfactory. This is a basis risk with respect to three-year forward two-year rates. While there is basis risk in this procedure, the more serious risk of changes in the general level of three-year forward two-year rates has been eliminated.

Swaps can also be applied to overcome undesirable features of liabilities. Suppose a client wants a seven-year GIC, but only five-year assets are available. A seven-year swap to receive fixed and pay floating combined with a five-year swap to pay fixed and receive floating effectively converts the final two years into a floating rate liability, thereby eliminating the interest rate risk arising from the term mismatch. Swaps could also be used to handle the situation where the liability term was shorter than the assets.

The spread locked in for the first five years would need to be satisfactory. Also, there is basis risk with respect to the five-year forward two-year rate.

6.7 Interest Rate Swaps and Portfolio Management

If it is anticipated that rates will increase, a portfolio manager may sell bonds and hold cash or shorter term bonds. However, these bond sales may not be desirable. There may be adverse tax or financial statement consequences. There may be a substantial market or transaction cost due to the size of the trades or the illiquidity of the bonds. The bonds sold may be desirable for portfolio reasons such as diversification or they may be part of a bond strategy. It may be anticipated that quality spreads will narrow at the same time rates increase. Continued ownership of the bonds permits participation in gains from a narrowing in quality spreads.

An interest rate swap to pay fixed and receive floating can reduce the portfolio exposure to an increase in rates without disrupting the bond portfolio. If rates do rise, as anticipated, an offsetting swap can be entered into. The unrealized capital loss attaching to the bonds from the rise in rates is offset by the positive spread earned on the two swaps.

An interest rate swap to receive fixed and pay floating can increase the portfolio's exposure to a drop in rates. The bond manager need not sell short-term bonds and replace them with longer term bonds. If a widening of quality spreads is anticipated, the bond manager can continue to hold cash and avoid participating in losses from the widening.

CHAPTER 7 – FUTURES, FORWARDS AND REPURCHASE AGREEMENTS

7.1 Futures and Forwards

A futures contract is an exchange – traded, highly standardized contract obliging a buyer and a seller to trade at a set price on a future date or during a specified delivery period, a fixed amount of a specified commodity, currency, specific financial asset or index. The future is a price-fixing contract because the buyer takes on the financial consequences of owning the asset as soon as the future contract is established. The futures price quoted is the price to be paid at maturity in exchange for the asset.

A futures exchange is a central marketplace where futures contracts are bought and sold competitively and openly. All contract terms and conditions are specified by the exchange except the price. The exchange establishes and enforces trading rules and collects and publishes market information.

The standard terms and conditions of a futures contract make it more liquid and easy to trade. Contracts of the same maturity are identical and consequently can be traded anonymously. A centralized clearing house records, registers and administers all contracts until they are closed out or until delivery. The clearing house guarantees each contract, eliminating the individual management of credit lines and counterparty risk.

A buyer of a futures contract, who holds it until expiry, is obligated to accept delivery of the underlying asset or index. The seller is committed to make delivery during the delivery period.

Most futures contracts are settled in cash by closing out the contract prior to the commencement of the delivery period, rather than through the exchange of the future price for the underlying commodity, currency, market index or asset. In the case of futures on indexes, cash settlement will be the only means of settlement. To close out their "open positions," buyers simply sell their contracts and sellers simply buy offsetting contracts. The purpose of futures contracts is generally to capture the change in market value of the underlying asset or index and not to secure delivery of the underlying asset or index.

At the time the futures position is established, the investor is required by the exchange to put up collateral or margin equal to a small, specified percentage of the contract's face amount. This margin is a good faith deposit and not a down payment. The exchange defines the amount of this "initial margin." Every day thereafter, the investor will either pay or receive a "variation margin" equal to the change in price of the underlying asset or index times the face amount of the contract. This daily settlement means that the difference between the price of the underlying asset at contract initiation and maturity will be paid over the life of the contract. Variation margin payments should be recognized as accounting gains or losses in a fashion consistent with the related investment.

The clearing house is responsible for the collection of margin deposits and the settlement of gains and losses. The clearing house acts as the buyer to every seller and the seller to every buyer. It guarantees payment on every transaction in the event of a default by one of the parties to the futures contract. The margin provides the clearing house with the financial resources to provide the guarantee along with the capital and support provided by the exchange members. In this way, the financial integrity of the clearing house is ensured. The clearing house also assigns deliveries.

A futures contract is an off-balance-sheet item. Consequently, the value of the financial instrument underlying a futures contract is not reported on the balance sheet in financial statements. Initial margin continues to be owned by the company and should be shown as a company asset. The securities underlying futures margin receipts provided to the clearing house (Trans Canada Options Inc. – TCO) will also be shown as company assets.

The theoretical strike price of a bond future equals the current price of the bond plus the cost of financing its purchase until the delivery date less the yield earned on the bond. Bond futures normally have a strike price lower than the current spot price because the short-term borrowing cost is normally less than the bond yield. Supply/demand expectations can cause the strike price of a commodity future to be less than the current spot price even though there is no earned income to help reduce the financing costs.

Forwards

A forward contract is an over-the-counter future. The contracts are more flexible than future contracts. The price quote on a forward is the forward price that is payable at maturity in exchange for the asset. A forward contract is executed over the phone. Subsequently, written confirmations and signed contracts are exchanged.

Normally, there is no margin. Cash changes hands only at maturity, when the buyer pays the forward price and receives the asset, or cash settlement of the difference between the asset and forward price takes place. Consequently, both parties have credit exposure to each other for the term of the contract. To reduce credit risk, collateral may need to be posted at the outset or when an adverse market move exceeds a predetermined threshold. A forward contract on a share usually has physical settlement.

One of the most common types of forward contracts is a forward rate agreement (FRA). Unlike a future, there is usually no initial or variation margin. The parties to the FRA contract agree to exchange the difference between the market rate on an index, such as three-month LIBOR, on the contract settlement date, which is six months from the start date, say, and a fixed rate agreed to on the purchase date of the FRA. The purchaser benefits from rate increases and the seller benefits from rate decreases. FRAs are referred to in terms of the number of months to the beginning and end of the FRA. A six-month FRA starting two months forward is a 2 X 6 FRA. An interest rate swap is a package of FRAs, one for each floating rate reset date.

The most common forward contract is the forward currency agreement (FCA). Currencies are bought and sold up to one year forward on a regular basis. Major currencies can usually be brought forward for at least five years without difficulty. Usually no money changes hands prior to maturity. The FCA fixes an exchange rate for exchanging currencies on the settlement date. Settlement may be by an actual exchange of physical currency, but usually involves a cash payment equal to the value of the difference between the exchange rate fixed by the contract and the spot exchange rate at the time of settlement.

The Ten-Year Bond Future

The ten-year Government of Canada bond futures contract (CGB) traded on the Montréal Exchange is an example of a futures contract. The trading unit is $100,000 of a notional Canada bond with a 9% coupon. Any Canada bond can be used in delivery with 6 1/2 to 10 years maturity as of the first day of the delivery month and a minimum of $3.5 billion outstanding as determined by The Montréal Exchange. The delivery day is any business day in the delivery month (seller's choice). Delivery should be settled through the Canadian Depository for Securities (CDS) on the fifth business day following tender of the delivery notice. The last trading day is the seventh business day preceding the last business day of the delivery month. The future is quoted per 100 of value in increments of .01. Delivery notices must be submitted on the fifth business day preceding the last business day of the delivery month. Minimum margin requirements per contract are $3,000 for speculators, $1,000 for hedgers and $300 for spreads. Positions are limited to 4,000 contracts unless prior approval is received from The Montréal Exchange (hedgers only).

The Conversion Factor

Sellers may deliver Canada bonds that do not have a 9% coupon and that vary as to maturity. The price amount for any delivery bond is calculated using a conversion factor. The purpose of the conversion factor is to bring all the deliverable bonds on to a common basis for delivery.

The conversion factor is the price at which the delivered bond with $1 par value with the same maturity and coupon would be sold to yield 9% on the first day of the delivery month (less accrued interest). A list of conversion factors are published by the Montréal Exchange before the contract is listed for trading.

The delivery settlement amount is the accrued interest plus the futures settlement price times the conversion factor times 1,000. The seller has the choice to select which bond to deliver. There will be one bond that maximizes the seller's gain or minimizes the seller's loss. This bond is referred to as the "cheapest-to-deliver" bond. The issue with the narrowest "basis" is the "cheapest-to-deliver" bond. The basis is the cash bond price – the futures price times the conversion factor.

The Toronto 35 Index Future

In 1987, the Toronto Stock Exchange developed the Toronto 35 index. The index consists of 35 liquid Canadian stocks representing most of the TSE 300 industry groups except real estate and construction. The index is highly correlated with the TSE 300 and is calculated every 15 seconds.

The selected stocks are large market capitalization, publicly listed, and heavily traded stocks. Many are interlisted on other international stock exchanges.

The Toronto 35 index futures contract (TXF) is valued at $500 times the Toronto 35 index futures price. Price increments are .02 or $10 per contract. There are position limits for speculators and hedgers and reportable positions. Contracts are available for the three consecutive near months. There are daily price limits and minimum client margins. Trading terminates at 4:15 p.m. on the Thursday before the third Friday of the contract month.

Open positions at the termination of trading are marked-to-market based on the official opening level of the Toronto 35 index on the following day. The opening level is calculated by the Exchange only when all 35 stocks in the index have opened for trading (board lots only). If the stock does not trade on that day, then the last trade price from the preceding day is used.

Actual delivery of the shares in the index never takes place. Settlement is always in cash. The cash settlement price is $500 times this official level. Settlement is on the second business day following the last trading day.

7.2 Hedging and Risk Management Uses of Futures

Futures can be used for hedging, portfolio or risk management and for leveraged speculation on prices or interest rates. A future can be sold to hedge excess assets or bought to hedge excess liabilities or to gain market exposure until an outstanding premium is received or excess cash can be invested.

Futures on bonds or money market instruments can be bought and sold to increase or decrease portfolio duration. The shift in duration may be to reduce a duration gap between assets and liabilities or it may be to achieve a shift consistent with the portfolio manager's views on interest rates.

Futures can be used in asset overlay strategies. Futures provide a fast efficient way for portfolio managers to implement investment strategies without impacting their portfolio. They can be used to rebalance relatively illiquid portfolios.

Bond Hedging Strategy

Assume $10 million par of excess Canada bonds are held. These bonds meet the delivery requirements for the CGB contract and The Montréal Exchange has established a 1.04 conversion factor for the bond. This means that $100,000 par of the Canada bonds can be delivered to meet $104,000 of contract requirement.

The insurance company would sell

$$\frac{10{,}000{,}000}{100{,}000} \text{ X } 1.04 = 104 \text{ contracts}$$

However the contract value changes, the $10 million par of excess Canada bonds can be used to deliver on the contract. The bonds are hedged.

Equity Hedging Strategy

Assume a pension fund portfolio manager has a $10 million Canadian equity portfolio with a beta relative to the TSE 35 of 1.1. She feels that the portfolio is particularly vulnerable at present market levels. The portfolio manager can approximately hedge this position by selling $11 million of TXF contracts.

Foreign Exposure

Registered pension plans in Canada are restricted to a maximum of 20% in non-Canadian stocks or bonds by Revenue Canada without suffering severe tax penalties. This restriction exists in cash markets. Revenue Canada treats non-Canadian futures contracts as “having no value” and, as such, futures contracts will not affect foreign content restrictions (with the exception of any foreign currency margins). As a result, some pension plans make use of the roughly 13 foreign exchanges that offer stock and bond futures to increase their foreign content above the 20% level.

Asset Overlay Strategy

The asset mix of a $1 billion portfolio is 20% stock, 60% bonds and 20% mortgages. It is desired to increase (decrease) the equity exposure to 25% (15%) and to decrease (increase) the bond exposure to 55% (65%) without disturbing the existing portfolios. In the cash market, $50 million of stocks would be purchased (sold) and $50 million of bonds sold (purchased). The overlay strategy would leave the portfolio intact but purchase (sell) $50 million of stock index futures and sell (buy) $50 million of bond (stock index) futures. TSE 35 index futures (TXF) and ten-year Government of Canada bond futures (CGB) could be used. The market exposure requirements are now met.

The asset overlay strategy might be preferred to a cash market transaction because it leaves a desirable portfolio intact, it defers the realization of gains and losses for reporting and tax purposes, it reduces the commissions payable (futures commissions are lower than cash market conditions) and it can be easily and rapidly implemented.

Fixed Income Portfolio Duration Adjustment

Suppose the liability duration is seven years and the asset duration is 6.5 years. The market value of both assets and liabilities is $1 billion. The portfolio manager is concerned about an interest rate drop and wishes to completely close the duration gap. The manager decides to use futures with a duration of six years and price of 105 to close the gap. The number of futures contracts to purchase can be calculated as

Contracts =

$$= \frac{\text{Required duration change}}{\text{Duration of the future}} \times \frac{\text{Market value of the portfolio}}{\text{Market value of the future contract}}$$

$$= \frac{.5}{6} \times \frac{1{,}000{,}000{,}000}{105{,}000} = 794 \text{ contracts}$$

The formula is obtained by equating the dollar duration impact required to the dollar duration impact of the contracts. The increase in value from a 1% uniform drop in rates on the 794 futures contracts when added to the increase in value on the $1 billion of assets should approximately equal the increase of the liability.

A Synthetic Asset Strategy

One strategy combines T-bills and a futures contract to create a return equivalent to the underlying Canada bond. The total return on the purchase of one contract ($100,000) could be calculated as follows:

Initial Investment	
Initial margin	$3,000
T-Bills	$97,000
	$100,000
Investment Income	
Interest on initial margin	$150
Interest on T-Bills	$3,850
Variance account	$1,000
	$5,000

Total return over period = 5%

Hedging Using BA Futures Contracts

If an insurer owned three-month bankers acceptances (BAs) and wished to fix the return earned on the BAs over a six-month horizon, it could purchase three-month BA futures contracts maturing in three months. The insurer would have fixed the rate earned on its BA position for six months, effectively extending the term of its BAs from three to six months.

When the yield curve is positively (negatively) sloped, a discount (premium) is factored into the price of the futures contract. For example, assume three-month T-Bill rates are 6% and 10-year Canada bond rates are 8%. Instead of buying the ten-year Canada bond future, the insurer could borrow for three months and buy a ten-year Canada bond. The insurer will earn the difference between the 6%, three-month rate and the 8%, ten-year rate. This "positive cost of carry" results in a discount on the futures price. If this discount is not reflected in the futures price, arbitrageurs will bid the futures price down until the discount is reflected.

Hedging Future Debt Issues

Futures may be sold to hedge future debt issues against rises in interest rates. If rates rise, the sold futures contracts will result in gains that offset the extra debt cost from the higher rates. If rates drop, a loss will be incurred that represents an opportunity cost (i.e., the opportunity to benefit from issuing debt at lower rates is sacrificed).

Hedging an Outstanding Premium

Futures may be bought to hedge future premium from a liability that has been priced. If rates drop prior to the receipt of the premium, the gains on the future position will offset the lower rate earned on the investments purchased when the premium is received. If rates increase, a loss will be incurred that represents an opportunity cost (i.e., the opportunity to benefit from investing the premium in a higher interest rate environment than assumed in the price is effectively sacrificed).

Arbitrage and Speculation

Arbitrageurs attempt to make money by taking advantage of differences between cash and future market prices. Speculators and arbitrageurs contribute materially to market liquidity by buying and selling large volumes of futures contracts.

7.3 Risks Associated With Future Contracts

The risk of owning (being "long") a future is the same as owning the underlying asset or index. The maximum potential loss equals the strike price and arises when the underlying asset or index has lost all its value. If the long future position is established as a hedge or as an alternative to a cash market transaction, this risk is no different from the risk of establishing the equivalent cash market position.

The loss at expiry, if any, from selling (being "short") a future equals the difference between the value of the underlying asset or index and the strike price. There is no maximum potential loss, since the value of the underlying asset or index can increase without limit. If the short future position is established as a hedge, this risk is an opportunity cost (i.e., the potential gain that would have been realized as a result of in prices).

When futures are not used to hedge or as an alternative to a prudent portfolio cash market transaction, the risks of futures are substantial. By depositing a small initial margin, the future can cause the investor to receive or pay several times that amount in daily variation margins. It is this leveraging or speculative use of futures that is of great concern to regulators, boards, and senior management of financial institutions.

When used in hedging strategies, there may be considerable basis or timing risk between the hedged position and the hedging future.

Futures are not available on all types of commodities, currencies securities, and market indices. Even when the required type of security etc. is available, it may not be available on the precise instrument required for a perfect hedge. A ten-year Canada bond future may be shorted to "hedge" a 12-year mortgage or corporate bond. A future on a stock index may be shorted to "hedge" a specific stock portfolio. In the absence of a perfect hedge, the futures position is subject to basis risk. Basis risk arises when there is not a perfect correlation between the change in value between the hedged position and the hedging future.

Even when the precise future required is available, differences in the cash and future market prices can arise as a result of supply and demand factors and a shift in the cash market yield curve. The price differential is called "the basis." Changes in "the basis" can be significant, and, at times, the cash and futures price can move in opposite directions. This risk can be reduced by structuring hedges to terminate in the delivery month of the futures contract. This reduces basis risk since the cash and futures prices will converge during the delivery month.

Many corporate end users, pension funds and mutual funds relied on the exchange rate mechanism to support a kind of "speculation" on currency correlations. Instead of hedging high EMS interest rate currency exposures, such as Italian lire, Spanish pesetas or Portuguese escudos with their own currencies, they “hedged” them with low interest rate currencies such as Deutschmarks or Swiss francs. They bet that the close correlation between these currencies that persisted for the period from 1985–1990 would continue. Such action substituted straight currency risk for currency correlation risk. For many, this “hedging” strategy actually increased risk and resulted in material losses when the mechanism that had preserved this artificial linkage between currencies finally broke down.

Timing risk arises when the hedging future does not expire at exactly the same time as the expiry of the risk being hedged. If the future expires late, the future may need to be unwound early at a value considerably less than the value needed to hedge a loss. If the future expires early, the hedge may need to be rolled over one or more times. Timing risk is especially acute if the futures are being used to hedge nonmarketable obligations with a deferred delivery date such as oil delivery contracts.

The daily fluctuations in the value of short-dated futures can vary considerably from the fluctuation in the value of long-dated futures. Short-dated futures should be viewed with considerable scepticism as substitutes for long-dated futures that may or may not be available. Timing risk was a factor in the Metallgesellshaft future “hedging” losses of $1.4 billion, where “backwardation” was relied upon to justify buying short-dated futures to “hedge” very long-dated fixed price oil contracts.

Normally, futures prices on non-income earning assets exceed spot prices for the underlying asset or index as a result of the costs of holding the underlying asset or index. However, current supply shortages can cause short-term commodity prices to exceed the long-term price. The situation in which the forward curve is negatively sloped is called backwardation. Backwardation had prevailed for a number of years in the oil market prior to the fall of 1993, when short-term oil prices fell about $5 a barrel, while long-term prices did not change. Reliance on backwardation and this sharp fall in price produced the major losses at Metallgesellshaft.

Even though perfectly hedged, an insurer will not be indifferent to interest rate movements if they result in margin calls to cover contract losses or receipts of cash from contract gains. Adjustments to the number of contracts in the hedging position may be necessary to reflect the change in the cash position.

7.4 Repurchase Agreements and Security Lending

The repo (repurchase agreement) market is sometimes called the “financing” market, because it began as the market used by security dealers to finance their bond positions. While dealers still use it for this purpose, many financial institutions use it as a low-risk method of enhancing yields. To make markets in equities, bonds and derivatives, dealers must be able to sell securities short. To do this, they must be able to borrow securities. Reverse repurchase agreements can be used to meet this need. Central banks use the repo market for short-term monetary control.

Consider an arrangement in which the holder of a security sells the security at market for cash to a counterparty with a simultaneous agreement to repurchase the securities at a fixed price (inclusive of interest) on a fixed date. Although a sale takes place, the seller retains the full market exposure to the security, since the seller must pay a fixed price for the security at a future date, whether the security increases or decreases in value.

The transaction is a repurchase agreement from the perspective of the counterparty selling the security for cash and a reverse repurchase agreement from the perspective of the counterparty paying cash for buying the security.

Repoed securities are usually not taken off the seller’s balance sheet. A debt is booked to the buyer for the full amount of the repoed security. Repoed securities are usually not included in the buyer’s balance sheet. A receivable is booked to the seller for the full amount of the repoed security.

The securities dealer, hedge fund or financial institution needing to finance a government bond position sells the bonds to a cash investor, while simultaneously agreeing to repurchase them at a later date. The seller is effectively borrowing cash and using the bonds as collateral. The purchaser of the security (cash investor) is effectively lending money to the seller on a fully secured basis and earning a return equal to the difference in cash paid to, and received from, the seller. This return is known as the repo rate.

The yield on repos is highly competitive with bank deposits, even though investment theory might suggest repos should provide a materially lower yield to reflect their fully secured nature. However, many participants in the repo market, such as securities dealers, are not members of central banking systems such as the Federal Reserve and so cannot enter the wholesale deposit market available to banks. Because dealer sources of financing are more limited, repo rates can even exceed deposit rates when dealers are competing for limited financing.

The minimum investment is usually $1 million. The U.S. Treasury repo market has thrived since the 1960's and has more (over half of the worldwide) daily turnover (in excess of $1 trillion) than any other financial market. It is regarded as a safe, flexible alternative to deposits, money market instruments and commercial paper.

Repos may be done for a specific term for any term from one day up to a year. This maturity flexibility is an attractive feature, since it enables the cash investor to tailor the arrangement to meet cash needs. Alternatively, they can be done on an open basis, where the repo is in place until one of the parties terminates it.

If the cash investor takes delivery of the bond into one of its accounts, settlement instructions will be needed and custody and transfer charges will be incurred. The most common arrangement is a "hold-in-custody" repo transaction, where the bonds are placed in a safekeeping account in a clearing bank, Euroclear or Cedel. In a tri-party repo transaction, a custodian bank or clearing house takes delivery of the securities on the investor's behalf and ensures that both parties fulfil their responsibilities. The dealer assumes all the custody and administrative costs.

To the extent that repos are not supported by a legally enforceable contract and a margin account, there is a risk that the counterparty will renege on the second leg of the arrangement. In 1990, Germany's DG bank tried to renege on agreements to repurchase Dm 6 billion of bonds that it had sold to at least eight French banks.

If the assets sold are held in custody by the seller in the repo arrangement (rather than by the purchaser or a third party), there is the risk of outright fraud. On March 23, 1994, Wallace Smith, a British merchant banker, was imprisoned for six months, for just such fraudulent activity in relation to repos worth 100 million pounds in relation to the Wallace Smith Trust Co.

It is possible to use reverse repurchase agreements to leverage asset duration beyond that available in the cash markets. Assume $100 million of 30-year Canada bonds are sold under a reverse repurchase agreement with a dealer. The seller retains the interest rate exposure to the $100 million of 30-year Canada bonds. The seller receives cash that it can use to purchase a further $100 million of 30-year Canada bonds. Even though the seller only owns $100 million of Canada bonds, the reverse repurchase agreement means the seller owns $200 million of interest rate risk exposure. In this way, it is possible to use reverse repurchase agreements to duration match very long duration liabilities. It is also possible to leverage the fund as with Orange County and many hedge funds in order to place speculative bets on interest rate movements.

Security lending is an alternative to reverse repurchase agreements. Institutions that own the securities being sold short lend them to the dealers against collateral, for a fee. Through security lending, institutions can earn incremental return. The size of the incremental return depends on the demand for the security, the supply of the security and the range and flexibility of permitted investments for the collateral account.

Security lending is usually thought to be a low risk activity. However, the discussion in Sections 2.1 and 2.1.1 of security lending losses absorbed by Harris Trust, Mellon Bank and Boatman National Bank indicate that market risk can lead to sizeable losses on cash collateral accounts, even without a borrower failure or a credit loss on collateral.

Usually, the securities lent are not taken off the lender's balance sheet. The securities are considered to be the borrower's property and are recorded on the borrower's balance sheet at market. A debt is recorded to the lender for the market value.

CHAPTER 8 – OPTIONS, FORWARD SWAPS, SWAPTIONS, CAPS, FLOORS, COLLARS

8.1 Options

An option is a contract in which the buyer pays a fee (called a premium) in exchange for the right, but not the obligation, to buy (a call option) or sell (a put option) a fixed amount of a specific commodity, currency, swap, futures contract, financial asset or market index at a set (strike) price within, or at, a specified time.

Dividends on individual stocks and coupon payments on individual bonds that are received during the option term are not usually paid or due to the call option owner. The option is on the underlying asset or index itself. The call (put) option price will be higher (lower), in the event that such payments are to be paid. In the case of options on total return indexes, these payments will be taken into account indirectly.

An option may be exchange-traded, with standard terms, or over-the-counter, with terms negotiated directly between the two parties. The amount that can be purchased/sold is the "face amount" of the contract. The premium paid is usually a small fraction of the face amount.

Stock option contracts and the rules of option exchanges usually immunize counterparties against stock splits, stock dividends, rights issues and other similar actions.

Exchange-traded option prices are quoted in cash terms. If the price of an over-the-counter option is expressed as a percentage, the end user needs to be clear as to whether the percentage applies to the strike price or the underlying asset value (if they differ). Prices quoted in percentage terms are not very sensitive to changes in the price of the underlying asset or index and may continue to apply, even if the market has moved.

Call options are not securitized, so they can be sold without the seller owning the underlying asset or index. This distinguishes a call from a warrant, which is a securitized call that can only be sold, if the seller owns the actual security. The warrant, being a physical security, must be physically settled.

Options terminate through their exercise, expiration or through an offsetting option purchase or sale (closing transaction). Options settle upon exercise through delivery of the underlying asset or index or through cash settlement of the difference between the strike price and the asset value. Options on indices almost always specify cash settlement. Options on single stocks usually have physical settlement.

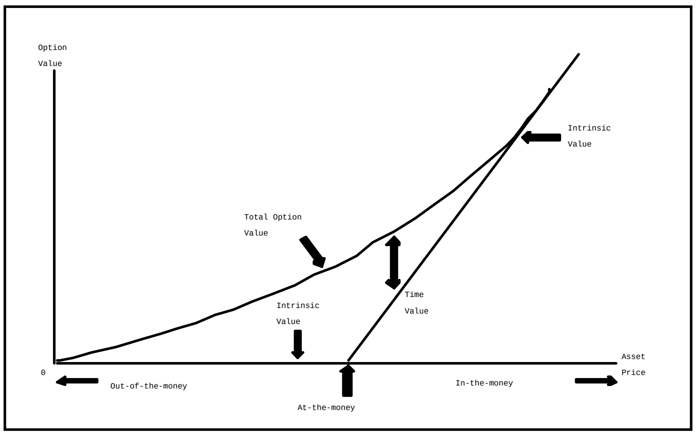
A European-style option is one which may be exercised only on the expiration date. An American-style option is one which can be exercised at the owner's choice, any time prior to expiration. "Transatlantic" or Bermudan-style options can be exercised before maturity, but only at specific times on specific dates (once a week, or once a month, etc.). An option is path-dependent if its value depends on the value of the underlying asset or index at more than one time. A European option is not path-dependent, whereas American and Transatlantic options are.

The risk of loss from an option depends on whether you are purchasing or selling, and, if selling, whether you are "covered" or "naked." The buyers of options cannot lose more than their option premium. A written call (put) option is "covered" if the writer owns the underlying asset or index or an offsetting call (holds cash or an offsetting put) in an amount equal to the amount of the option written. The cost of covered call writing is one of opportunity. A written option is "naked" if it is not covered. The potential loss on a naked call is unlimited and on a naked put is 100% of the strike price.

A call or put option is said to be at-the-money, if the strike price equals the current value of the underlying asset or index. A call (put) is said to be in-the-money, if the strike price is less (greater) than the current value of the underlying asset or index. A call (put) is said to be out-of-the-money, if the strike price is greater (less) than the current value of the underlying asset or index. A call (put) is said to be deep-in-the-money or deep-out-of-the-money, if it is in or out-of-the-money, respectively, and the difference in strike price and the current value of the underlying asset or index is viewed as being large. If an out-of-the-money option is purchased to partially hedge a position, the hedger can lose an amount equal to the premium plus the difference between the current and strike price.

Put-call parity refers to the notion that the European put option premium should equal the European call premium (for a call with the same strike price and expiry date) plus a short position in the underlying plus the present value of a riskless investment that will accumulate at the risk-free rate at option expiry to an amount equal to the strike price.

The intrinsic value of an option is the difference between the current price of the underlying asset or index and the option strike price for in-the-money options, and zero for other options.



The solid line is the intrinsic value and the dashed line is the total option value (premium) at some time prior to option expiry. The difference is by definition the time value. While time value clearly increases with time to option expiration, it also increases with price volatility and the cost of carry. The time value is greatest when the option is at-the-money and decreases as the difference between the strike price and the current asset price increases.

8.2 Option Premiums and Pricing

If the probability distribution for the price of the underlying is known at option expiration, the value of a European option can be calculated as the sum of the present value of the probability weighted option values at expiry based on this distribution. The distribution is often taken to be lognormal with mean equal to the current forward price to prevent risk free arbitrage. The option premium can thus be seen to depend on the time to expiry (which impacts both the breadth of the distribution and the impact of present valuing), the price volatility of the underlying asset (which impacts the breadth of the distribution), the strike price (which impacts the option value at expiry at any point on the distribution), the current forward price for the underlying (which impacts the mean of the distribution) and current interest rates (which are used in taking the present value).

A broader distribution and consequent higher premium arises the longer the time to option expiry and the greater the price volatility of the underlying asset. The option tends to lose value as time passes because the distribution of outcomes at option expiry narrows with the passage of time.

More precisely, call (put) option premiums increase (decrease), the higher the current stock or bond price, the lower the strike price, the higher current interest rates and the lower the expected dividends or interest payments. Call and put premiums both increase, the higher the expected volatility and the higher the face amount. American and Transatlantic call option premiums are equal to, or greater than, European call option premiums. American and Transatlantic put option premiums are greater than European.

Call option premiums increase the longer to maturity. However, put option premiums may or may not increase the longer to maturity. Increases in time to maturity decrease the present value of the strike price and hence the value of the put option. However, increases in time to maturity increase the likelihood of profitable exercise of the put option. The net impact of these factors may increase or decrease the put option value.

Analytical or closed-form option pricing models find an explicit solution for the option price using mathematical equations. Many of these, like the Black-Scholes model, specify and solve a stochastic differential equation. These models cannot be used to price American-style options whose value depends on the price of the underlying security throughout the period prior to option expiration, since the security price cannot be expressed as a single parameter. The models cannot easily handle variations in the risk-free rate or volatility and so are increasingly less accurate the longer the option period.

Numerical techniques are sometimes used to estimate the premium for early exercise of an option. This numerical estimate is then added to the European option price obtained using a closed-form option pricing model in order to estimate the premium for an American-style option. The Barone-Adesi-Whaley model, for example, uses a quadratic approximation approach to accurately value American-style puts and calls on assets paying continuous dividends.

An arbitrage-free option pricing model is based on the assumption that arbitrage of the underlying variable is not possible. The Cox-Ingersoll-Ross, Ho-Lee, Heath-Jarrow-Morton and Hull-White interest rate models are arbitrage-free. Constraints are placed on interest rate changes to prevent arbitrage.

The Black-Scholes option pricing model was developed in 1973 and remains the industry standard for pricing European stock options. It provides an arbitrage-free value for European style options on stocks as a function of the share price, the exercise price of the option, the risk-free interest rate, the time to option expiry and the variance of this stock price. It assumes no dividends, no taxes, no transaction costs, a constant risk-free rate and a constant stock price volatility. It also assumes that the stock price is log normally distributed, that the market operates continuously, that the stock price changes continuously from one time to another, and that no penalties apply to short sales. The assumption of constant stock price volatility causes the Black-Scholes model to undervalue near-maturity options, deeply out-of-the-money options and options on low volatility stocks and to over value long-term options, deeply-in-the-money options and options on high volatility stocks.

The Black-Scholes model describes how a risk-free portfolio can be constructed, which contains the option, a position and an offsetting “mirror” position consisting of the underlying stock and a money market position. The riskless position can be maintained by continuously buying or selling the underlying stock in the correct amount. On the no-arbitrage assumption, this riskless position must earn the risk-free rate of return. Consequently, the value of the portfolio at any time is its value at expiry discounted back at the risk-free rate. The price of the option can then be determined from the price of the underlying based on the lognormal assumption about stock price.

The Black’s model extends the Black-Scholes model to valuing interest rate options. The model assumes the probability distribution of future interest rates is lognormal with a mean equal to the forward interest rate and a standard deviation equal to an observed volatility that depends on both the time to option expiry and the term of the rate. This model is used to value caps, floors, European bond options and swaptions. It cannot be used to value path-dependent options.

The Garman-Kohlhagen pricing model extends the Black-Scholes option pricing methodology to pricing currency options with modifications to allow for two interest rates and the fact that a currency may trade at a forward premium or discount.

The Cox-Ingersoll-Ross option pricing model generalizes the Black-Scholes model by modelling expected returns from changes in the term structure of interest rates. The Ho-Lee, Heath-Jarrow-Morton, Black-Derman-Toy and Hull-White models model volatilities at different points in the term structure to derive a probability distribution for an arbitrage-free lattice of the term structure. For example, the Hull-White model uses the observed volatility of the short-term rate "*a*" and an observed reversion rate "*b*" to reflect that long rates are less volatile than short rates. These models allow the whole-term structure to be stochastic and not just the single price of an underlying asset or interest rate. This allows long- and short-term interest rate options to be priced consistently.

The Ho-Lee model assumes the returns on zero-coupon bonds at different terms are perfectly correlated. The Heath-Jarrow-Morton model is a two-factor term structure model that does not make this assumption. The term structure and its volatility through time are inputs.

A binomial option pricing model uses a binomial tree or lattice to price the underlying. It thus uses an algorithm instead of a closed form formula. Binomial trees are particularly useful in valuing American-style and interest rate options. The time to option expiry is divided into a series of discrete time intervals. The price or yield is assumed to move up by a proportion u of the value at the beginning of the interval with probability p or down by a proportion d with a probability $1-p$ at each interval. The values of u, d and p are based on the assumption of a normal distribution. By working backwards through the intervals from the option expiry date, when the option value is known, to the present, the arbitrage-free value of the option can be calculated. The Cox-Ross-Rubenstein model is the best-known.

If a move up followed by a move down results in the same price as a move down followed by a move up, the branches of the tree recombine and the process is path-independent. A tree in which branches do not recombine are "exploded" trees. They are computer intensive since the number of branches increases exponentially. However, they can be used to price path-dependent options. Trinomial and multinominal models allow three or multiple movements.

8.3 Option Uses and Strategies

To hedge a position against losses from an increase (decrease) in rates, a put (call) option on a bond of appropriate term would be purchased. The put (call) option increases in value with increases in rates above (below) the rate equivalent to the strike price on the option. These option gains hedge the losses on the position hedged.

To hedge a stock portfolio that is highly correlated with the TSE 300 against a decline in value, put options could be bought on the TSE 300 index. Should the index decline in value below the put strike price, the put option will increase proportionately in value. Assuming the amount of puts purchased bought protection for the entire portfolio and that the portfolio loses value to no greater extent than the index, the gains on the puts will offset the losses on the portfolio.

Options used for hedging can be expensive. To reduce the cost, the strike price of a call (put) can be increased (decreased). While reducing the cost, this also means a greater loss must be absorbed before the protection of the option kicks in.

To reduce the cost of hedging, the purchaser of a call (put) can write an otherwise identical option with a strike price that is higher (lower) than the strike price of the purchased option. This is referred to as an option spread. While the cost of the "hedge" is reduced, the potential benefits from the "hedge" is restricted to the difference between the two strike prices. The losses on the hedged position arising from increases (decreases) in rates above (below) the rate equivalent to the strike price on the put (call) that has been sold must be born by the "hedger." The draft NAIC Model Investment Law does not allow use of option spreads.

The cost of purchasing a call (put) can be reduced by simultaneously writing a put (call) with a lower strike price. The combined option positions are referred to as a collar. The strategy can be prudent, if the balance sheet is exposed to losses from increasing (decreasing) rates and gains from decreasing (increasing) rates, say. The losses on the hedged position arising from increases (decreases) in rates are offset by gains on the purchased put (call). While relatively inexpensive protection is thus provided, this strategy gives up the opportunity to benefit from gains on the hedged position from decreases (increases) in rates. Any gains on the hedged position from decreases (increases) in rates will be offset by losses on the call (put) that has been sold.

Option spreads can be used to take positions rather than hedging. A bull call (put) spread is the simultaneous purchase and sale of call (put) options, with the same expiry date, where the purchased call (put) has a lower strike price than the sold call (put). The benefits from an increase in the value of the underlying asset or index are capped, but the loss is limited to the net premiums paid. A bear call (put) spread is like a bull call (put), except that the purchased option has a higher strike price than the one sold and the investor benefits from a decrease in the value of the underlying asset or index. Complex combinations of options, such as the combination of bull and bear spreads, are called butterfly spreads.

A long (short) straddle is the purchase (sale) of a put option and a call option on otherwise identical terms. A long (short) strangle is a long (short) straddle in which option strike prices are equally out-of-the-money.

A horizontal spread involves the simultaneous sale of an option with a nearby expiry date and the purchase of an option with a later expiry date, both of the same type and with the same exercise price. A vertical spread involves the simultaneous sale and purchase of options of the same type and expiry date, but a different strike price. A diagonal spread involves the simultaneous sale and purchase of options of the same type with different expiry dates and strike prices.

8.4 Delta, Gamma, Theta, Vega, Rho

Delta is the ratio of the price sensitivity of the option to small changes in the price of the underlying asset or index. It is the first partial derivative of the option price with respect to the price of the underlying. Delta lies between –1 and +1. The delta of a call option can be interpreted as the probability of the option expiring in the money. An option whose price changes by $1 for every $2 change in the price of the underlying asset or index has a delta of .5.

The value of a call increases with increasing value of the underlying asset or index and with the time to expiration. At very low values of the underlying asset or index (i.e., when the option is deep-out-of-the-money), delta approaches zero. At high option values (i.e., when the option is deep-in-the-money), delta approaches one.

Owning a deep-out-of-the-money call option provides almost no exposure to the underlying asset or index. Owning a deep-in-the-money call option is like owning the underlying asset or index. The transition from a delta of zero to a delta of one is more rapid the closer you are to option expiry.

The value of a put increases with decreases in value of the underlying asset or index and with time to expiration. At very low option values (i.e., when the put is deep-out-of-the money), delta approaches zero. At very high option values (i.e., when the put is deep-in-the-money), delta approaches minus one.

Owning a deep-out-of-the-money put provides almost no exposure to the underlying asset or index. Owning a deep-in-the-money put is like "shorting" the underlying asset or index, because the put increases (decreases) in value when the underlying asset or index decreases (increases) in value.

The risk exposure to an asset can be hedged by purchasing put options on the asset in proportion to one over the delta of the option. If one dollar of option changes in value by *c*, the asset will change in value by *c* times delta divided by delta (i.e., *c*). This approach is called delta hedging. A delta-neutral position exists when the combined financial position of options and underlying asset or index is unaffected by small changes in the price of the underlying asset or index. Delta hedging is strictly analogous to duration hedging in the context of interest rate risk management.

As time passes, a position that is initially delta hedged will not remain hedged, since the price of the underlying asset or index will change and this will produce changes in the price sensitivity of the option. The process of continuously adjusting the hedge to maintain delta-naturality is called dynamic hedging. This is analogous to the need to continuously adjust a duration neutral position through time.

Gamma (omega) is the second (third) derivative of the option premium with respect to the price of the underlying asset or index. Gamma measures the sensitivity of delta to small changes in the value of the underlying asset or index. The gamma of a call is greatest for an at-the-money call. The gamma of a put is identical to that of a call. In particular, it is greatest for an at-the-money put. Gamma increases as volatility decreases for an option which is at-the-money.

Gamma indicates how much of the underlying asset or index must be traded to keep a hedge on. A delta neutral position with a high gamma will need to be rebalanced frequently and the position is exposed to gamma risk (i.e., risk that shifts in the value of the underlying asset or index are not exactly offset by shifts in the value of the options). As an option approaches expiration, the gamma of an at-the-money option is quite high indicating that a lot of trading may be required to keep a hedge on.

Theta is the negative of the ratio of the change of an option price to a change in expiration date. The longer the time to expiration, the more likely it is that the option will expire in-the-money and so the more valuable the option will be. That portion of the option's value that results from this relation is referred to as its time value. Theta measures how fast the time value of the option vanishes.

Vega is the ratio of a change in an option price to a change in the volatility of the underlying asset or index security. It measures volatility risk. Volatility risk is greatest when the time to expiration is greatest. It declines as expiration approaches. Vega is always positive. At-the-money options are most sensitive to changes in volatility, while deep-in-the-money and deep-out-of-the-money options are insensitive. A change in the volatility assumption used to price an option will produce a change in option value even if there is no change in the value of the underlying asset or index. A position that is both delta and gamma hedged may thus still lose value.

Rho is the ratio of the change in an option price to a change in interest rates. Rho measures an option's interest rate risk. It is a kind of duration measure. In general, higher rates increase the value call options and decrease the value of put options.

8.5 The Forward Swap

The forward swap is just like the floating-fixed swap except that the exchange of payments does not commence until a future date. The fixed rate is based on rates prevailing at the time of transacting for the forward swap agreement. It can be used when there is potential for loss from a rise in rates, or when it is desired to move the realization of current bond gains or losses forward or backwards in time.

A corporation may have a future refinancing need due to a call date or maturity date on existing debt they have issued. A forward swap, commencing at this date, can lock in the current refinancing cost. If the debt is rolled over into floating debt, a forward swap to pay floating can lock in a fixed rate cost based on current rates. The forward swap can also lock in the cost of future borrowing in the case of real estate or project developments.

Since the fixed rate on the forward swap is based on current forward rates, the forward swap makes sense only when rates are expected to rise above the forward rates or there is a decision to hedge against such an outcome.

A forward swap can be used to hedge a liability in which the receipt of the premium is deferred. The commencement date of the swap would be the date of the receipt of the premium and the term of the swap would be the term of the liability. The liability writer would agree to receive a fixed rate. Upon receipt of the premium, fixed rate investments are made and the swap is unwound. If fixed rates have dropped prior to premium receipt, the fixed swap rate at premium receipt will be lower than the fixed rate on the forward swap. This positive spread, when added to the rate on the investment made at premium receipt, will support the liability rate, when combined with the lower rates received on the permanent assets in which the premium is invested.

If the rates have dropped since issue, the issuer of a callable bond can realize the gain now, by entering into a forward swap commencing at the call date to pay the fixed rate on the callable bond to its maturity. The forward swap counterparty will pay an amount up front reflecting the value of the excess of the callable bond rate over the regular forward swap rate. This allows the capture of the intrinsic value of the call option (i.e., the difference between the bond rate and the current level of rates). The time value of the call option must be forgone, however.

Forward swaps can be used to lock-in existing bond gains, while deferring the recognition of those gains for tax purposes. Forward swaps are written commencing at the desired disposal or maturity date of the bonds. If rates rise (fall) prior to this date, the bond value will decline (increase), but that of the forward swap will rise (decline).

Basis risk applies. For example, assume the spread over Canada bonds for the permanent assets narrows by 10 basis points, between the time the liability is sold (the price is set) and the premium is received and invested. If the spread over Canada bonds on the forward swap is the same as the spread on the offsetting swap (entered into at the time the premium is invested), the spread achieved will be 10 basis points less than was assumed in the pricing.

8.6 Swaptions

In a swaption, one of the counterparties has the right, but not the obligation, to enter into a forward swap on the exercise date. The option exercise date, the swap commencement date, the swap maturity date, the floating rate index, and the fixed rate are all determined in the swaption agreement at the outset.

The cost of the option feature can be paid up front, or at the exercise date, or it can be amortized over a period of time. The option can be American (i.e., exercisable at any time during the option period with the swap commencing immediately upon exercise or at the end of the option period). The option can be European (i.e., exercisable only at the end of the option period), with the option normally commencing at that date. The option can be Transatlantic (i.e., exercisable a number of times during the option period, but only on predetermined dates).

The swaption is similar to a rate cap (see below). However, the swap market is more efficient at longer terms than the cap market. Consequently, the longer term swaption costs will normally be less than cap costs for the same maturity. Shorter dated caps, say of two years or less, are relatively cheap.

A callable (puttable) swap is one in which the fixed rate payer (receiver) has the right to terminate the swap at one or more predetermined dates or points on the swap curve. An extendible swap is one in which one counterparty has the right to extend the swap term. The call, put and extension right is equivalent to the purchase of a swaption.

In a reversible swap, one of the counterparties has the option to switch from being the floating to being the fixed payer or vice versa at a specified date. It is a combination of a swap and a swaption for twice the principal amount of the swap.

Suppose an insurer sells a GIC at a fixed rate to apply for one year upon the receipt of a known deposit amount in two months. Since no cash is received at the time of the sale, cash market hedging may not be feasible. A two-month forward on a one-year swap to receive fixed and pay floating could be used in hedging. Alternatively, a two-month option on the same one-year swap might be preferred, if one-year rates were expected to increase prior to the receipt of the premium. The swaption premium would be paid for the opportunity to participate in any increases in one-year rates. If increases occur, the option is left to expire unexercised.

A company interested in putting a ceiling on its fixed rate borrowing costs, but wishing to take advantage of any drop in rates, can use a swaption. In this way, the swaption premium buys insurance against an increase in interest rates. The firm arranges a floating rate banking facility in combination with a swaption to pay a fixed rate. The fixed rate puts a ceiling on borrowing costs as the option can be exercised if rates increase. If rates decrease, the option is not exercised and the firm can enjoy the lower borrowing costs.

Forward swaps enable the issuer of a callable bond to capture the intrinsic value of the bond call option. Swaptions enable the issuer to capture both the intrinsic and time value of the option, in effect, the issuer can sell the call option attached to a bond. The company sells a swaption to pay the bond coupon rate from the call date to the maturity date. The buying counterparty has the right, but not the obligation to exercise the swaption at the call date. It pays a premium that exceeds the corresponding premium on the similar forward swap, the excess representing the time value of the call option.

A cancellable swap is like a standard swap except that the purchaser has the right to exit the swap at one or more dates fixed in advance, without paying a cancellation penalty. A cancellable swap combines a standard swap with one or more swaptions.

8.7 Interest Rate Caps, Floors and Collars

Options can be bundled together to form option-based contracts called caps, floors and collars. Just as protection from losses from increasing (decreasing) rates can be purchased by buying a put (call) or put (call) spread, so it can be purchased by buying a cap (floor), a cap (floor) spread or a collar (long a cap, short a floor or long a floor and short a cap).

Just as there can be options and forwards on swaps, so there can be options and forwards on caps, floors and collars. Just as there can be amortizing and accreting swaps, so there can be amortizing and accreting caps, floors and collars, in which the notional principal amount decreases or increases according to a pre-set schedule or pre-defined formula.

A cap (floor) is like an option in that a premium is paid (usually in a single payment at purchase) and a “strike rate” specified. It is like a swap in that it is over-the-counter, involves a notional principal amount, periodic payments based on a reference rate, reset frequency, a term and a reference index rate. As with swaps, the notional amount is never exchanged, but is only used to calculate the payment amounts to be made.

If the index rate exceeds (is below) the strike rate on a reset date, the cap (floor) seller pays the purchaser an amount based on the product of the notional principal amount, the difference in the rates, and the fraction of year since the previous reset date. The final payment is made at the end of the term.

The notional amount and strike rate are usually fixed, but could vary by schedule or formula. The reference rate is often three-month BAs, LIBOR, prime or a government or swap constant maturity rate. The term can range from shorter than a year, to five or more years. The higher (lower) the cap (floor) strike rate, the less the premium. The reset frequency is usually monthly, quarterly or semi-annual. Payments are usually made at a reset date in arrears, based on the reference rate at the previous reset date. The premium can be paid at inception or over the term.

The cap (floor) is, in effect, a series of European put (call) options on the reference rate, with one option exercisable at the end of each reset period. A series of American options could be packaged, which would give the purchaser the right to exercise one option at any time during each reset period.

A cap (floor) can be created from any series of any different kind of option. A binary cap would be a series of binary put options (see Section 8.6), paying a fixed amount, if and only if the reference rate exceeded (fell below) the strike rate on any reset date.

A cap protects floating rate liabilities and fixed rate assets from a rise in rates. A floor protects floating rate assets and fixed rate liabilities from a drop in rates. Caps and floors thus provide “term stop-loss insurance” against a rise or fall in rates.

A minimum rate guarantee in an insurance product is a “floor” that the insurer has embedded in its insurance product. The assets supporting a product may be unable to fully support the minimum rate in some circumstances. A floor could be purchased, as deemed appropriate, to cover some or all of this risk. Conversely, assets supporting a product with highly competitive renewal rates may be unable to support a competitive rate should rates rise sharply. A cap could be purchased, as deemed appropriate, to provide the basis for a competitive rate.

Often caps and floors are expensive. Costs can be reduced by setting the cap (floor) rate sufficiently out-of-the-money. Costs can also be reduced by the purchaser of the cap (floor) writing an otherwise identical cap (floor) with a strike rate that is higher (lower) than the strike rate of the purchased cap (floor). This is referred to as a cap (floor) spread or corridor. While the cost is reduced, the potential benefits are restricted to the difference between the two strike rates. Losses on the hedged position from rate increases (decreases) below the strike price of the cap (put) that has been sold, must be borne by the hedger. The draft NAIC Model Investment Law does not allow use of cap (floor) spreads.

Costs can be reduced, in general with collars, which are equivalent to simultaneously buying a cap and selling a floor or vice versa on the same underlying asset or index for the same term, but different strike prices. A two-year collar on three-month BAs would involve buying a two-year cap and selling a two-year floor on three-month BAs. If the collar has a cap of 10% and a floor of 8%, the purchaser receives payments for rate increases above 10% and pays for rate declines below 8%.

Normally, no premium would be paid for the collar, since the seller of the collar normally specifies either the floor or the ceiling rate so that no net premium need be paid. The so-called "costless collar" may be quite "expensive" in implied volatility price terms, even though there is no dollar cost. The strike price on the cap and floor may imply a substantial volatility spread. If the buyer specifies the floor and ceiling rates, then a net premium equal to the premium on the ceiling being purchased reduced by the premium on the floor being sold would be paid.

Caps and collars are useful to borrowers wishing to lock in a maximum cost of funds. Floors are useful to investors wishing to fix a minimum rate for funds lent.

A collar (long a cap and short a floor, say) protects the hedged position from increases in rates, since the purchased cap increases in value with increases in rates. However, gains on the hedged position from decreases in rates must be foregone, since decreases in rates increase the amount that must be paid on the floor that has been sold.

Interest rate collars thus reduce the volatility of gains and losses arising from volatile interest rates. They can be useful in periods when interest rates are expected to be more volatile than normal due to political, monetary or fiscal policy events.

CHAPTER 9 – EXOTIC OPTIONS[1]

There are a wide variety of exotic options available from most dealers. The fact that an option is labelled exotic does not mean that it cannot be simple to understand the payout profile nor does it mean that it cannot be of very practical use in risk and portfolio management. Exotic options are sometimes referred to as second-generation or nonstandard options. Exotic options are "exotic" from the market maker's perspective, since they usually require sophisticated hedging and pricing techniques, are usually difficult to trade and manage, and usually place more capital at risk. For these reasons, they may command a high premium.

9.1 Options on a Single Underlying Asset or Index

The first and simplest class of options involves one underlying asset or index and the price of that underlying asset or index on one specific date, the date of expiration. Standard put and call options are examples.

Binary Options

A binary (all-or-nothing) option is an exotic option linked to only one asset and one date, that is actually simpler than a standard option. Consider a binary option on the TSE 300 expiring in three months with a strike price of 4000 and a payoff of X. The binary option pays exactly $X, if and only if, the TSE 300 is above 4000 at the expiry date. Quite complex structures can be constructed by combining a group of binary options with various "laddered" strike prices and payoffs.

A second class of exotic options involves a single underlying asset or index, but the option involves the price of this underlying asset or index on more than one date. These are path-dependent options. Examples are compound options, extremum options, lookback options and average rate options. For extremum options, the value of the option depends on the maximum or minimum price achieved throughout the option period.

Lookback Options

A lookback option confers the right to buy an asset at its minimum price or sell it at its maximum price during a specified "lookback" period. A lookback call (put) is like the standard call (put), except that the strike price resets when the price of the underlying asset or index declines (increases). If the price of the underlying asset or index subsequently rises (declines), the strike price does not. The strike price stays at the lowest (highest) level attained by the underlying asset or index.

Lookback options have large premiums compared to standard options and so are not that useful in risk management. The premium can be reduced by reducing the frequency of "looking back" from daily to weekly to monthly, and by restricting the lookback period (last three months of a one-year option).

They can be useful if the investor is anticipating a wide fluctuation in values. If the market is also anticipating greater volatility, however, the premium will be that much greater.

A look forward call (put) confers the right to the difference between the highest (lowest) value of the underlying asset or index attained during the option term and the spot price at the beginning of the option period.

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[1] This chapter is based to some degree on Eric S. Reiner "Using Nonstandard (Exotic) Derivatives in Managing Portfolio Risk," *Derivative Strategies for Managing Portfolio Risk*, Association for Investment Management and Research, ed. Keith C. Brown, Charlottesville Va., 1993.

Barrier Options

The payoff from a European-style barrier option depends on whether or not the underlying asset or index ever crosses a value specified as the barrier and on the value of the underlying asset or index at expiration. A barrier above (below) the current value is an up (down) barrier.

Barrier options are most common in relation to specific stocks or stock indexes. However, barrier options have been sold where the barrier is a cap or floor rate on a floating rate index or where the barrier is an exchange rate or commodity price.

An “in” barrier option pays off only if the barrier is crossed. An “out” barrier option pays off only if the barrier is not crossed. There are thus four call and four put barrier options depending on whether the barrier is up or down and whether the option is in or out.

An out (in) barrier option is said to be knocked out (in) when the value of the underlying asset or index crosses the barrier. If you feel the probability of being knocked out is low, then out barrier options will seem cheap. If you feel the probability of being knocked in is high, then in barrier options will seem cheap.

If you own both an in and out barrier call (put) option with the same expiration date, strike and barrier, then you will receive the same payoff as if you own a call (put). For example, the value of a down and in call (put) plus the value of a down and out call (put) is equal to that of a call (put) option.

Barrier options make it possible to pay only for those outcomes that are consistent with your market views by eliminating the payoff on possible outcomes that you believe to be unlikely. Suppose you believe that the underlying asset or index is almost certain to increase in value above 103% of its current value. However, you also believe that if its value drops below 98% of its current value, it is almost certain not to appreciate significantly. You can buy a down and out call with a strike price of 103% and a barrier of 98%. A significant reduction in option premium results from the elimination of the payoff from those scenarios in which the underlying asset or index first declines below 98% and subsequently rises above 103% at the end of the exercise period.

Suppose you wish to hedge an asset from declines in value of more than 10%, but that you will sell the asset should it rise in value by more than 10%. Or suppose you are concerned about a major political event, whose outcome is difficult to predict. If the outcome is favourable, asset values will increase and continue to do so for many months. If the outcome is unfavourable, asset values will decrease and continue to do so for many months. A put option struck at 90% provides the downside protection, but continues to do so, even if the underlying asset or index appreciates by more than 10%, when you no longer need protection. Buying an up-and-out put with a strike price of 90% and a barrier of 110% matches your hedging needs exactly and at reduced cost.

Barrier options can be used to construct “ladder options.” A ladder call option might provide the right to buy an asset at the current market price. If the asset rises 5%, 10%, 15% or 20% above its current level, then the payoff at maturity will be at least 5%, 10%, 15% or 20% of its current value. The ladder call option is constructed from a series of up-and-in barrier call options.

A binary up-and-in call (down-and-in put) option pays a fixed amount if the value of the underlying asset or index crosses the barrier from below (from above) during the option period. A capped (floored) European-style call (put) is like a regular call (put) except that if the value of the underlying asset or index crosses the barrier from below (from above), then the option terminates and the holder is paid the difference between the barrier and the strike either immediately or at the end of the option period.

Compound Options

A compound option is an option on an option. It consists of a put on a put or call, and a call on a put or call. An investor might want exposure to the underlying asset or index, but be reluctant to pay the full premium for a call option. He/she might be willing to pay something to fix the current premium for the call option should he/she subsequently conclude that he/she would like to own the call. The investor might be concerned that some future political, fiscal or monetary event might materially increase call premiums. If the underlying asset or index increased in value, or expected volatility increased, or interest rates, etc., increased prior to deciding to own the call, the call's premium would have increased. A call option on a call option would fix the premium on the underlying call, thereby locking in current market conditions. The option value depends on the date when the decision to buy the underlying call option expires as well as the date on which the underlying call option expires.

A chooser option allows the buyer to decide at (or prior to) a specified date whether the buyer wishes to have a put or call on the underlying asset or index. Upon choice, the option becomes a standard option. A complex chooser option involves a choice between a put or call with different strike price or expiry date. A chooser option may cost less than buying put and call options separately. This can be useful if some event is expected to establish a price trend in the underlying asset or index, but it is not clear in which direction. The put/call straddle position is costlier and provides unnecessary protection, (i.e., protection against the possibility of a reversal in trend after the event).

A forward starting option starts at some date in the future at a strike price set on that date. The option premium is fixed based on current market conditions. It locks in current pricing, if the investor is concerned about increases in option prices. It is often used in a ratchet structure where periodic payments are made equal to any increase in the underlying asset or index value.

Average Rate Options

The payoff on an average rate option depends on the average value of the underlying asset or index during the entire option period or a part of it. A sampling period such as daily close, weekly close or month end close would be chosen. The average may be arithmetic or geometric.

If cash flows are to be received approximately uniformly over a period of time and these cash flows are to be converted from one currency to another or invested in an underlying asset or index of a specific type, an average rate option is attractive. There is really no need to attempt to hedge each cash flow separately. The average rate option hedges the entire cash flow stream at once. This use of the average rate option is especially valuable in the context of foreign subsidiary earnings, where U.S. accounting rules require that foreign currency earnings be translated at average rates.

This type of option provides protection from a sharp drop in the value of the underlying asset or index just prior to option maturity. A standard option would lose most, or all of its value, whereas an average rate option would retain most of its value. Giving up the opportunity to gain from a last minute upswing in value may be a small price to pay for such protection.

The price of the average rate option will be less than the sum of the prices of the options on each cash flow, because its volatility will be less. The more frequent the sampling, the cheaper the option. This is a practical and popular type of option.

9.2 Options On Multiple Underlying Assets or Indices

A third class of exotic options called rainbow options involve options that depend on the value of multiple underlying assets or indices, portfolios of several asset classes or several currency exposures or any combination of these. A rainbow option depending on two (three,...) assets is a two (three,...) colour rainbow.

Derivatives involving a quanto (currency protection) feature, for example, enable the end user to enter into a swap, cap, floor, option, swaption or any other derivative defined in terms of one currency, while settling payments in another currency at a predetermined exchange rate. The payout in the predetermined currency does not depend on exchange rates. The premium for a quanto option may be less than the premium in the domestic currency of the underlying asset or index, if forward exchange rates at the time of option purchase anticipate a weakening of the payoff currency relative to the domestic currency. Quanto options are usually only settled in cash.

If Canadian dollar-based investors invest in the Japanese stock market, their Canadian dollar return depends on both the stock performance in Japanese dollars and the Canadian/Japanese dollar exchange rate. A quanto option might involve a call option on the Nikkei 225 index-linked to a fixed Canadian/Japanese exchange rate for the payoff on the call option.

An outperformance or "best-of" option pays the best performance of two or more underlying assets or indices, say, the better of the Nikkei and the TSE 300 indexes, where the Nikkei 225 index performance is after conversion to Canadian dollars. Outperformance options are expensive, but they are more likely to pay off at maturity than options on only one underlying asset or index. Outperformance options can be same currency and across multiple assets.

A relative performance option might pay the difference between or the ratio of two asset prices. An investor may believe the TSE 300 will outperform the S & P 500 in the next year. The investor might buy a one-year relative outperformance call option on the TSE 300 – S & P 500 index spread to implement this view.

A basket call (put) option pays any excess of two or more asset prices over (under) the strike price. A basket option on specific assets might fit investor needs better than an index option. It is usually cheaper than buying options on each underlying asset or index, because the volatility of the basket is less than the volatility of each underlying asset or index.

The fourth class of exotic options involves the value of multiple assets at more than one date. An average rate basket option, averaged across multiple currencies, would be an example. This could be useful for a company that has relatively uniform cash flows in many countries that it will convert back to home currency dollars on receipt. It would be especially useful in the context of a number of different foreign subsidiaries, where it was desirable to hedge their earnings back to U.S. dollars.

The price of an option on a basket of currencies can be materially less than the price of a set of options on each currency because the volatility of the basket will be less. In particular, the price of the basket option will decrease as the correlation between the basket currencies declines.

APPENDIX 1 – FACTORS IMPACTING THE INTEREST RATE SWAP SPREAD

Corporate Bond Spreads

The influence of corporate bond spreads on swap spreads can be understood by returning to the classical interest rate swap. From the perspective of the BBB corporation, the fixed swap rate equals the BBB longer term borrowing rate, less the difference between the BBB rate borrowing cost and the floating rate index, less the BBB corporation's share of the arbitrage opportunity exploited through the swap. In the example in Section 6.4.2, this would be 11.25% – .60 – .40 = 10.25%. The upper limit to the fixed swap rate applies, when the BBB corporation's arbitrage share is zero and equals the BBB long-term borrowing rate less the difference between the floating rate BBB borrowing cost and the index floating rate (i.e., 10.65%).

From the perspective of the AAA bank, the fixed swap rate equals the AAA bank fixed borrowing rate, less the difference between the AAA bank floating rate borrowing cost and the floating rate index, plus the AAA bank share of the arbitrage opportunity. In the example in Section 6.4.2, this would be 10.00% – .25 + .50 = 10.25%. The lower limit to the fixed swap rate applies when its arbitrage share is zero and equals the AAA bank fixed borrowing rate less the difference between the AAA bank floating rate and the index floating rate (i.e., 9.75%).

If the predominate players in the longer term swap market are (strong) AA and (weak) A corporations, then it is their borrowing costs that will tend to determine the upper and lower bounds of the fixed swap rate. The upper limit will be the A corporation fixed rate borrowing costs less the difference between the A corporation borrowing costs and the floating rate index. The lower limit will be the AA corporation fixed rate borrowing costs less the difference between the AA corporation floating rate borrowing costs and the floating rate index. The AA floating rate difference might be negative, if they can borrow at a rate below the floating index rate.

As in the case of the (strong) AAA bank and (weak) BBB corporation, the (strong) AA corporation can borrow more cheaply than the (weak) A corporation in both bond and money markets, but the greatest difference applies in the bond market. This creates an arbitrage possibility that fuels the swap market.

If the primary demand for interest swaps arises from corporate AA and A borrowing requirements, then the swap spread will tend to lie between corporate AA and corporate A bond spreads. This has been largely the case in the U.S.

Bank Paper and Canadian Swap Spreads

Banks are the major swap market makers in Canada and they are large issuers of fixed rate debt. In combination, these two factors imply that the bank credit spread in the new issues market is the primary determinant of fixed swap rate spreads in Canada.

If bank paper spreads widen relative to swap fixed rates, it will be cheaper for banks wanting to raise fixed rate debt to borrow at floating rates and to pay fixed swap rates. The floating swap payments that the bank receives are then used to cover the interest cost of their floating rate debt. In effect, they have created a source of fixed rate funds at a cheaper rate than available through direct issue of bank paper.

If bank paper spreads narrow relative to swap fixed rates, it will be cheaper for banks wanting to raise floating rate funds to borrow at fixed rates and to pay floating swap rates. The fixed swap payments that the bank receives are then used to cover the interest cost of fixed rate debt. In effect, they have created a source of floating rate funds at a cheaper rate than available through direct borrowing in the short-term market.

Interest Rate Expectations and Interest Rate Risk

If companies expect future rates to rise or the yield curve to steepen, they create a demand for swaps in which they make fixed payments in order to lock-in a relatively low fixed rate. If financial intermediaries are at risk from rising rates, they will create a demand for swaps in which they make fixed rate payments in order to reduce their interest rate exposure. The demand for swaps in which fixed payments are made will put pressure on the swap spread to widen.

The swap spread will tend to narrow to the extent that companies wish to float their debt in expectations of lower rates or a flatter yield curve and to the extent that financial intermediaries need to reduce their exposure to a decline in rates.

The impact of these factors can be short lived, but they can, on occasion, shift the spread beyond the upper and lower limits created by corporate borrowing rates or away from the rates indicated by bank paper rates.

Eurobond Issues

When a non-Canadian currency borrower issues in the Euro-Canadian bond market, they may want to swap out of the Canadian currency into their own domestic currency. To do this, they will enter into a Canadian dollar swap in which they receive fixed and pay floating. This converts the Canadian dollar debt from fixed to floating. They will also enter into a currency swap, in which they receive floating Canada and pay floating in their domestic currency. This converts their floating Canadian dollar debt to floating domestic currency debt. Finally, they will enter into a swap in their own domestic currency in which they receive floating and pay fixed. The combined result of the three swaps will fix the cost of their debt to them in their own currency.

From the perspective of the Canadian interest rate swap market, Canadian Eurobond issuance can create a demand for interest rate swaps in which the Eurobond issuer receives fixed payments. This will tend to reduce Canadian swap spreads.

If swap spreads narrow as a result of Euro-Canadian bond issues, the cost of issuing Canadian dollar debt will increase to a non-Canadian currency borrower. This increased cost will discourage Euro-Canadian bond issuance and take pressure off the fixed spread to narrow. The spread will then tend to widen again.

Investment Opportunities and Interest Rate Swaps

Asset transactions combined with simultaneous swap execution can influence swap spreads. Assets, such as Eurodollar bonds, mortgages, or MBSs that have a term longer than required by an institution to support its liabilities, may be purchased by an institution because of an attractive rate and then combined with a swap in which the institution pays fixed. The spread of the asset over the fixed rate is locked-in over the term of the swap. In effect, the institution has created a floating rate investment earning the floating rate plus the fixed spread. When this spread is wide, this type of asset-driven swap activity increases and swap spreads widen.

Cheap floating-rate investments that have a shorter term than required may be purchased and combined with a swap to receive fixed. In effect, a fixed rate instrument is created at a rate equal to the fixed rate plus the spread of the floating rate investment over the floating rate on the swap. When this spread is wide, this type of asset-driven swap activity increases and swap spreads narrow.

Swap Dealer Hedging Costs

Hedging costs can influence swap spreads. When a dealer agrees to pay fixed on a swap, the dealer will hedge by purchasing a government security with the same term as the swap. Typically, financing would be done through the short-term reverse repurchase market, since this would be cheaper than bank borrowing. The difference between the floating rate swap payment received by the dealer and the repurchase rate paid by the dealer represents a positive cost of carry. As this cost increases, the dealer will offer a higher fixed rate on the offsetting swap. Thus, swap spreads tend to widen as the floating rate repo spread widens.