Hong Kong Monetary Authority

\[
N(d_1) = \text{Cumulative normal distribution function}
\]

\[
N(d_2) = \text{Cumulative normal distribution function}
\]

\[
e = \text{Exponential function}
\]

\[
\ln = \text{Natural logarithm function}
\]

\[
\sigma = \text{Standard deviation (or volatility)}
\]

\[
T = \text{Time to maturity of the option in years}
\]

\[
F = \text{Strike price (continuously compounded)}
\]

\[
t = \text{Time to maturity of the option in years}
\]

\[
S_0 = \text{Current stock price}
\]

\[
C_0 = \text{Current option value}
\]

\[
d_1 = \frac{\ln \left( \frac{S_0}{F} \right) + \left( \frac{1}{2} \sigma^2 \right) T}{\sigma \sqrt{T}}
\]

\[
d_2 = d_1 - \sigma \sqrt{T}
\]

For a European call option:

\[
C = S_0 N(d_1) - F e^{-rT} N(d_2)
\]

This is the famous Black-Scholes formula.

Plain Words in Derivatives
This book was received in accordance with the Books Registration Ordinance Section 4
Derivatives in Plain Words

by Frederic Lau, with a Preface by David Carse
# DERIVATIVES IN PLAIN WORDS

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All opinions expressed in this book are those of the authors and not necessarily those of the Hong Kong Monetary Authority.
Ever since derivatives took centre-stage in the world financial markets, they have generated much publicity and controversy. On the one hand, critics argue that derivatives have the potential to adversely affect banking stability. They took some of the blame (undeservedly) for the downfall of Barings and other notorious losses such as those suffered by the Daiwa Bank and Orange County. On the other hand, they are applauded by those who see derivatives as a hedging tool to reduce financial risks.

While the derivatives market in Hong Kong is not as large as that of New York, London or Tokyo, it has grown substantially in the 1990s. Based on the triennial survey organised by the Bank for International Settlements, Hong Kong was the seventh largest derivatives trading centre in the world in April 1995 with an average daily turnover of US$74 billion. The 1995 volume almost doubled that of 1992. There is an increasing trend for financial institutions and investors in Hong Kong to use derivatives as a hedging and yield enhancement vehicle. For example, the Exchange Fund Ordinance gives the Hong Kong Monetary Authority (HKMA) the authority to use derivatives prudently to minimise risks when investing the funds of the Exchange Fund.

Sound supervisory regime

The growth of the derivatives market has been a catalyst for major changes in the way in which both banking and securities regulators approach their task. From the supervisory point of view, financial institutions must have adequate systems in place to ensure prudent risk management. They must also have sufficient capital in place to support the risks. The market itself also has an important role to play in reinforcing self-discipline, provided that it is given sufficient information to do so. Like other regulators around the world, the HKMA has been developing a supervisory approach to derivatives based on these three pillars.
Risk management systems

Both banks and supervisors have always been concerned with the adequacy of risk management systems. However, this concern has become more highly developed and explicit in recent years as a result of certain features of derivatives. In particular, the capacity of derivatives to quickly change the risk profile of a bank can make assessment of its financial condition at a particular point in time less meaningful. This has led to greater emphasis by supervisors on satisfying themselves that banks and other financial institutions have adequate systems in place for measuring, managing and controlling risk on an ongoing basis. The new approach, which is forward looking, shifts the focus of attention more to processes rather than historical financial performance.

The key elements of a sound risk management system have been spelt out in the guidelines issued by the Basle Committee. In particular, there is emphasis on the role of the board of directors in setting the overall risk appetite of the bank and approving policies and procedures designed to ensure that the risk exposures incurred by the bank are consistent with that appetite. Once risk management policies have been approved by the board, it is the job of the management to implement these. One of the features of modern risk management is the more scientific approach which is now possible towards the quantification of risk. This is important because when risk can be accurately measured, it becomes possible to take on risk in a more informed and controlled manner. In other words, banks should be in a better position to control their own destiny rather than being at the mercy of market forces which they do not fully understand.

This trend towards better quantification of risk is evident in the increasing use of statistical models which attempt to measure the potential loss in a portfolio associated with price movements of a given probability over a specified time period. This approach has the advantage of incorporating not only a measure of the sensitivity of the portfolio to shifts in prices, but also an estimate of the likelihood of those shifts occurring. It also enables the risks across different portfolios to be aggregated and reduced to a common
denominator, value at risk, which can be more intuitively understood by the board and senior management. This approach has been developed in relation to the measurement of market risk, but it also has application in measuring credit risk across a portfolio.

The HKMA welcomes the use of value at risk and other statistical models. However, there are important caveats. First, it is possible for senior management to be lulled into a false sense of security by such models. While on the face of it the mathematics of the models may be quite complex, they are in fact based on a set of simplifying assumptions, including that changes in prices or rates are normally distributed and that positions can be traded out within the assumed holding period. It is important therefore that models should not be seen as supplying the right answer under all circumstances. If volatilities change dramatically and if market liquidity dries up, the potential for loss may be greater than that predicted by the model. This means that stress tests should also be used to calculate the exposure under worst case market scenarios, which may not be probable but which are certainly possible. This may then lead management to set more conservative limits than the value at risk model would otherwise imply. Thus, subjective judgement still matters.

The second point is that, as the Basle Committee has emphasised, the qualitative controls surrounding how models are used are just as important as the mathematics. In particular, as recent events have demonstrated, it is vital that the data on prices and volatilities which are fed into models are accurate and are regularly checked by an independent risk control unit. The models themselves should be subject to regular independent review and back-testing. This principle of checks and balances and segregation of duties is absolutely vital for all aspects of a trading operation.

Supervisors need to have the capability to evaluate risk management systems and the way in which models are used. In Hong Kong, we have set up a specialist Derivatives Team to help in formulating regulatory policies and practices, conducting examinations of treasury operations and reviewing in-house models.
Sufficient capital to withstand losses

However, risk management is not the whole story. Even in well-run trading operations it is possible that losses may occur as a result of unexpected market movements and it is thus necessary to ensure that banks have sufficient capital to be able to withstand such losses. The existing capital adequacy framework in Hong Kong is based on the 1988 Basle Capital Accord which almost exclusively deals with credit risk. In 1996, the Basle Committee amended the Accord to take account of market risk. By the end of 1997 we shall have changed our capital adequacy rules in Hong Kong to take account of this.

It does not appear that the introduction of market risk will have a great impact on the capital ratios of most local authorised institutions using the “standardised approach” of the Basle Committee. Even so, in line with the Basle recommendations, we propose to give institutions the opportunity to economise still further on the use of capital by allowing those who are qualified to do so the alternative of using their own internal statistical models to calculate the capital requirement. This is in keeping with the Basle Committee’s objective of giving banks every opportunity to improve their own internal risk management. However, as modelling is still not an exact science, the Basle Committee has insisted that the value at risk produced by a model should be multiplied by a factor of at least three in order to arrive at the capital requirement.

Increased market transparency

The final leg of the supervisory approach is to try to improve the quality of information about the derivatives activity being conducted in markets around the world and by individual market participants.

First, supervisors are trying to improve their understanding of how derivatives affect the overall risk profile and profitability of banks and securities firms. The Basle Committee and the International Organisation of Securities Commissions (IOSCO) have therefore jointly developed a framework for
the kind of information that supervisors should seek from their institutions. The HKMA will take account of this framework in further developing the reporting regime in Hong Kong.

Second, banks and securities companies are being encouraged to expand the amount of public disclosure which they make about their overall involvement in the derivatives market and trading, the impact of these activities on profitability and their performance in managing the risks. If provided with meaningful information, the market should be able to exert its own discipline on institutions to manage their derivatives business in a prudent fashion. If so, this should complement the efforts of the supervisors. In Hong Kong, the information published by banks in their annual reports about their involvement in derivatives and trading activities has increased greatly in recent years. This policy of more transparency will continue.

Third, central banks are trying to obtain more statistics about activity in global derivatives markets so that they can better monitor the macroeconomic as well as the prudential aspects of this business. Hong Kong is participating in this exercise.

About this book

As part of our efforts to raise the level of awareness of our staff on derivatives and to keep abreast of market developments, Mr Frederic Lau, the leader of the HKMA Derivatives Team started to write a series of articles on the subject. Other past and present members of the Team, Dr Chau Ka-lok, Dr Hui Cho-hoi, Mr Cedric Wong, Mr Henry Cheng and Mr Adrian Pang, also contributed to the series. The articles, circulated within the HKMA, were intended to augment the various seminars and training programmes on derivatives organised in-house or by outside organisations for banking supervisory staff.

We believe the series have grown to such a size that it is worth publishing them in the form of a book to make them accessible to a larger audience.
There is no shortage of books on derivatives available in bookstores. This book is not intended for traders or market professionals or academics who wish to acquire advanced knowledge of derivatives. Rather, it is what its title suggests — a guide to derivatives in plain words intended for a wide audience of non-experts. The book focuses on the underlying concepts of derivatives, the nature and risks of different derivatives products and the appropriate risk measurement and management techniques. Also covered are new market developments such as credit derivatives.

I hope that this book will help to demystify derivatives and contribute to the healthy growth of the market in Hong Kong.

David Carse
Deputy Chief Executive
Hong Kong Monetary Authority
ACKNOWLEDGEMENTS

This book is a team effort of the Hong Kong Monetary Authority's (HKMA's) Derivatives Team. Dr Chau Ka-iok not only wrote some part of the book while he was with the HKMA, he also provided useful comments and recommendations for other parts of the book. Dr Hui Cho-hoi provided useful comments. Mr Cedric Wong drafted a portion of Chapter 3. Mr Henry Cheng and Mr Adrian Pang wrote the last chapter and edited the entire book.

In addition, Mr Donald McCormick of the Office of Thrift Supervision, US Department of Treasury, reviewed the book and made his suggestions.
INVESTMENT RETURN AND ASSOCIATED RISK

"Risk, and risk alone, determines the degree to which returns will be above or below average."

Burton G. Malkiel

As we all know, investment returns consist of dividend or interest income plus change in principal or market price.

There are many ways to measure investment returns. The most common ways are return on equity, return on assets, earnings per share, etc. But there is one problem. All these return measurements do not tell you how much risk is involved in the investment. For example, you invested in an oil-drilling business, and the returns of your investment in the last five years were -10 percent, 25 percent, 15 percent, -40 percent and 75 percent respectively. The geometric mean or annual compound or time-weighted rate of return of this investment is 6.32 percent. What do you think about this investment? And what kind of expected return should you have for this type of investment? If there is a government bond yielding 6.32 percent for the last five years, which investment would you rather have? It is clear that in order for us to appropriately measure returns, we have to know the associated risk.

What is risk? The American Heritage Dictionary defines risk as "the possibility of suffering harm or loss". In the financial field, most would consider that risk is the chance that expected investment returns will not be materialised and, in particular, that the investment will fall in price.

1 The world renowned finance professor at Princeton University, and the author of "A Random Walk Down Wall Street".  
2 The geometric mean or annual compound rate of return is \((0.9 \times 1.25 \times 1.15 \times 0.6 \times 1.75)^{1/5} - 1 = 0.0632 \text{ or } 6.32\%.

Risk and Return
While most market participants define risk as the chance of loss, the academics define financial risk as the variance or standard deviation of returns.

Harry Markowitz in 1952 provided a pioneering framework of modern portfolio theory. It says that rational investors should conduct themselves in a manner which reflects their inherent aversion to absorbing increased risk without compensation by an adequate increase in expected return. In other words, risk-averse investors would like to minimise risk while maximising return. This means that for any given expected rate of return, rational investors (risk-averse investors are rational investors) will prefer a portfolio containing minimum expected deviation of returns around the mean. Thus risk was defined by Markowitz as the uncertainty, or variability of returns, measured by standard deviation of expected returns about the mean.

In the banking industry, sophisticated American and European banks have been using “risk adjusted return on risk adjusted capital” (RARORAC) to measure a bank's performance for a number of years. The RARORAC concept applies a charge to all returns based on the amount of risk capital which each activity utilises, so that business activities can easily be compared against each other, as well as against internal target rates of return. Management uses RARORAC to measure the performance of each line of business, compare the profitability of different activities, and allocate human and capital resources.

In the fund management industry, a commonly used performance measure is the Sharpe Ratio, which is the ratio of extra return (investment return minus the risk free rate) to standard deviation. The Sharpe Ratio is a measure considering both return and risk. Nowadays, sophisticated financial institutions often use the Sharpe Ratio to measure traders' performances.

**Measuring risk**

What is standard deviation? In brief, standard deviation measures variation around an average. Say the average of 30 monthly rates of return is 15 percent, and the standard deviation is 5 percent. Conceptually, the returns between 10
percent \((15 - 5)\) and 20 percent \((15+5)\) fall within one standard deviation of the average return. Similarly, the returns between 5 percent \([15 - (2\times5)]\) and 25 percent \([15+(2\times5)]\) fall within two standard deviations of the average.

In a normally distributed sample, approximately 68 percent of the values are within one standard deviation, approximately 95 percent of the values are within two standard deviations, and 99.7 percent of the values are within three standard deviations of the mean.

Based on what we just described, an investment whose returns are not likely to deviate far from its average return or expected return is said to carry little risk. An investment whose returns from year to year are quite volatile (the oil-drilling business described earlier) is said to be a risky investment. From the eye-balling technique, we all see the annual returns of the oil-drilling investment are volatile — negative 40 percent for one year, positive 75 percent for another. The standard deviation of the oil-drilling investment is calculated as follows:

<table>
<thead>
<tr>
<th>Year</th>
<th>Return %</th>
<th>Change in return (A)</th>
<th>A - Mean of change (B)</th>
<th>B²</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>25</td>
<td>+35</td>
<td>13.75</td>
<td>189.1</td>
</tr>
<tr>
<td>3</td>
<td>15</td>
<td>-10</td>
<td>-31.25</td>
<td>976.6</td>
</tr>
<tr>
<td>4</td>
<td>-40</td>
<td>-55</td>
<td>-76.25</td>
<td>5,814.1</td>
</tr>
<tr>
<td>5</td>
<td>75</td>
<td>+115</td>
<td>93.75</td>
<td>8,789.1</td>
</tr>
<tr>
<td></td>
<td>Mean of change = 21.25</td>
<td></td>
<td></td>
<td>Sum of B² = 15,768.9</td>
</tr>
</tbody>
</table>

Standard deviation = \(\sqrt{15,768.9/4}\)
= 62.8

The simple mean, or arithmetic mean, of returns in this case is 13%. Therefore, returns between -49.8% and +75.8% fall within the range of one standard deviation. \(\text{We discussed earlier that the annual compound rate of return}\)

Risk and Return
of this investment is 6.32 percent which is different from the simple mean of return here.) Obviously, the risk for this investment is tremendous.

There are other ways of measuring risk. Besides standard deviation, other risk measurement concepts such as beta, and the latest risk measurement concept, value at risk.

**Value at Risk**

Value at risk is “the expected loss from an adverse market movement with a specified probability over a period of time.” A simple illustration may make the picture a little clearer:

A bank has an open US$/DEM position of $1.0 million. The historical data indicates that the one-day volatility during an adverse US$/DEM exchange rate movement is 0.08 percent. The value at risk based on one standard deviation, or $1 \sigma$, is:

$1.0 \text{ million} \times 0.08 \text{ percent} = 800$

The value at risk based on two standard deviations is:

$1.0 \text{ million} \times 2 \times 0.08 \text{ percent} = 1,600$

The value at risk based on three standard deviations is:

$1.0 \text{ million} \times 3 \times 0.08 \text{ percent} = 2,400$

Graphically, it is:

![Graphical representation of Value at Risk]

This example can be interpreted as there is an approximately 16 percent probability based on the past price movement experience that the bank may lose $800 overnight (or there is an approximately 84 percent probability that the loss will not be greater than $800), approximately 2.3 percent probability the bank may lose $1,600, and approximately 0.14 percent probability the bank may lose $2,400.

Management can use this information to measure, control and manage the bank's open positions, design limits structure, and allocate capital. Regulators can use this information to supervise and monitor the bank's trading activities.

From the above example, we know we need at least three things to measure value at risk: (1) the notional amount of the underlying, (2) the number of standard deviation required, i.e. the protection level, and (3) the volatility. The notional amount is self-explanatory. The standard deviation is determined by the person or persons who measure the value at risk. Market practitioners often use two standard deviations when they measure value at risk. It means that there is one in 40 chances that the event would occur. Market practitioners consider this acceptable. Regulators, on the other hand, are more conservative. In the recent Basle market risk capital adequacy proposal, a 99 percent confidence interval (approximately 2.33 standard deviations) was proposed, and for our example above, the value at risk amount is $1,864. That means banks may have to set aside more risk capital, $264 in our example, than when using two standard deviations. The third element, volatility is the market price fluctuation during a specific period of time. Market participants usually use historical data of one day's price movement to determine volatility. Some may use a longer holding period, two days or one week instead of one day. The longer the holding period, usually the higher the volatility. The Basle proposal requires a 10-day holding period which again creates some debate in the industry. Basle's argument is that during an adverse market, the time needed to liquidate a position is longer than normal. However, market participants think that the 10-day holding period is unrealistic. The Basle Committee also requires that historical data should cover at least one year's data in order to be representative.
Mathematically, the relation between a one-day value at risk and a 10-day value at risk is the multiplication factor of square root of 10 (the so-called square root of time rule). That means the value at risk in our example based on a holding period of 10 days and 99 percent confidence level is $1,864 \times \sqrt{10}$ or $5,894$. The Basle Committee also imposes a multiplication factor of at least three to the resultant value at risk to capture estimation errors. This again is being seen as excessive by the banking industry. The argument of the industry is that a combination of a 10-day holding period and a multiplication factor of three is equivalent to a holding period of 90 days ($3 \times \sqrt{10} = \sqrt{90}$) which is grossly excessive and unrealistic. The Basle Committee thinks that the multiplication factor of three is a proper safety net for the inaccuracy of the bank's value at risk model and other unforeseen factors.

The concept of value at risk is relatively new. It is also much more meaningful than notional amount, because it directly relates to the level of risk. A simple example can illustrate this point. If someone tells you that he just bought $50,000 of ABC Company's bond, all you know is that he has a position of $50,000 and nothing about how much risk he is taking. But if he also tells you that the usual daily price change of this bond is one percent, you should realise that his daily price risk is $500.

Value at risk has a distinct advantage over notional amount, because notional amount tells you nothing about the level of risk in which the bank is statistically involved. Whilst it may be argued that the past cannot predict the future, and implementing the value at risk concept is not an easy job, value at risk is nevertheless an extremely powerful tool for decision-makers in a bank as all the risk exposures can be summarised into one single number.
In this chapter, we will discuss some of the common derivative products and the fundamentals relating to these instruments.

**Definition of derivatives**

What is a derivative instrument?

A derivative instrument is a contract whose value depends on, or derives from, the value of an underlying asset or index. For example, the value of an option on IBM depends on the share price of IBM. If the share price of IBM rises, the value of the call option of IBM also rises, although not in the same proportion.

Derivatives include a wide variety of financial contracts, including: futures, forwards, options, swaps, and various combinations and variations thereof, such as caps, floors, collars, structured debt obligations, collateralised mortgage obligations (CMO), pass through mortgage-backed securities (MBS), warrants, etc.

**Types of derivatives**

Derivatives can be classified into two types: forwards and options. Forward derivatives include mainly forwards, futures and swaps. The payoff pattern of these instruments is linear and symmetric. It means that the change in the value of the derivative is in the same direction and proportion as the change in value of the underlying.

For example, counterparties A and B enter into an interest rate swap contract in which A pays floating and receives fixed. If interest rates go up by one percent, A will lose, say $10,000, and B will gain $10,000. If interest rates go down by one percent, A will gain, say $10,000, and B will lose...
$10,000. (For simplification of presentation, we assume a parallel shift of the yield curve and no convexity.) The symmetric payoff pattern in this example is apparent.

Option derivatives include options, caps, floors and all financial instruments with embedded options such as warrants, callable bonds, MBS and CMO. The payoff pattern of these instruments is non-linear and asymmetric. It means that the change in value of the derivative is not in the same proportion and may not be in the same direction as the change in value of the underlying. For options transactions, an option buyer’s risk exposure is known and limited. This option buyer pays a premium for purchasing a call option. The maximum amount he would lose is the premium he pays. The upside potential for him is unlimited, because the price of the underlying could theoretically go up by 10 times, 20 times or even 100 times. The option writer’s situation is just the opposite. He receives a premium for selling the option. The maximum gain for him is the premium he receives. If the price of the underlying soars, his loss could be tremendous. Therefore, an option writer’s risk exposure is unknown and unlimited.

In the above discussion, you can also see how leverage comes into play in option transactions. The option buyer pays a relatively small premium to participate in the market. On the one hand, he could lose all the premium he pays. On the other hand, he could gain 10 or even 100 times of the premium he pays if the market soars.

Some history about derivatives

The history of derivatives goes back as far as the Middle Ages. In those days, farmers and merchants used futures and forwards to hedge their risks. For instance, a farmer harvested grain in July. But in April, he was uncertain about what price of grain he would get in July. During the years of oversupply, the farmer bore tremendous price risk as the price of grain would be lower than he expected, and he might not recover the cost of production.

A grain merchant also bore tremendous price risk during the years of...
scarcity when the price of grain was higher than expected. Therefore, it made sense for the farmer and the merchant to get together in April to agree upon a price in July for grain. This was how the futures and forwards market developed in grain hundreds of years ago; and then pork bellies, cotton, coffee, petroleum, soya bean, sugar, currencies, interest rates ... and even garbage. The Chicago Board of Trade started trading three kinds of garbage — plastics, glasses and paper in October 1995.

PARTICIPANTS IN DERIVATIVES MARKETS

Three kinds of people participate in derivatives markets: the hedgers, the speculators and the arbitrageurs.

Hedgers are risk-averse. Like the farmer and the merchant in the above example, they want the future sales price of the merchandise to be known in advance and the transaction be consummated at this known sales price. In doing so, they may give up some upside potential. In the example, if the price of grain rose substantially in July, the farmer would not benefit from it because he had already sold the merchandise at a price determined in April. Hedgers do not care much about the future potential. All they want is to reduce their price risk. However, now that both the merchant and the farmer had hedged their risks, this does not mean that they had nothing to worry about. The farmer still worried that the price of grain in July would fall drastically and the merchant would not fulfil his promise to buy the grain at the agreed upon price. Or the merchant simply did not have the money to pay for the grain in July. This is what we call credit risk. Hedgers can hedge away their price risk, but they cannot eliminate credit risk.

Contrary to hedgers who want to avoid uncertainty in price movements, speculators want to take advantage of price movements. For example, if a speculator thinks that the stock market in Hong Kong will go up in the next several months, he can buy a three-month Hang Seng Index (HSI) futures contract at the current index level of 14,500. If the stock market in

Some Fundamentals of Derivatives
Hong Kong does go up and the HSI rises to 15,000, the speculator can sell the three-month futures contract at 15,000 and take a 500 point profit. But we know that the chance for the market to go up or down is 50/50 if the market follows a random walk. In other words, the speculator has a 50 percent chance of losing and a 50 percent chance of winning. The speculator may lose a substantial amount of money if his prediction of market does not materialise.

The third kind of participants are arbitrageurs. Arbitrageurs look for opportunities to lock in a riskless profit by simultaneously buying and selling the same (or similar) financial product in different markets. The fundamental behind arbitrage is that financial markets are not perfect. From time to time, price differential of the same product between different markets in different parts of the world at the same time does exist, especially combining the currency element. For us, arbitrage strategy will not work, because the transaction cost will probably wipe out the profit even if we do find an arbitrage chance. Big investment houses incur very little transaction cost. They are the major players in this market. But remember Barings, its management put the company to the ground using a supposedly riskless arbitrage strategy.

When bank regulators conduct examinations, it is sensible for them to find out what the institution’s strategic goal in derivatives business is. Is it a hedger, speculator or arbitrageur? Regulators can also review the institution’s revenue report to identify the sources of treasury revenues. If 80 percent of an institution’s treasury revenues are from position-taking activity, examiners usually would watch that institution’s treasury operation a bit closer. The reason is that position-takers in treasury instruments, both cash and derivatives, are speculators. In other words, they are gamblers. As we have just discussed, when you take an out-right position in any financial instrument, there is a 50 percent chance that the price of that instrument will go up and a 50 percent chance it will go down. As soon as you have taken an out-right position, you have no control over what the price will be in the next minute.

Some Fundamentals of Derivatives
Should we criticise banks for engaging in position-taking business? Not really. All businesses involve some degree of risk taking and speculation. Banking business is no exception. But it all depends on how much a bank speculates. Most banks conduct derivatives business because they have to serve their clients who either take or hedge their business risks. They come to banks for solution. In the process of serving these clients, it is inevitable for banks to take some out-right positions. Also, banks' trading activities can facilitate liquidity which would reduce transaction cost for all market participants. In addition, banks take positions because they have to get the "market feel" to better serve their clients. Moreover, from time to time, banks have their own views on interest rate or exchange rate movements. It is perfectly all right for them to take out-right positions in those circumstances. When banks engage in position-taking activities, they have to consider a number of things, such as the capital level of the institution, business strategies, trading expertise, management's understanding of the markets, systems and controls, back-office supports, etc.
CHAPTER 3

PRICING OF A FORWARD CONTRACT
AND THE YIELD CURVE

PRICING OF A FORWARD CONTRACT

We are now going to look at the spot and forward price relationship. There are at least two ways to purchase an asset at a future date. One way is to purchase the asset now and store it until the target future date. The other way is to enter into a forward contract that calls for the purchase of the asset on that target future date. In theory, these two methods should lead to the same result. If the results are different, someone (the arbitrageurs) can make a risk-free profit by selling the asset in one market and buying in another simultaneously. This arbitrage activity will continue until the spot and forward prices go back to their respective theoretical levels.

For example, you plan to host a Christmas party one year from now for all your colleagues and you need 100 turkeys. To have all the turkeys you need, you can either:

**Strategy A**

Buy 100 turkeys and pay the market price of turkey (assuming it to be $100 each) in cash today for $10,000 and put them in the refrigerator and store them for one year (assuming there is no storage cost).

**Strategy B**

Enter into a one-year forward contract today to buy 100 turkeys at a total price of $x and invest some money to make the total principal and interest just enough to pay for the forward contract one year from now. Now the question is: how much should $x be in order to prevent any arbitrage activity?

1 Part of this chapter was written by Mr Chau Koolak and Mr Cedric Wong.

Pricing of a Forward Contract and the Yield Curve
In Strategy A, you pay $10,000 to obtain 100 turkeys today. Your $10,000 are gone and you cannot use them again to do anything. But in Strategy B, you do not pay the $10,000 for the turkeys today. You pay one year later. All you have to do now is enter into a forward contract. So what are you going to do with the $10,000? The most logical way is to invest them in some risk-free assets, such as US Treasury Bills.

Assuming that the current risk-free rate of return is 5 percent, compounding annually,

\[ S_f = $10,000 \times (1 + 5\%) \]
\[ = $10,500 \]

And $10,500 is the forward price which is what you should pay for the 100 turkeys one year from today.

What happens if the forward price is now quoted at $11,000? An arbitrageur can sell the forward contract to you at $11,000, borrow $10,000 from a bank at a rate of 5 percent (assuming he can obtain this risk-free borrowing rate), buy 100 turkeys and store them for one year (again assuming there is no storage cost). After one year, the arbitrageur can make a risk-free profit of $500 by repaying the bank $10,500, deliver 100 turkeys to you and get your $11,000. And if the arbitrageurs keep selling these one-year turkey forwards, the forward price will eventually decline to say, $10,900. At $10,900, the arbitrageurs can still make a risk-free profit of $400 and they will continue to sell these forward contracts. This process continues until the forward price reaches its theoretical level of $10,500.

This is the simplest way to explain the price relationship between spot and forward. Pricing forwards actually is more complicated because storage is usually not free. For arbitrageurs, risk-free borrowing rates are usually unattainable.

*Pricing of a Forward Contract and the Yield Curve*
Cost of carry

In the above example, it is shown that an "equilibrium" will be reached so that the forward price of an asset can be determined. In that example, it is assumed that no cost will be incurred for storing the turkeys for one year. Now the question is: what should the three-month forward price be if it costs $1.00 to store each turkey for one year?

We can use the strategy above and change the forward period from one year to three months. We borrow $10,000 today from the bank at an interest rate of 5% per annum to buy 100 turkeys. For a three-month period we have to pay 5/4 = 1.25% interest. Therefore we have to pay $10,000 x (1+0.0125) = $10,125 back to the bank. At the same time, we have to pay the warehouse $100 x 1/4 = $25 for the storage cost. That means it would cost us $10,150 in total. In order to prevent arbitrage opportunities, the forward price would come down until it converges to the price given by this strategy, which is $10,150/100 = $101.50 per turkey.

If the forward price at two years is required, then the amount paid back to the bank has to be calculated with compound interest, that is $10,000 x (1+0.05)^2 = $11,025. Adding a storage cost of $1 x 100 x 2 = $200, the forward price is thus $(11,025+200)/100 = $112.25.

The above illustrates the relationship between the forward price and the spot price (the price of the asset today), and it can be summarised in terms of what is known as the cost of carry. This measures the storage costs plus the interest that is paid to finance the asset less the income earned on the asset. Storage costs may include transportation costs and other costs that are incurred during the period (t). Usually the storage costs and income are expressed in terms of amount per asset (as in the definition of the risk free interest rate r). For a commodity with a storage cost u that is measured as a percentage of the price, the cost of carry is r + u. For a dividend paying stock, it is r - q where q is the dividend. The forward price F is then related to the spot price S by

\[ F = S(1 + r + u - q)^t \]
THE YIELD CURVE

In the above sections, you have seen the pricing of simple forward contracts relating to physical assets. The same principle can be applied to the pricing of equity related forwards. However, the pricing of interest rate and foreign exchange related contracts is slightly more complicated. Before we move on to interest rate related derivatives, it is important to understand some basics about the markets. The most important concept is the yield curve. Many people working in investment banks are paid “telephone-number-like” salaries just for guessing and playing with the “shapes” of the yield curves and putting in trades in order to benefit from the movements of these curves, so you would appreciate the importance of this.

For a simple definition of a yield curve, though it is arguable, most people would use one of the following: it is a plot of 1) yield of government securities or 2) annual compounded interest rate (zero coupon yield, or the yield of a zero coupon bond) against time. For most currencies, you will see interest rates for maturities of five years or more. An example is given in the graph below.

![An example yield curve](image)

This graph is sometimes referred to as the “Term Structure of Interest Rates”.

In many markets, zero coupon rates of less than one year in maturity are quoted by different banks and brokers. However, rates for longer than one-year maturity are not quoted. They are usually obtained from the prices of other traded instruments, for example interest rate futures and
interest rate swap rates. From these prices, the equivalent zero coupon bond yields of the different maturities are calculated. This process is known as “stripping” the yield curve.

How could we know what the level of the rates should be in a few years time? We need to have some reference interest rates to start with. In most big countries, the government would issue some debt instruments to borrow money from the public. These instruments have fixed coupons and have a wide range of maturities. As expected, the US government is the biggest issuer of debt instruments, and the Treasury bills and bonds have maturities ranging from one week to thirty years. Other governments usually issue instruments of shorter maturities. The Hong Kong Monetary Authority (HKMA) has recently issued some bonds with maturity in ten years, which give indication of the interest rates up to ten years. From these bond yields, the market would establish the rates of the different traded instruments, usually at a “spread” above the bond yields.

**THEORIES OF TERM STRUCTURE OF INTEREST RATES**

Most of you would have come across time deposit accounts. The big banks usually offer fixed term deposits from one week up to one year and offer different interest rates for different fixed periods. After deregulation, these interest rates are affected by the market rates, so this is very close to the actual yield curve. (In reality, the deposit rates offered by banks are slightly higher than the Hong Kong dollar yield curve. This reflects the credit risk of the banks.) It is common knowledge that in most circumstances the longer the fixed period, the higher the interest rate. In fact, historically, yield curves are mostly upward sloping, which means that long-term interest rates are higher than short-term interest rates. People have been trying to explain this phenomenon and come up with three popular theories:

*Unbiased Expectations Theory*

This theory proposes that the forward rate represents the average opinion of the expected future spot rate (or short-term interest rate) for the period in question. For example, if today’s one-year interest
rate is 6% and it is expected that this one-year interest rate will rise to 8% in one year’s time, then this situation would be reflected in today’s two-year rate. There should be no difference between a) we invest the money for a fixed one-year period and re-invest this amount with interest for another year; and b) invest the money for a fixed two-year period. Given the interest rates above, the two-year rate today could be calculated by:

\[(1 + r) \times (1 + r) = (1 + 0.06) \times (1 + 0.08)\]

which gives \( r = 6.995\% \). In other words, this theory suggests that, if today’s two-year rate is 6.995\%, it implies that the marketplace (that is, the general opinion of the investors) believes that the one-year rate would rise to 8\% in one year’s time.

**Market Segmentation Theory**

Under the theory, different investors and borrowers are supposed to be restricted by law, preference, or custom to certain maturities and they do not switch maturities. There need be no relationship between short-, medium-, and long-term interest rates. The short-term interest rate is determined by supply and demand in the short-term bond market, the medium-term interest rate is determined by supply and demand in the medium-term bond market, and so on. However, this theory is not as popular as the other two theories as it does not directly explain why yield curves are upward sloping more often than downward sloping.

**Liquidity Preference Theory**

In some ways this is the most appealing theory. It argues that forward rates should always be higher than expected future short-term interest rates. The basic assumption is that, as an investor, you would probably like to put money in a short-term fixed period account (if the interest rate offered is the same as that of a longer-term fixed account) because it would not tie up the money for too long in case you need it.
Borrowers, on the other hand, usually prefer to borrow at fixed rates for longer periods of time. For example, if the bank offers a relatively low mortgage rate today, you would probably want to arrange a fixed rate mortgage for say the next 10 years so that you would be certain that you get a good offer for a long period of time. In the absence of any incentive to do otherwise, this is how people would behave, i.e. investors would deposit their money for short time periods, and borrowers would choose to borrow for longer periods. Banks would then find themselves financing substantial amounts of longer-term fixed rate loans with short-term deposits. This would involve a high degree of interest rate risk. In practice, in order to match depositors with borrowers and avoid the risk, banks raise long-term interest rates relative to expected future short-term interest rates. This reduces the demand for long-term fixed rate borrowing and encourages investors to deposit their money for long terms.

This theory leads to a situation that long rates are higher than the expected future short-term rates. It is consistent with the empirical result that yield curves tend to be upward sloping more often than they are downward sloping.

These three theories or the combination thereof provide the fundamental framework explaining the term structure of interest rates.
INTEREST RATE FUTURES AND FORWARD RATE AGREEMENTS

In the last chapter we have looked at some theories about the yield curve. In this chapter, we will look at some applications. The simplest kinds of interest rate derivatives are futures and forward rate agreements (FRAs). These two types of contracts are essentially identical; one major difference is that a futures contract is an exchange-traded contract and has fixed terms for the notional amount, length of contract, expiry date etc. whereas an FRA is an over-the-counter (OTC) contract which is a binding agreement between two parties. Another difference is that, as with other exchange-traded products, a minimum margin payment is required for the futures contract, whereas the actual payment for the FRA would only be settled at the expiry date. Other than these differences, the two types of instruments are priced in the same way.

For instance, today is 24/1/97 and assume that we have the following term structure of interest rate: 6-month rate of 5%, 9-month rate of 5.5%. What is the 3-month forward rate in 6-months' time, using today's market rate?

\[
\begin{align*}
\text{today} & \quad 6 \text{ month} \quad 9 \text{ month} \\
5\% & \quad 5.5\% \quad r\%
\end{align*}
\]
Again we use our method of having two strategies which should arrive at the same result (i.e. a no-arbitrage method). If we assume the forward rate to be \( r \), starting with $1 today, at the end of 9 months we would either get

\[
(1 + 5.5\% \times \frac{9}{12}) \quad \text{[A straightforward 9-month fixed rate deposit]}
\]

or

\[
(1 + 5\% \times \frac{6}{12}) \times (1 + r\% \times \frac{3}{12})
\]

[6-month fixed rate deposit, rollover for another 3 months]

giving \( r = 6.34\% \). This is the interest rate for the period between 24/7/97 and 24/10/97 as of today, and is equivalent to a quoted futures price of \( (100 - 6.34) = 93.66 \).

If today's date becomes 24/4/97. At this day, the 3-month rate has become 6%, whereas the 6-month rate is 6.5%. The forward rate for the period between 24/7/97 and 24/10/97 is then calculated by:

\[
(1 + 6.5\% \times \frac{6}{12}) = \frac{(1 + 6\% \times \frac{3}{12})}{(1 + 5.5\% \times \frac{9}{12})}
\]

which gives \( r = 6.90\% \) (or a futures price of 93.10).

What is the implication on the profit-and-loss of the trade? If this is marked to market, it implies that there is a 56 basis point loss (93.66 - 93.10) if the position in the futures contract is to be closed out immediately. If this is a US dollar futures contract and the notional amount is US$1,000,000, the loss converts to $1,000,000 \times 0.0056 \times \frac{3}{12} = $1,400.

The above examples give an illustration of a method of calculating interest rate forwards. Alternatively, we can express the calculation in a more general way. Recalling the definition of the discounting factor (DF, the amount today which represents a future value of $1 using today's interest rate), we see that in the first example the discounting factors for 6-month and 9-month are

\[
DF_{6\text{-mth}} = \frac{1}{(1+5\%x^{6/12})} = 0.9756, \quad DF_{9\text{-mth}} = \frac{1}{(1+5.5\%x^{9/12})} = 0.9604
\]

Forwards and Futures
The equation to calculate the forward rate between 24/7/97 and 24/10/97 is then

\[
(1 + \frac{r\%}{i})^\frac{9}{12} = \frac{(1 + 5.5\% \times \frac{9}{12})}{(1 + 5\% \times \frac{6}{12})} = \frac{DF_{6\text{ month}}}{DF_{3\text{ month}}}
\]

In other words, if we have to calculate the forward rate between time \(a\) and \(b\) (where \(a\) is before \(b\) and \(a, b\) are expressed in years), the formula to use is

\[
[(1 + \frac{r\%}{i}) \times (b - a)] = \frac{DF_{a}}{DF_{b}}
\]

Real market situations are seldom as simple as that. The first complication is when the discounting factor of more than one year is required, a compounding formula has to be used instead of calculating it as a simple interest. Other than that the same principle could be used and the above general formula could still apply. Secondly, when marking-to-market, the rates for the start and end dates are seldom given directly. In the above example, we assume that 3-month periods are exactly 0.25 year. To be more accurate, the time period should be calculated based on the day convention of the market. If the day convention is actual/365, the time period should be calculated by the difference in the number of days between the start and the end divided by 365. Assume that today is 10/3/97 and the forward rate between 24/7/97 and 24/10/97 is required. In the market, only rates for 1, 3, 6, 9, 12 months are quoted. To calculate the discounting factors at 24/7/97 (which is 136 days from today) and 24/10/97 (which is 228 days from today), some kind of interpolation is required. Using the figures in the above example (3-month rate is 6%, 6-month rate 6.5%), and assuming the 9-month rate is 6.8%, we work out the 136-day rate \((n)\) and 228-day rate \((r_1)\) using a simple linear interpolation,

\[
\frac{r_1 - 6\%}{6.5\% - 6\%} = \frac{(24/7/97 - 10/6/97)}{(10/9/97 - 10/6/97)}\quad \frac{r_2 - 6.5\%}{6.8\% - 6.5\%} = \frac{(24/10/97 - 10/9/97)}{(10/12/97 - 10/9/97)}
\]

giving \(r_1=6.239\%\), \(r_2=6.645\%). Different banks use different methods in interpolating for the rates between fixed dates and the answer could be slightly different (e.g. interpolate on the product of rate times maturity instead of on the rate, or fitting a curve to all the fixed points on the curve). There is no absolutely "correct" way to get to the right answer. Using these

Forwards and Futures
rates, the forward rate for the period 24/7/97 to 24/10/97 can be calculated as follows:

The discounting factors are:

\[
DF_1 = \frac{1}{1 + 6.239\% \times \frac{36}{365}} = 0.9773, \quad DF_2 = \frac{1}{1 + 6.645\% \times \frac{228}{365}} = 0.9601
\]

The forward rate is calculated using

\[\frac{[1 + r\% \times \frac{(228 - 136)}{365}]}{DF_2} = DF_1\]

which gives \(r = 7.11\%\).

**Movements of the yield curve**

Before we move on to other types of derivatives, there is one final concept to be introduced here. We often hear from the news that “central banks are cutting the interest rates”. Have you ever wondered what exactly this means? It does not imply that the central bank has cut the interest rates across all maturities by the same margin. If so, the curve would always move in a parallel fashion. In reality only one reference rate (usually an overnight rate) is changed. The effect on the rates with long maturities is usually different from that of the short maturities. There are three important ways that the yield curve can move:

1) Parallel shift – the whole curve moves up or down by the same margin.

2) Change of slope – the curve moves in opposite direction around a pivot point. (The curve “steepens” or “flattens”.)

3) Change of convexity – rates of different maturities move by different magnitudes. (The curve “twists”.)
In the first part of this chapter, it is shown that the price of an interest rate forward can be obtained using today's market data. That is what the rate is expected to be given today's information. However, for some more complicated derivatives, we need to know what the yield curve would possibly look like in the future. For example, we are asked to price an option today of the 3-month forward given in the above example. In that case, although we know that the expected forward rate given by today's data is 6.34%, it is also very likely that the yield curve will move in the next 6 months. In order to price the option we need to know how this curve will move. This is considerably more difficult than the pricing of derivatives on other assets, because here we have to model the movement of the whole curve, whereas for other asset classes only the spot variable (e.g. the exchange rate or the stock price) needs to be modelled.

People have carried out research as to how these yield curves move over time in practice. Empirical results using US data show that a combination of parallel shift and change of slope can explain over 90% of the movements of the curves. This is an important piece of information because by knowing that two kinds of movements can account for most of the changes in the yield curves, we can simplify the modelling process and approximate the movements by summarising these using one or two "factors", which makes the life of the "rocket scientist" much easier.

2 A nickname for those people who used to study Astrophysics and similar subjects and then apply this knowledge to design exotic financial derivative products.

Forwards and Futures
CHAPTER 5
SWAPS

In this chapter, we will discuss what a swap is, its related concepts, and the mechanism of interest rate swaps, cross currency swaps and other types of swaps.

WHAT IS A SWAP?

When we talk about swaps, we usually talk about interest rate swaps and cross currency swaps. These are so called generic or basic swaps. In general, a generic swap is a contract in which two parties agree to exchange periodic payments within an agreed time period. Other generic swaps include contracts which involve exchanging baskets of securities or commodities. There are also non-generic swaps. They usually contain variations of generic swaps and other derivative instruments.

WHY FINANCIAL INSTITUTIONS SWAP?

The concept of a swap is quite simple. It is no more complicated than swapping things between two parties. If I have commodity A that I do not need, you have commodity B that you do not need, and we both need the other’s commodity, the best solution is to exchange (swap) these two commodities at a reasonable pre-determined price. Please see example below:

ABC Bank’s asset/liability structure is liability sensitive (this is a bankers’ jargon which means that the liabilities are re-priced faster than the assets) because the duration (it means the term-to-maturity here) of its deposits is shorter than the duration of its loans. This creates a mismatch between its assets and liabilities. In order to balance this mismatch, ABC Bank can do two things: (1) extend its liability duration by offering only longer-term deposits or shorten its asset duration by making only shorter-term loans or floating rate loans; and/or (2) utilise risk management tools (derivatives) to modify its asset/liability structure.
It is not practical to actually change a bank's asset or liability duration by intentionally lending short or borrowing long. This may prove to be more costly. The practical way to extend its liability duration or shorten its asset duration is to utilise risk management tools, such as swaps to accomplish this task. We will discuss this arrangement in detail later.

XYZ Life Insurance Company's asset/liability structure is asset sensitive. It collects insurance premiums from policy holders each month for many years and pays them out when the policy expires (usually in tens of years) or when the insured is dead. This also creates a mismatch between assets and liabilities. Its situation is just the opposite of ABC Bank. Therefore, XYZ Life Insurance Company and ABC Bank can come to an agreement to swap something in order to balance their asset/liability structures.

The history of swaps

The idea of financial swap was created in the UK as a means of circumventing foreign-exchange controls in the 1970s, which were intended to prevent an outflow of British capital. At that time, the British Government imposed taxes on foreign-exchange transactions involving the British pounds to make outflow of capital more expensive in order to induce domestic investment. During that period, companies frequently used back-to-back loans to avoid such taxes. The mechanism of back-to-back loans is: they involved two companies domiciled in two different countries. One company agreed to borrow funds in its own country and then lend those borrowed funds to the other company. The second company, in return, borrowed funds in its own country and then lent them to the first company. By doing so, both companies were able to access the foreign capital market without formal exchanges of currencies and thus avoided paying any foreign exchange taxes.

This simple arrangement later developed into more sophisticated cross-currency swaps and interest rate swaps with banks and investment houses as middle men to bridge counterparties who needed these arrangements (This may be a good example to prove to the free-market advocates, whc
often complain that there is too much regulation, that regulation could sometimes lead to the best for the market.) The first currency swap was written in London in 1979 between the World Bank and IBM, and was put together by Salomon Brothers. It allowed the World Bank to obtain Swiss Francs and Deutschemarks to finance its operations in Switzerland and West Germany without entering these two countries’ capital markets directly.

**Comparative advantage**

Before we get into the mechanism of interest rate swaps, two more concepts need to be established. Companies can exchange something of which they have a comparative advantage over their counterparties. For example, XYZ Insurance Company and ABC Bank both want to borrow $100 million for five years. XYZ wants to borrow floating rate funds and ABC wants to borrow fixed rate funds. XYZ can borrow fixed rate funds at 6 percent and floating rate funds at LIBOR plus 0.5 percent in its own country. ABC can borrow fixed rate funds at 7.5 percent and floating rate funds at LIBOR plus 1.0 percent in its own country. XYZ has an absolute advantage over ABC in both fixed and floating rate markets (probably because XYZ is more credit-worthy and banks are prepared to lend to it at a lower rate or because the markets are imperfect). But the important thing is: ABC has a comparative advantage over XYZ in floating rate markets. This is because the difference between the two fixed rates is 1.5 percent and the difference between the two floating rates is 0.5 percent. In other words, ABC pays 1.5 percent more than XYZ in fixed rate markets but only pays 0.5 percent more than XYZ in floating rate markets. When we say ABC has a comparative advantage over XYZ in floating rate markets, it does not mean that ABC pays less than XYZ in floating rate markets. What it means is that ABC pays less more than XYZ in floating rate markets. On the other hand, XYZ has a comparative advantage over ABC in fixed rate markets because it pays more less than ABC in fixed rate markets. What makes a swap work in this situation is that XYZ wants to borrow floating but it has a comparative advantage over ABC in fixed rate markets; and ABC wants to borrow fixed but it has a comparative advantage over XYZ in floating rate markets.
**SWAP DEALERS**

The second concept we need to understand is the concept of the middleman – the swap dealer. In the real world, we do not call everybody in the financial market telling them that we have a comparative advantage over them and ask them to make a swap deal. Finding the right counterparties is usually through swap dealers (or brokers). They make the finding of the right counterparties a much easier job and substantially enhance the market liquidity. These middlemen will charge market participants a fee - usually in the form of bid/ask spread. This concept is also important because without swap dealers, the swap market will not develop that fast.

**INTEREST RATE SWAPS**

Interest rate swaps involve a counterparty paying a floating rate based on an agreed-upon index and the other counterparty paying a fixed rate for the entire term of the contract. In the earlier example, ABC Bank and XYZ Life Insurance Company could swap what they need and what they do not need in order to achieve their asset/liability management goals. We would ignore the transaction cost and the middleman and assume ABC and XYZ negotiate this contract directly. XYZ agrees to pay ABC LIBOR flat and ABC agrees to pay XYZ 6.0 percent fixed on $100 million for five years.

Does this swap benefit both parties? If yes, by how much?

All the relations of this transaction can be seen easily in the following diagram:

```
Outside lender 6.0% XYZ LIBOR 6.0% ABC LIBOR +1.0% Outside lender
```

From the above diagram, we can see that XYZ has three cash flows:

1. It pays 6.0 percent to its outside lender,
2. It pays LIBOR flat to ABC, and
3. It receives 6.0 percent from ABC.
ABC also has three cash flows:

1. It pays LIBOR plus 1.0 percent to its outside lender,
2. It pays 6.0 percent fixed to XYZ, and
3. It receives LIBOR flat from XYZ.

For XYZ Life Insurance Company, its net funding cost in this transaction is LIBOR flat, which is lower than LIBOR plus 0.5 percent at which it can borrow in its own country. It also has achieved its objective by modifying its asset/liability structure using derivatives. In this case, XYZ has shortened its liability duration by entering the swap. Instead of paying 6.0 percent fixed, XYZ now pays LIBOR flat.

For ABC Bank, its net funding cost in this transaction is 7.0 percent, which is also lower than the rate of 7.5 percent at which it can borrow in its own country. It also has achieved its objective by modifying its asset/liability structure using derivatives. In this case, ABC has extended its liability duration by entering the swap. Instead of paying LIBOR plus 1.0 percent, ABC now pays 7.0 percent fixed for 5 years. (You may assume that ABC has a $100 million fixed rate five year loan portfolio and a $100 million 7-day deposit portfolio. By entering into this swap, its interest rate risk or asset/liability maturity mismatch has largely reduced.)

Coincidentally, both ABC and XYZ reduce their funding cost by 0.5 percent.

**Cross Currency Swaps**

The main difference between interest rate swaps and cross currency swaps is that cross currency swaps usually involve exchange and re-exchange of principals whereas interest rate swaps do not. A typical cross currency swap has three sets of cash flows: the initial exchange of principals at the beginning, the exchange of interest payments during the contract period, and the re-exchange of principals at the end. The following diagrams illustrate the three sets of cash flows of a cross currency swap:
At inception

Counterparty A $10 billion → Counterparty B
US$100 million

On each settlement date (including maturity)

Counterparty A $5 billion → Counterparty B
US$ @ LIBOR

Counterparty A $5 billion → Counterparty B
US$ @ LIBOR

At maturity

There are also cross currency swaps which do not involve exchange of principals.

**Valuation of Swaps**

As an example, please consider an interest rate swap with the following conditions:

- the notional amount is US$100 million;
- the term of the contract is five years;
- ABC pays XYZ 6 percent fixed and receives 6-month LIBOR;
- XYZ pays ABC 6-month LIBOR and receives 6 percent fixed; and
- interest payments are settled semi-annually.

We can make the above example a bit closer to our traditional banking business. If we assume exchange and re-exchange principals do exist (similar to cross currency swaps), the above example is the same as the following:

- ABC lends to XYZ US$100 million at 6-month LIBOR for five years; and
- XYZ lends to ABC US$100 million at a fixed rate of 6 percent for five years.

You can even consider that ABC has purchased a $100 million floating rate bond from XYZ and sold to XYZ a $100 million fixed rate bond for the same terms.

*Swaps*
Assuming that there is no transaction cost, at the inception of a swap transaction, the market value of both sides of the transaction is zero. The reason is obvious - in a liquid and generally efficient market, nobody can take advantage of its counterparty or else the counterparty will transact the deal with someone else. Swap pricing is the process of setting the fixed rate so that the present value of cash flows of the swap is initially zero. Credit spread will then add to one side of the swap to reflect the credit quality of the counterparty.

During the life of the swap, if the yield curve (in particular, this implied forward rates) remains unchanged, the market values for both sides are always zero. However, say, after one year, the current market fixed rate for a new four year interest rate swap is 7 percent. The swap would have a negative mark-to-market (M-T-M) value to XYZ and a positive M-T-M value to ABC. This is because XYZ has a contract with ABC to receive fixed rate of 6 percent and pay LIBOR for four more years while everyone else in the market can enter into a swap contract to receive fixed rate at 7 percent and pay LIBOR for four years. But unless XYZ defaults, its contract with ABC remains legally binding for four more years.

Using the present value cash flow concept, we can calculate the loss for XYZ:

\[
\sum_{t=1}^{8} \frac{3,500,000}{(1+0.035)^t} - \sum_{t=1}^{8} \frac{3,000,000}{(1+0.035)^t} = 3,436,978
\]

(There are 8 settlements remaining in the contract. $3,500,000 and $3,000,000 are the semi-annual fixed interest payments at 7 percent and 6 percent respectively.)

If you have an HP 12C financial calculator, you can do the following to calculate the M-T-M loss for XYZ in the above transaction:

$100 million : FV
8 : N
3 : PMT
3.5 : i
PV = -96,563,022
Loss = $100,000,000 - $96,563,022 = $3,436,978

Swaps
The loss for XYZ is the gain for ABC. You can easily see that ABC is at a position just opposite to XYZ. It has the benefit of paying 6 percent fixed for four more years while the market rate for a similar transaction is 7 percent.

In the above example, a simple approach is used to demonstrate the M-T-M calculation. Sophisticated market participants would create a new zero coupon curve to discount the cash flows at each settlement point. Nevertheless, the concept of present value cash flow is still the same.

**Credit Risk of Swaps**

The principles that govern the management of credit risk of swaps are the same as other traditional banking business. Nevertheless, the measurement of the exposure of a swap is more complicated.

The credit risk of a swap is the swap's current exposure, which is the replacement cost or the current M-T-M value, if positive, plus its future replacement cost. This is the so-called "current exposure method". The current exposure method is not just an appropriate method for measuring credit risk of swaps. It is recommended by the Basle Committee and the G-30 for measuring credit risk of all derivatives.

The current exposure is straightforward. It is just the current M-T-M value of a swap position if positive. If the M-T-M value is negative, the holder of the position does not have current credit exposure. This is because credit default occurs when a counterparty does not fulfill its financial obligation. It will not default if it has a financial instrument with a positive market value.

Conservative market participants usually assign a zero value for an instrument whose M-T-M value is negative unless there is a bilateral netting agreement.

The measurement of the future replacement cost or the "potential exposure" of a swap or a derivative instrument is quite complicated. It usually needs
simulation techniques and mathematical models to derive a meaningful measurement result. The analysis generally involves modelling the volatility of the underlying variables and the effect of movements of these variables on the value of the derivatives. For interest rate swaps, the variable is interest rates.

Because it does not involve exchange and re-exchange of principals, the risk profile of a typical interest rate swap is shown in the diagram below:

![Diagram](image)

(The scale on the left is the percentage of notional amount at risk.)

The expected exposure is the mean of all possible probability-weighted replacement costs. The maximum potential exposure is an estimate of the "worst case" exposure at any point in time.

The so-called "hump-back" profile is due to two offsetting effects: diffusion effect and amortisation effect. The diffusion effect says that due to the passage of time, there is an increase of probability that the value of the underlying instrument will drift substantially away from its original value.

---

1 This diagram is adapted from "Derivatives: Practices and Principles" by the Group of Thirty.
The amortisation effect is the reduction in the number of settlements as time elapses.

For an interest rate swap, its peak exposure for default is when sufficient time has passed, the counterparty finds itself at an adverse position, and there is sufficient time remaining for this adverse position to continue. This usually happens at about the intermediate point during the life of a contract. Because there is no final exchange of principals, the risk exposure drops gradually to zero at maturity after it reaches the maximum.

For cross currency swaps, the risk profile is different because the re-exchange of principals at the end increases the diffusion effect and reduces the amortisation effect.

How do you aggregate the maximum exposure of these two swaps? It is incorrect to simply add the two notional amounts together or add the two maximum exposure amounts together and say that is the maximum exposure. Why? It is easy to see it if you stagger the two above diagrams together. The maximum exposure of the interest rate swap happens at about the mid-point of the transaction while the maximum exposure of the currency swap is still increasing. The maximum exposure for the currency swap is at the end of the transaction. At that time, the exposure for the interest rate swap has reduced to zero. For a portfolio of two swaps, you can still manage to aggregate the risk manually. If there is a portfolio of hundreds or thousands of swaps, it is necessary to use simulation technique to aggregate counterparty credit risk.
The calculation of credit risk process has not finished yet. So far, we have only measured the potential current and future exposures if a counterparty defaults. But what is the probability that this counterparty will default? The probability of default is generally viewed to be a function of credit ratings and of the maturity of the transaction. The lower the credit rating and the longer the maturity, the higher the probability of default. The maturity factor is straightforward and does not need any explanation. Credit analysis for swaps, however, is more a qualitative analysis than quantitative analysis, and is an art rather than a science. Again, it is no different from credit analysis for regular loans or for any other banking products.

After a reasonable probability of default factor is derived, the simplest way to estimate credit loss for a swap is to multiply the expected or maximum exposure by the specified probability of default factor. Others use more sophisticated simulation analyses.
In the previous chapter, we introduced two simple kinds of generic swaps: interest rate and currency swaps. These are usually known as “plain vanilla” deals because the structures of these swaps are simple and more or less similar, except for the contract details. These constitute a large part of derivatives trading. However, a swap in its most general form is a security that involves the exchange of cash flows according to a formula that depends on the value of one or more underlying variables. There is therefore no limit to the number of different types of swaps that can be invented. In this chapter, we would give you a taste of some “real life” swap structures which you may come across in the future as these become more and more common.

**Some Different Kinds of Interest Rate Swaps**

In many occasions, an institution enters into a swap transaction with a bank in order to hedge its interest rate exposures. A plain vanilla swap involves the exchange between payments based on a floating rate and a fixed rate. However, depending on the nature of the exposures, an institution may enter into a *basis swap* with a bank, for which the payments are based on two floating rate references. For example, bank A has a mortgage portfolio which receives floating rate payments based on the prime rate, and the portfolio is funded with 3-month deposits, the deposit rate being based on HIBOR. Assume that bank A expects the spread between HIBOR and prime will narrow quite substantially in the future (at present it is, say, 3.5%). In order to lock in this margin, bank A may enter into a swap transaction with bank B, for which

![Diagram](Bank A) \[\text{prime rate}\] \[\text{HIBOR+3.2\%}\] \Rightarrow (Bank B)

1 This chapter was written by Mr. Chau Kau-ak.
The payments are exchanged every three months, for a term of 5 years. By this deal, even if the spread between HIBOR and prime narrows in the future, bank A is certain to gain 3.2% for each payment received provided that no counterparty defaults.

Why should bank A only receive 3.2% instead of 3.5% on top of HIBOR for each payment? In order to price any swap, the important principle is that at the inception of the deal, it should be fair to both parties, otherwise no one would enter into the contract with you. If the future spread between prime and HIBOR is forecast to be reduced, then a fixed margin has to be calculated today based on the present information so that the net present values of all cash flows would be zero at inception.

Basis swaps could involve many different kinds of reference rates for the floating payments, the commonly used references are 3-month LIBOR, 6-month LIBOR, prime rate etc. Another special kind of swap which is worth mentioning is the **Constant Maturity Swap** (CMS) or **Constant Maturity Treasury swap** (CMT swap). These swaps, which are very common in the US, typically use a swap rate or T-bill rate as one of the floating references (for example, a swap which exchanges between 5-year swap rate and 6-month LIBOR). Pricing these swaps (i.e. to calculate the fixed margin required) is difficult and advanced techniques are required.

In the cases mentioned above, the notional principal remains constant throughout the life of the swap. However, sometimes the bank may want to use a simple swap to hedge the exposure of a loan with an amortisation schedule. This leads to another important type of swaps known as **amortising swaps**. The principal reduces according to a fixed schedule decided at inception. An example of this is:

<table>
<thead>
<tr>
<th></th>
<th>fixed @ 6%</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>6-month LIBOR</td>
<td>Bank A</td>
<td>Bank B</td>
</tr>
</tbody>
</table>

Payments are made every 6 months, for a total period of 4 years. The reference principal amounts are:

- Year 1: $10 million
- Year 2: $8 million
- Year 3: $5 million
- Year 4: $3 million

**Different Types of Swaps**
The pricing of this swap (i.e. to calculate the required fixed rate using today's market rates) is not difficult. Effectively this is equivalent to a series of swaps added together. The first one is a 4-year swap with notional principal of $10 million. The second one is a 3-year swap starting in one year's time (i.e. a forward starting swap, another common variation of the plain vanilla type), with a notional principal of $2 million in the opposite direction. The third one is a 2-year swap starting in two years' time with a notional principal of $3 million in the opposite direction. The last one is a one-year swap starting in three years' time, with a notional principal of $2 million in the opposite direction.

A closely related type is the index amortising swap (IAS). Instead of having a fixed amortising schedule as in the above example, the schedule depends on an on-going reference rate (or index), and the manner in which this rate changes in the course of time. For example, the schedule can be:

end of Year 1  if 6-month LIBOR > 7%, principal is reduced by 10%
end of Year 2  if 6-month LIBOR > 7.5%, principal is reduced by 10%
end of Year 3  if 6-month LIBOR > 8%, principal is reduced by 20%

The principal amount at each payment date depends on how the 6-month LIBOR has moved. Assume an initial principal of $10 million, the amount at each payment date for the following two scenarios will be:

a) LIBOR at end of:
   Year 1: 6%, Year 2: 8%, Year 3: 8.5%.
   Principal amount at:
   Years 1 and 2: $10 million, Year 3: $9 million, Year 4: $7.2 million.

b) LIBOR at end of:
   Year 1: 7.5%, Year 2: 8%, Year 3: 7.5%.
   Principal amount at:
   Year 1: $10 million, Year 2: $9 million, Years 3 and 4: $8.1 million.

Contrary to simple amortising swaps, the pricing of IAS is difficult because a full model of the yield curve has to be used to forecast the behaviour of

Different Types of Swaps
the reference rate. When this type of swap was introduced in the late eighties, huge margins were charged. Subsequently the margins became tighter as more and more people traded these instruments. However, some people began to realise that the original pricing method was incorrect. Even today we can see many banks use a wrong model in pricing these swaps.

Another variation of the swap family is the differential swap (also commonly known as diff swap or quanto swap). This product was first developed in the early nineties in order to suit the needs of customers who had strong views on the spread between interest rates in different countries.

For example, the treasurer of company A, a US based company, gets today’s market data for US and Japan’s yield curves. He thinks that due to the strong growth in the US economy relative to Japan’s, the US interest rates are likely to rise faster than what the market suggests now, i.e. the spread between US interest rates and Japan interest rates would widen even further than today’s prediction. A simple strategy is for company A to enter into a cross currency swap with Bank B:

\[
\text{Company A} \quad \frac{¥ @ 6\text{-mth LIBOR}}{US$ @ 6\text{-mth LIBOR}} \quad \text{Bank B}
\]

With the exchange of principals at the start and end dates, this constitutes a typical cross currency swap (refer to Chapter 5). However, the problem with this kind of swap is that the amount paid in Yen is subject to foreign exchange risk. It is quite likely that even if Japanese rates increase only slightly, Yen could suddenly become much stronger, and the benefit from the increase in US LIBOR would be offset by the appreciation of Yen which makes the payments more valuable from a US company’s point of view.

Ever so eager to capture new markets, the “rocket scientists” in investment banks came up with an unnatural product. Instead of paying Japanese LIBOR in Yen, both payments would be made in US dollars, i.e.
US$ @ 6-mth Japanese LIBOR + margin

US$ @ 6-mth LIBOR

Since all the payments would now be made in US dollars, company A would not be exposed to foreign exchange risk anymore, and the product fully captures its view. In a sense, the Japanese LIBOR only acts as a kind of reference rate. Again, the difficulty for this kind of swap is to calculate the fair value of the fixed margin at the inception of the swap. Fat margins were charged by investment banks initially, with the margins coming down gradually in recent years.

Tailor-made structures

So far we have only introduced swaps where coupons are exchanged based on some reference rates. Features of the other big family of derivatives, options, could be added to plain swaps to create some new type of products. The simplest one is the option on a swap, or swaption. A typical deal is: in one year’s time, the buyer has the right to enter into a plain vanilla 3-year swap, where he pays fixed at 6% and receives floating LIBOR every six months. There is a very active over-the-counter (OTC) market in trading these instruments, with different maturities of the option (one year in the above example) and different maturities of the underlying swaps (3-year above). As with other types of options, a premium has to be paid upfront to purchase the right. This is different from typical swap structures for which no counterparty has to pay any upfront fees because the deal should be fair to both parties at inception.

Another common type of OTC swaps with option features is the extendible and puttable swaps. These instruments allow one counterparty the right to extend or cancel the swap at the end of a specified period. For example, an extendible swap can be:

Company A  fixed @ 5.5%  6-mth LIBOR  Bank B

in the first 2 years. After 2 years, company A has the right to extend the swap for a further year. If it does not exercise the right, the swap terminates at year 2.
Effectively this is just a 2-year swap plus a 2-year option on a 1-year swap. For this kind of deal, the premium is usually included in the fixed rate. In the example above, the market 2-year swap rate is probably lower than 5.5% (say 5.2%). Company A pays 0.3% above the market rate for the four payments in the first 2 years to compensate for the option premium.

Finally, a swap deal can have a high degree of leverage. Here we use an example similar to the diff swap example above. Germany's and France's interest rates are usually closely linked together, and the spread between the rates are quite constant. However, if customer A thinks that the spread would widen with France's rates higher than that of Germany's, a swap deal which could capture this view is:

\[
\text{fixed @ 10%} \quad \frac{(\text{France 6-mth LIBOR} - \text{Germany 6-mth LIBOR}) \times 20}{\text{Company A}} \xrightarrow{\text{Bank B}}
\]

This is a highly leveraged deal because the payments are very sensitive to even small movements in the two yield curves. For example, if at the first settlement date, France LIBOR is 4% and Germany LIBOR is 3.5%, then the payments are equal \((4 - 3.5) \times 20 = 10\%\). However, if at the next settlement date the LIBORs are 4.2% and 3.3% respectively, company A would receive \((4.2 - 3.3) \times 20 = 18\%\) while paying 10%, and a net 8% is earned. For a big notional amount (say $20 million) this already represents a profit of $0.8 million (for six months). However, one could as well lose as much. You may think that these deals are just like gambling, but it is not uncommon to find trades like these.

Armed with the different types of swaps and options features introduced above, a bank can tailor-make almost anything according to the customers' needs. In many structured deals, more than two counterparties are involved, which means that two or more simultaneous swaps are entered. Usually the more exotic the instrument becomes, the higher the risk it bears. One of Proctor & Gamble's deals with Bankers Trust, which ended up in a lawsuit, is of the highly leveraged kind. This probably gives the word "derivatives" a bad name.

Different Types of Swaps
Chapter 7

Duration and Convexity

Duration

What is duration? Duration is a measure of the average life of a security. More specifically, it is the weighted average term-to-maturity of the security's cash flows. Mathematically, it is:

\[
\text{Duration} = \frac{t_1 \times PVCF_1 + t_2 \times PVCF_2 + t_3 \times PVCF_3 + \ldots + t_n \times PVCF_n}{k \times PVTCF}
\]

where

- \(PVCF_t\) = the present value of the cash flow in period \(t\) discounted at the yield-to-maturity
- \(PVTCF\) = the total present value of the cash flow of the security determined by the yield-to-maturity, or simply the price of the security
- \(k\) = number of payments per year

The following is an example of duration:

<table>
<thead>
<tr>
<th>Period (t)</th>
<th>Cash flow</th>
<th>PVCF</th>
<th>(t \times PVCF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$4.0</td>
<td>3.8462</td>
<td>3.8462</td>
</tr>
<tr>
<td>2</td>
<td>4.0</td>
<td>3.6982</td>
<td>7.3964</td>
</tr>
<tr>
<td>3</td>
<td>4.0</td>
<td>3.5560</td>
<td>10.6800</td>
</tr>
<tr>
<td>4</td>
<td>4.0</td>
<td>3.4192</td>
<td>13.6769</td>
</tr>
<tr>
<td>5</td>
<td>4.0</td>
<td>3.2877</td>
<td>16.4385</td>
</tr>
<tr>
<td>6</td>
<td>4.0</td>
<td>3.1613</td>
<td>18.9675</td>
</tr>
<tr>
<td>7</td>
<td>4.0</td>
<td>3.0397</td>
<td>21.7777</td>
</tr>
<tr>
<td>8</td>
<td>4.0</td>
<td>2.9228</td>
<td>23.3821</td>
</tr>
<tr>
<td>9</td>
<td>4.0</td>
<td>2.8103</td>
<td>25.2931</td>
</tr>
<tr>
<td>10</td>
<td>104.0</td>
<td>70.2586</td>
<td>702.5867</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>100.0000</td>
<td>843.5331</td>
</tr>
</tbody>
</table>

Macaulay's duration = \(843.5331/(2 \times 100) = 4.2177\)

This example is adapted from "Price Volatility Characteristics of Fixed Income Securities" by Frank J Fabozzi, Mark Pitts and Roy E Detotreyen.

Duration and Convexity
This measure of duration is referred to as Macaulay's duration, which is named after Frederick Macaulay, who first computed it in 1938 in his article, "Some Theoretical Problems Suggested by the Movement of Interest Rates, Bond Yields, and Stock in the US since 1856".

Duration is a single number that is measured in units of time, e.g. months or years. For securities that make only one payment at maturity, such as zero coupon bonds, duration equals term-to-maturity.

**Use of Duration**

Duration is a very useful measure. First, it converts a very complex cash flow structure into a single number that represents the rate sensitivity of the financial instrument. Second, it can be used in a formula to calculate the change in the security's market value that occurs as a result of a change in market rate. Third, it can also be used to measure the overall rate sensitivity of a portfolio of instruments or the entire asset liability structure.

The relationship between Macaulay's duration and security price volatility is:

\[ \text{Percentage change in price} = - \frac{1}{1 + \text{yield/k}} \times \text{Macaulay's duration} \times \text{yield change} \times 100 \]  

For easy calculation, academics and market practitioners usually combine the first two expressions on the right-hand side into one term and call it "modified duration":

\[ \text{Modified duration} = \frac{\text{Macaulay's duration}}{(1 + \text{yield/k})} \]

The relationship can then be expressed as follows:

\[ \text{Percentage change in price} = - \text{modified duration} \times \text{yield change} \times 100 \]

To illustrate this relationship, consider a change in yield (change in market rate) from 8.00 percent to 9.00 percent for the bond described earlier:

\[ \text{Modified duration} = \frac{4.2177}{(1 + 0.08/2)} = 4.0555 \]

\[ \text{Change in price} = -4.0555 \times (+0.01) \times 100 = -4.0555 \text{ percent} \]
In other words, when the interest rate increases from 8.00 percent to 9.00 percent, the bond originally sold for 100, is now priced at 95.9445, a decrease of 4.0555 percent.

Equation (3) is quite accurate for small changes in yields, but is only an approximation for large changes in yields. This will be discussed later in this chapter.

From the above example and the previous illustration, we can see how duration applies to bond pricing analysis. (We constrain our discussion to option-free securities.)

First, we see from the illustration that we have converted a 5-year bond with 10 cash flows into a single number - a modified duration of 4.0555. What does it mean? It means that if the interest rate increases by, say one percent, the price of the security decreases by 4.0555 percent; or if the interest rate decreases by one percent, the price of the security increases by 4.0555 percent. Therefore, this modified duration of 4.0555 represents the interest rate sensitivity of this 5-year bond.

Second, as we can see in equations (3) and (5), the percentage change in bond price due to a change in interest rate can be easily calculated.

Third, by using the duration concept, we can perform some forms of asset/liability management. We can match the durations between assets and liabilities portfolios to create a “duration-matched portfolio”. Or we can construct an “immunised portfolio” that provides assured returns over a target holding period.

In addition, because modified duration is the percentage change in the price of a security given a change in yields, and a change in yields is a measure of the change in the bond market, modified duration actually plays a similar role of measuring market risk for bonds that beta plays for stocks.

Although the duration concept is simple and easy to apply in bond pricing

*Duration and Convexity*
analysis, it also has its shortcomings. As we mentioned earlier, duration is quite accurate in calculating changes in price for small changes in yields. For large changes in yields, duration only provides an approximation, and we have to rely on the concept of convexity for more accurate estimations.

**Convexity**

The true relationship between a change in price and a change in interest rate for option-free securities is not linear. The following graph demonstrates this relationship:

The actual price of the security is the curve AA', and the straight line BB' which is tangent to the AA' curve represents the duration of the security. Therefore, as the graph shows, the straight line approximation creates errors that grow with the magnitude of the interest rate changes. For small changes in yield, e.g. from Y to Y2 or Y3, duration does a good job in estimating the actual price. But for larger changes, e.g. from Y to Y1 or Y4, duration becomes less accurate and the errors become larger. Convexity is what we use to correct this problem.
Mathematically, modified duration is the first derivative of bond price while convexity is the second derivative. Convexity measures the rate of change of duration:

\[
\text{Convexity} = \frac{\alpha x (\alpha + 1) \times \text{PVCF}_1 + \alpha x (\alpha + 1) \times \text{PVCF}_2 + \ldots + \alpha x (\alpha + 1) \times \text{PVCF}_n}{(1 + \text{yield/k})^2 x (k^2 \times \text{PVTCF})}
\] (6)

The convexity of the security in our previous illustration is 20.1886 (following the calculation format illustrated on page 41.)

The price change that is due to the curvature is shown in the following formula:

\[
\text{Percentage change in price due to convexity} = \frac{1}{2} \times \text{convexity} \times (\text{yield change})^2 x 100
\] (7)

Now we can put things together. For a 100 basis point change in yield from 8.00 percent to 7.00 percent, the true theoretical price, taking into consideration both duration and convexity, is:

- Percentage change in price due to duration = \(-0.0555 \times (-0.01) \times 100 = 0.5555\%
- Percentage change in price due to convexity = \(\frac{1}{2} \times 20.1886 \times (-0.01)(-0.01) \times 100 = 0.1009\%
- Total percentage change in price = 0.5555\% + 0.1009\% = 0.6564\%

As you can see, when the interest rate decreases, the convexity actually accelerates the price appreciation. Further, the change in price due to convexity is largely determined by the change in interest rate. If the yield change is small, the square of yield change is negligible. If the yield change is large, this term can be significant and thus affects the outcome of equation (7).

Similarly, the true theoretical price change if the interest rate increases from 8.00 percent to 9.00 percent can be calculated as follows:
Percentage change in price due to duration = \(-4.0555 \times (+0.01) \times 100\)
= \(-4.0555\%

Percentage change in price due to convexity = \(\frac{1}{2} \times 20.1886 \times (+0.01)(+0.01) \times 100\)
= 0.1009%

Total percentage change in price = \(-4.0555\% + 0.1009\%
= -3.9546\%

When rate increases, the convexity actually decelerates the price depreciation. As shown on the graph on page 44, the tangent line lies below the theoretical price line. This implies that duration always underestimates the true security price.

All we are doing here is to figure out what the true theoretical prices are. In reality, observed market prices may be different from the theoretical prices because of bid-ask spread, demand and supply, market liquidity, market sentiment, etc. Asset pricing is more an art than an exact science and all mathematical models are just tools to facilitate the pricing analysis. I had once tried to confirm the market value of a multi-billion dollar, illiquid and below-investment-grade bond (or junk bond) portfolio in order to determine the viability of the institution who held these bonds. A world-famous junk bond consultant group was called in to do the evaluation. After days of hard work, the consultants delivered their final analysis. The market values of most of these bonds given by the consultants ranged between 55 and 85 percent of par. The consultants said that if everything (including the economy, market sentiment of the company, market sentiment of junk bonds, interest rates, management's ability, etc.) went well, the price could be 85, and if everything did not go well, the price could be 55. In other words, the user of the analysis had to make a lot of subjective assumptions in order to come to a definitive conclusion.

Duration and convexity are very useful in bond pricing analysis. They are also useful tools in trading and derivatives activities. Traders often use something called price value basis point (PVBP) to measure the sensitivity of risk of their positions. PVBP uses the duration concept to measure the
change in price of a security if rates move one basis point. This is a very useful tool for traders to measure their position sensitivity. However, the shortcoming of this measure (and all other duration measures) is that it assumes a parallel shift of the yield curve which usually does not happen in the real world. Therefore, PVBP is more useful for traders who trade short-term instruments.

Dr Sam Srinivasulu of Michigan University has drawn an excellent analogy regarding duration, convexity, delta and gamma. He said, “duration (or delta) is the speed, and convexity (or gamma) is the acceleration.” It is amazing to see how those bright people connect science and finance together. So we should not be surprised to see that more and more rocket scientists are now invading our finance territories.
Options are generally perceived by many of us as quite complicated and difficult to understand. Justifiably so when we hear options traders talking about delta, gamma, vega, and other Greeks. However, every complicated thing is built on something simple and options are not different. Complex options transactions are built on some simple forms of options. If you understand the fundamentals, with a little extra effort, you will understand many complex forms of options.

**A SIMPLE FORM OF OPTION**

For example, I want to buy a house. I go shopping around to look for my dream home. Suppose I find one which satisfies all my requirements. However, I consider the asking price of $10 million a little bit too high. But the seller refuses to lower the price. What shall I do? I can do one of the following: (1) I can stop shopping around and settle for this house which I consider a little bit over-priced. (2) I can continue to shop around until I find my dream house which is properly priced. However, I have to consider the possibility that I may never find another house which is better than this one. And by the time I decide to come back to buy this house, it may not be available or the price may be even higher. (3) I can ask the seller to grant me an option that the seller will hold the property for me at the same asking price for one month. (Although this practice is not popular in Hong Kong, contracts of leasing with an option to buy are not uncommon in the US.) I then can continue to shop around and hopefully find a better one in a month's time. The seller says, “fine, but you have to pay me a fee for my generosity for allowing you a month of time to commit yourself to purchase the property.” This is a simple form of call option. Whilst in this example, a house is not a homogeneous product and I may not be able to find an exact replacement, most financial products are homogeneous, liquid.
and finding a replacement is not a problem.

**SOME COMMON TERMS OF OPTIONS**

Financial options such as stock options are quite similar to this simple form of option. Here are some financial jargons of options:

- A **call option** gives the option buyer the right but not the obligation to buy a financial instrument or a commodity at a specific price on or before a particular date in the future. This specific price is usually called the exercise price or strike price.

- A **put option** gives the option buyer the right but not the obligation to sell a financial instrument or a commodity at a specific price on or before a particular date in the future.

When you buy an option (or any financial instruments or commodities), you are an option holder and you are said to have a *long* position of the option.

The seller or the writer of an option is said to have a *short* position of the option.

- An **American option** allows the option holder to exercise the option on or before the option expiration date.

- A **European option** allows the option holder to exercise the option only on the expiration date.

- An **at-the-money** option is an option whose exercise price is the same as the market price.

- An **in-the-money** option is an option whose exercise price is lower than the market price for call options and higher than the market price for put options.

- An **out-of-the-money** option is an option whose exercise price is higher than the market price for call options and lower than the market price for put options.

*Introduction of Options*
**Option's Payoff Pattern**

What about an option writer's right and obligation? An option writer is obliged to sell (in the case of a call option) the financial instrument or the commodity to the option holder at a specified price on or before a particular date if the option holder chooses to exercise the option. In return, the option writer receives a premium for selling the option. In the earlier example, the seller grants me a right to purchase the property at $10 million within a month in exchange for an option fee. If the property price raises to $11 million, he is still obliged to sell the property to me at $10 million. If the property price drops to $9 million, I will not exercise my option right to purchase the property at $10 million because I can buy it for $9 million (here we assume that a house is a homogeneous product that I can easily find a replacement). I will just simply let the option run out. The option writer will simply pocket the option fee. From here we can see one thing: the option writer's profit is fixed (the option fee he received) but his financial risk is unlimited. (If the property value goes up to $15 million or $20 million, he still has to sell it to me at $10 million. Here we focus only on the option contract.) This is what we call the asymmetric payoff pattern of options.

My financial situation as a call option holder is just the opposite of the option writer. My total financial obligation is the amount of the option fee. My upside potential can be unlimited if the real estate market skyrockets in one month. If the market price of the subject house rises to $12 million, I can still buy it at $10 million because I am holding a legitimate option contract. My downside risk is limited - the option fee I have paid. But my upside potential is unlimited. Therefore, the payoff pattern of an option holder is also asymmetric.

**Option's Premium**

How much fee should I pay him? I do not want to pay him too much as I understand that this is not a good faith deposit; it is an option fee and I will not see this money again after I have paid him. The seller also wants to be properly compensated because he bears a financial risk by granting me this option.
The option fee (also called option premium or value of the option) is determined by the following factors:

1. The difference between the market price and the exercise price

   If the option contract between me and the property seller allows me to buy the property at several different sales prices, say, $10 million, $10.2 million, $10.4 million, etc., how much should the option premium be? It is obvious that for call (put) options, the higher the sales price, the lower (higher) the option fee I would want to pay. These different levels of sales price in options are called exercise price or strike price. There is one important concept which should be addressed here: intrinsic value. For a stock call option, the intrinsic value equals the difference between the market price and the strike price if the market price is higher than the strike price; it is zero otherwise. For our real estate example, if the real estate market goes up and the market price of my dream house is now $10.8 million and I hold an option to purchase at an exercise price of $10 million, the intrinsic value of the option is $800,000. Using jargons, an option is more expensive when it is more in-the-money.

2. The volatility of the price level

   The premium is higher if the real estate prices in Hong Kong fluctuate a lot. For example, if the rate of volatility of real estate price is 10 percent per month in Hong Kong based on some historical data, it is probable (here we are talking about a 66 percent chance or one standard deviation) that the price of my dream house may fluctuate anywhere between $9 million and $11 million. The option writer may suffer a $1 million financial loss if the price of the house does go up to $11 million in one month (here we focus only on the option contract). If the rate of volatility of real estate price in Hong Kong is 30 percent per month, it is probable that the price of my dream house may range from $7 million to $13 million. In this case, it is possible for him to lose $3 million instead of $1 million. Obviously, he will ask for a higher option fee to compensate for the higher potential risk.

Introduction of Options
Volatility is the most important factor in option pricing. Unlike other factors, the actual volatility is not known (or cannot be observed) at the time of the option transaction. In our real estate option example, the 10 percent or 30 percent volatility level is based on historical data. It is not the actual volatility, because the actual volatility is not observable at the time of the option transaction. In option language, vega is the amount of change of an option price with one-percent change in the volatility of the underlying.

3. The option time period
This is also obvious. The longer the option time period, the higher the option premium (for both calls and puts). This is what we call time value of an option. This factor is on the side of option writers. If all things remain constant, the time value of the option decreases every day and eventually decreases to zero at maturity. For at-the-money or out-of-the-money options, because the intrinsic value is zero, the option becomes worthless at maturity. For in-the-money options, because there is some intrinsic value left at maturity, the option holders can still exercise the option to purchase the underlying asset at a price better than the market price. Therefore, it is still worth something. An option value changes due to changes in time to expiration. This is called theta and is always referred to as time decay.

4. The level of interest rates
The higher the interest rate, the higher the call option premium. This is not so obvious and an example is needed to illustrate this point. If I want to buy a property or a financial asset and I am given the chance of delaying the payment, I will, as I consider myself a rational investor, put the money in a bank to earn some interest in this period. This will partially offset my premium expense and I am willing to pay a higher premium. Therefore, for call (put) options, the higher the interest rate the bank pays me on my deposit, the higher (lower) the option premium I am willing to pay. Rho is the amount of change in an option value due to changes in interest rates. In pricing financial options, market participants usually use the real interest rate or the risk-free interest rate.

Introduction of Options
Three of these four factors (actually there are five elements involved - the difference between the market price and the exercise price includes two elements) are known at the time of the option transaction: risk-free interest rate, exercise price and the level of the asset price, and the option time period. The volatility, however, has to be estimated, or based on some historical data. Market participants usually use implied volatility to price options. (Implied volatility is the volatility level for the underlying that the option price implies. It is a reverse process because the option price is observable but the volatility is not.) Assuming that the seller and I have agreed on all of these five factors, the option premium can be calculated by using an option formula, such as the Black-Scholes formula. This process is just a matter of mathematics. We will introduce the Black-Scholes formula in the next chapter.

The following table summarises the factors of option pricing we just discussed:

<table>
<thead>
<tr>
<th>Premium of</th>
<th>Call</th>
<th>Put</th>
</tr>
</thead>
<tbody>
<tr>
<td>Higher strike price</td>
<td>lower</td>
<td>higher</td>
</tr>
<tr>
<td>Higher volatility</td>
<td>higher</td>
<td>higher</td>
</tr>
<tr>
<td>Longer option time period</td>
<td>higher</td>
<td>higher</td>
</tr>
<tr>
<td>Higher risk-free interest rate</td>
<td>higher</td>
<td>lower</td>
</tr>
</tbody>
</table>

For stock options, there is one more factor which affects the value of an option - dividend. Right after a company pays its stock dividend, its share price usually drops by an amount reflecting the dividend paid adjusting for the tax effect (stock price may go down somewhat less than the dividend amount because of the tax effect). Therefore, dividends can be interpreted as the reduction in share prices and thus reduce the value of calls and increase the value of puts.
Trading options becomes more popular these days. Options traders are sometimes perceived to be some of the smartest traders in dealing rooms because they always deal with some complex pricing models and talk in Greek - at least some letters of Greek.

In this chapter, we will discuss two very important concepts about options and the famous Black-Scholes formula, and hopefully uncover some of the mystique about options.

**The Payoff Pattern of Options**

In the previous chapter, we discussed that options have an asymmetric payoff pattern - the buyer of an option pays a premium to obtain the right to purchase (for a call option) or sell (for a put option) an asset at a specific price (the exercise or the strike price) within a specific time period. His cost (the premium he has paid) is fixed; however, his potential benefit can be unlimited. The seller of an option receives a premium to commit an obligation to allow the buyer of the option to purchase or sell an asset at a specific price within a specific time period. The following graphs illustrate the payoff pattern of a call option at maturity:
As shown in the above graph, the down-side risk for writing options is potentially unlimited. Because writing options is a high risk operation for a bank, the management should stipulate in the policy document the option trading strategies such as whether traders are allowed to write naked options, i.e. writing options without holding the underlying asset, or whether traders are required to hedge (fully or partially) the positions. If writing options is allowed, how the management controls this risk should be clearly written down in the policy statement.

**The Delta of an Option**

The payoff line of the above graph for the option buyer kinks at $100 and then slopes upward. The slope of this line can be anywhere from zero to one for call options (-1 to 0 for put options). How does the slope of the payoff line relate to options trading? An important point to remember is: a call option (at a specific strike price) with a slope of 0.5 means that when the price of the underlying increases by $1, the price of the option increases by $0.5. The slope of the payoff line is also called the hedge ratio. Market participants commonly call the hedge ratio the option’s delta.

If the option writer does not want to take the potentially unlimited down-side risk, he can fully hedge his positions. For every at-the-money call option written, he needs to purchase 0.5 share of the underlying stock if the delta is 0.5. For example, you have written 10 at-the-money options, the stock price is currently at $100 and the hedge ratio or the delta is 0.5. You need 5 shares of stock to fully hedge the position. This is because if the stock price increases by $1.00, the value of the 10 options increases by $0.5 x 10 options = $5.00. The value of the 5 shares of stock also increases by $101 x 5 - $100 x 5 = $5.00.

**What if the delta is 0.7?**

If the delta increases from 0.5 to 0.7, you need 2 more shares of stock to fully hedge your position. This is because if the stock price increases by $1.00, the value of the 10 options increases by $0.7 x 10 options = $7.00.
You need to hold 7 shares of stock to offset the loss of $7.00 when the option holder exercises the option ($101 \times 7 - 100 \times 7 = 7.00$).

**The Black-Scholes Formula**

Here is the famous Black-Scholes formula:

For a European call option, \[ C_0 = S_0 N(d_1) - X e^{-rT} N(d_2) \]
and
\[ d_1 = \frac{\ln(S_0/X) + (r + \sigma^2/2)T}{\sigma T^{1/2}} \]
\[ d_2 = d_1 - \sigma T^{1/2} \]

where

- $C_0$ = current option value
- $S_0$ = current stock price
- $X$ = strike price
- $r$ = risk-free interest rate (continuous compounding)
- $T$ = time to maturity of the option in years
- $\sigma$ = standard deviation (or volatility)
- $\ln$ = natural logarithm function
- $e$ = 2.71828
- $N(d)$ = cumulative normal distribution function

It took Drs Black and Scholes, and Dr Merton many years to derive this famous option-pricing formula in the early 70s. During the last some twenty years, academics and practitioners put many variations, enhancements and refinements to the basic Black-Scholes formula and the formula becomes the necessary tool for options traders.

If we ignore the $N(d)$ terms in the formula, we have $C_0 = S_0 - X e^{-rT}$. We know $S_0$ is the current stock price and $X$ is the strike price and the term $X e^{-rT}$ is just the present value of $X$ with continuous compounding (the term can be expressed as the present value of $X$ if this makes you a little easier to understand it). This simplified formula is more straightforward than the original one. It says that the value of a call option is the current stock price minus the present value of the strike price. Another way to understand this is to recall the definition of intrinsic value of a call option which is the
difference between the market price and the exercise price if the market
price is higher than the strike price, or zero otherwise. Our simplified
Black-Scholes formula simply modifies the strike price to the present value
of the strike price by adding the elements of time and risk-free interest rate.

We can now put the N(d) terms back to the formula without changing the
value of it. This can be achieved only if the N(d) terms are both equal to
one. This makes sense if we interpret the term N(d) as the probability of
the option expiring in-the-money. If we are absolutely positive that the
option will expire in-the-money, the probability, or the term N(d) will be
equal to one. (Theoretically it can only be very close to one because of the
time value. As long as there is time left, anything can happen to security
prices. Therefore, technically, N(d) can never be 0 or 1 until the option
expires.) On the other hand, if there is absolutely no chance for the option
to be exercised, the N(d) terms will be equal to zero. In other words, the
N(d) term ranges from zero to one. This also makes statistical sense. If
you play around with the numbers, you will find that the values of N(d)
increase when the stock price increases. The full explanation of the N(d)
terms needs more advanced mathematics and statistics and is out of the
scope of this book.

With the following data, the at-the-money call option price can be calculated:

Stock price (non-dividend paying): $100
Time to maturity: 3 months
Risk-free interest rate for 3 months: 6 percent per annum
Volatility: 10 percent

\[
\begin{array}{|c|c|}
\hline
d & N(d) \\ \hline
0.16 & 0.5636 \\ 0.18 & 0.5714 \\ 0.20 & 0.5793 \\ 0.22 & 0.5871 \\ 0.24 & 0.5948 \\ 0.26 & 0.6026 \\ 0.28 & 0.6103 \\ 0.30 & 0.6179 \\ 0.32 & 0.6255 \\ 0.34 & 0.6331 \\ 0.36 & 0.6406 \\ \hline
\end{array}
\]

*Delta and Volatility*
\[ d_1 = \frac{\ln(100/100) + (0.06 + 0.1^2/2) \times 0.25}{(0.1 \times 0.25^{1/2})} \]
\[ = 0.3260 \text{ or } 0.33; \text{N}(0.33) = 0.6293 \]

\[ d_2 = 0.3260 - 0.1 \times 0.25^{1/2} \]
\[ = 0.2760 \text{ or } 0.28; \text{N}(0.28) = 0.6103 \]

\[ C_0 = 100 \times 0.6293 - (100 \times e^{-0.06 \times 0.25}) \times 0.6103 \]
\[ = 62.93 - 60.12 = 2.81 \]

If the volatility is 15 percent instead of 10 percent, with other factors unchanged, the value of the option will be higher at $3.96.

The Black-Scholes formula is not perfect. It makes some assumptions. For example, it assumes that the underlying stock does not pay dividends. And it values American options not so accurately because of the early exercise cause. However, it is considered an easy-to-get approximation of the price of an option.

Applying the Black-Scholes formula is much easier than understanding the concepts behind it. From the above equations, we can first solve for \(d_1\) and \(d_2\), and then \(C_0\). All you have to do is to plug all the necessary numbers into the equations. With the technology nowadays, you can get the option value in a second using the Black-Scholes formula.

For data inputs, we can obtain the stock price, strike price, risk-free interest rate, and time to maturity of the option very easily. But how do we get the standard deviation of a stock?

**IMPLIED VOLATILITY**

The standard deviation (or the volatility) of a stock cannot be readily observed like the other inputs. Market practitioners usually use the historical data, scenario analysis or prices of other options to measure a stock's standard deviation. Because there is no uniform way to derive a stock's volatility, the true price of the option and the option price calculated using the Black-Scholes formula can be different.
In practice, traders usually ask what the right volatility is in order for the option price to be consistent with the Black-Scholes formula. This is the so-called implied volatility. It looks like a chicken-and-egg problem. But this is what market practitioners are practising. Options traders usually judge whether the actual volatility exceeds the implied volatility. If he thinks that the actual volatility exceeds the implied volatility, he will buy options. This is because the higher the actual volatility, the higher the option value.
Chapter 10
Trading Options is Trading Volatility

In the previous chapter, we discussed the concept of delta and implied volatility. We also introduced the Black-Scholes formula. In this chapter, we will use these concepts to explain two other option trading issues - (1) delta hedging and (2) trading options being equivalent to trading volatility. We will continue to discuss why we said in our last chapter that the policy of the institution should stipulate the option trading strategy and establish option trading limits.

People usually have a wrong conception of what the real meaning of options trading is. Simply buying an option and looking for the increase of the option price or selling an option for premium income is not really trading options. Some people buy call (put) options when they are bullish (bearish) on the stock; or sell options (both call or put) when they think the price of the stock will not reach the level of the strike price so that they can pocket the premium. All of these are strategies of people using options as a tool to participate in the stock market. The benefit of these strategies is the leverage - instead of investing the full amount to purchase the underlying stock, they can invest a fraction of it and still get the similar result. Nevertheless, the risk of using such strategies is also higher than that of trading the underlying stock.

Professional options traders consider these investment actions merely trading the underlying security and do not call them options trading. Trading options is trading volatility. We have touched the volatility issue in the last chapter. A simple diagram can reinforce our understanding of option volatility.

Trading Options is Trading Volatility
The above graphs illustrate the volatility profile of Stocks A and B. (For simplicity reason, we assume a normal distribution for stock prices here rather than a more realistic lognormal distribution). Which option has a higher value? The answer is Stock A. This is because it has higher uncertainty or volatility. During a specific period of time, say one year, the price of Stock A has more potential to reach $150, as compared to Stock B which has a limited potential to reach $150, based on historical data. Holding an option is different from holding a stock, because there is no down-side risk. Therefore, the option (either call or put) of stock A is worth more.

Volatility measures one standard deviation of the stock price distribution within a specific time period. A 20 percent volatility means that the security price will (about 68% probability) be traded plus/minus 20 percent of the current price within one year. In other words, Stock A has a volatility of 50 percent and Stock B has a volatility of 20 percent. (This is explained in a simplified manner. In order to calculate the future price distribution, we have to know the expected return of the stock. In reality, stock prices are not normally distributed.)

**How can an option trader make money by trading volatility?**

A professional option trader buys (or writes) an option contract when he thinks that the implied volatility will increase (decrease) before the option expires. He is said to hold a long (short, if he writes) position on the volatility of the option. This is analogous to an equity trader who buys a stock when he thinks that the stock is under-priced and the price of the

_Trading Options is Trading Volatility_
stock will go up in the near future. But before an option trader can make money in option trading, there is one condition - he has to maintain a fully hedged or delta neutral position. If he does not keep a fully hedged position, he is trading the underlying, at least some part of it.

Assume that an option trader sells 100 one-year at-the-money put options of Stock A and does not want to take any risk of the underlying. He can fully hedge his position under the following scenarios:

1. The option writer can immediately buy an option contract with exactly the same terms of the option contract he just sold. He can still make money by earning a spread. For example, he sells the option contract to the option buyer for a 5.50 percent premium and buys back a mirror contract for 5 percent. He will earn the 0.5 percent spread.

   Or he can do one of the followings:

2. If he knows for sure in one year the price of Stock A will be higher than the strike price of $100, he will do nothing, because he knows that the option holder will not exercise the option.

3. If he knows for sure in one year the price of Stock A will be lower than the strike price of $100, the option holder will exercise his right to sell 100 shares of Stock A to him at $100. In order to fully hedge his position, the option writer will sell 100 shares of Stock A at $100 now to fully hedge this position.

Since at this moment he has no way to know what the price of Stock A will be in one year, he has to use a little mathematics to determine how much he should hedge. For at-the-money options (assuming that the stock has zero growth rate for simplicity reason), there is a 50 percent chance that the stock price will be lower than the strike price. Therefore, he fully hedges his position by selling 50 shares of Stock A. Or we can say that there is a 50 percent probability that the option writer will have to buy 100 shares of the underlying stock at $100 if the option holder exercises his option. Therefore, the option writer has to sell 50 shares of the stock in order to be fully hedged.
From the last chapter, you know that the 50 percent or 0.5 is the option's delta. We also know that delta is the hedge ratio. In order to fully hedge an at-the-money call (put) option written, an option writer needs to purchase (sell) a certain number of shares as determined by delta multiplied by the number of shares under the contract.

But what if the price of Stock A drops to $90, or increases to $110?

When the stock price of A drops from $100 to $90, the put option is in-the-money and the probability of the option being exercised is higher than 50 percent. Assume that the delta is now 0.7. The option writer has to hedge 70 percent of his position by selling 70 shares of Stock A. Since he has already sold 50, he has to sell 20 more.

When the stock price of A increases from $100 to $110, the put option is out-of-the-money and the probability of the option being exercised is less than 50 percent, say at 30 percent, or the delta is now 0.3. At this time, the option writer has to buy back 20 shares of Stock A in order to remain delta neutral. (He should sell 30 shares but he has already sold 50.)
If the stock price of A continues to increase to $120, and assuming that the delta is now 0.15, the option writer should buy back 15 more shares in order to remain delta neutral. This is the so-called delta-neutral hedge.

Since stock price does not usually jump from $100 to $110, how often should the option writer hedge his position? Should he hedge every time when delta changes?

In theory, if the option writer remains perfectly hedged at all times and the actual option volatility is the same as implied volatility, the aggregate hedging cost equals approximately the amount of the option premium of the mirror option (here we refer to the option premium in the professional market), assuming there is no transaction cost. This leaves the option writer with a 0.5 percent profit for this transaction in our example. He will surely ask himself, "why do I have to go through all the troubles to hedge? I'd better just buy a mirror option and earn the 0.5 percent spread." The key for this strategy to make more money depends on the option trader's professional judgement on the volatility. If the volatility indeed decreases from 50 percent to 20 percent after six months as the option trader expected, he can buy a mirror option with a premium lower than that he has collected. (Here we focus only on the volatility factor for easy explanation. In reality, the option trader has to consider other factors, such as the change of the intrinsic value of the option, etc.) Now he has accomplished all the things he is supposed to do: (1) he remains delta neutral at all times (or at least most of the time) during this period; (2) he has squared off his option positions; and (3) he has made a profit - the difference between the amount of premium he collects and that he pays, plus the 0.5 percent spread.
Besides that, option traders are normally given a certain degree of freedom for not maintaining a perfectly hedged position. Every time an option trader decides not to have a perfectly hedged position, he is running an open position. Management usually controls option traders' freedom by imposing option trading limits, such as delta and gamma limits. They are usually expressed in dollar amount. An option trader can make his professional judgements by holding long or short positions, or by over-hedging or under-hedging the positions he holds, as long as he acts within his limits.

How much freedom an option trader should be given is a management decision. It is determined by a lot of things, such as the institution's risk tolerance level, market outlook, product nature and characteristics, trader's expertise and past performance, existing trading systems, projected revenue, risk management and internal control systems, etc.

The basic mechanism of trading options has been discussed above. It is obvious that for prudent risk control, management should stipulate the options trading strategies and establish options trading limits. In the policy statement, management should clearly answer the following questions: what are the purposes of trading options? Is it mainly a customer-driven business or mainly a proprietary trading business? What is the planned revenue allocation between customer business and proprietary trading business? Should traders be allowed to buy options simply to participate in the stock market? How much freedom should traders have when using the delta-neutral strategy? What are the delta limits? What are the gross position limits for both the options and the underlying assets? All these should be documented in the institution's options trading policy and limits structure. Without them, it is very questionable how management can adequately manage, control and monitor the institution's options trading activities.
In the previous two chapters, we discussed option's delta and volatility (vega) and their application in options trading. In this chapter, we will talk about another feature of option - gamma, also a Greek alphabet.

The gamma of a portfolio of options on an underlying asset is the rate of change of the portfolio's delta with respect to the price of the underlying asset. In other words, gamma is the second derivative with respect to the underlying.

For a small change in the underlying, say from \( Y \) to \( Y_1 \), the option price changes from \( X \) to \( X_i \). In this case, delta does a relatively good job because the curvature of \( OO' \) is small in this price range. However, for a larger change in the underlying, the curvature of the \( OO' \) line becomes larger. Using delta alone will create a hedging error as the graph indicates. The magnitude of the error depends on the curvature of \( OO' \). Gamma measures...
this curvature. If gamma is large in absolute terms (more curvature), delta
is highly sensitive to the price change of the underlying.

The relation of delta and gamma is similar to that of duration and convexity.
If you go back to Chapter 7, you will find that the above graph and the
graph in that chapter illustrate the same point: the curvature of the actual
price line makes duration and delta an inaccurate measurement tool, and
convexity and gamma can correct this inaccuracy.

In Chapter 9, we say that a call option with a delta of 0.5 means that when
the price of the underlying increases by $1, the price of the option increases
by approximately $0.5. Now, adding the gamma element into the picture, if
the price of the underlying increases by $1, the price of the option with a
delta of 0.5 and a gamma of 0.1 will increase by approximately $0.6 instead
of $0.5.

Option traders usually express gamma in the change of delta per one point
change in the underlying. Also, traders express a delta of 1.00 as 100 deltas
and a change of 0.1 delta a change of 10 deltas. For example, if a trader holds
10 option contracts with a delta of 0.1, he is said to be holding a position of
100 deltas.

You will quickly realise how important gamma is to a trader's hedge position.
A trader has to increase his hedges in order to stay within his trading limit,
if he has a position with a delta of 0.45 and a gamma of 0.45. Assume he
has 10 such contracts and a risk limit equivalent to the amount of 500
deltas, he may appear within his risk limit (450 deltas) if considering only
the delta. However, he is in a danger zone of exceeding his limit if the
market moves. If the underlying moves by one point, he will exceed his risk
limit by 400 deltas because he will have a 900 delta position (10 contracts
x (45 + 45) = 900). Thus, it is very important to set a gamma limit.

The profile of gamma changes against the underlying depend very much on
the time remaining until expiration of the option. This means that when an

The Gamma of an Option
at-the-money option approaches its expiration closer and closer, its gamma becomes bigger and bigger for every unit change of the underlying.

An article written by John Braddock and Benjamin Krause has an excellent description about the relation between gamma and the option’s remaining time to expiration:

Suppose there is a basketball game. Team A and Team B are of equal strength. At the time when the game starts, the score is 0 and 0 and both team’s chance of winning the game is 50 percent. This is analogous to purchasing an at-the-money call option with a delta of 0.5.

During the game, there are times when Team A is in front by a few points and it has a higher probability of winning the game. This is equivalent to the price of the underlying stock goes up and so does the delta of the call option.

How much should the delta go up? This is the same question as the one we will ask regarding how big a chance it is for Team A to win the game at this time when it is leading by a few points.

It all depends on how much time remains in the game if both teams are still of (approximately) equal strength. If Team A is leading by 3 points at half-time, its winning chance is surely higher than 50 percent, but probably not by much, say, 55 percent. However, if Team A is leading by 3 points with only 30 seconds left in the game, its chance of winning is probably very high, say, 95 percent. Although the margin of the lead for Team A is the same, the chance of winning is different.

It is the same for options. Assume that for an at-the-money option with three months to the expiration date, the delta is 0.5 and the gamma is 0.02. After one day, the price of the underlying changes by one point. At this time, the delta may change from 0.50 to 0.52 - a relatively small change because there is plenty of time for the price of the underlying to go either
way. However, if the time is now one day before the expiration date, and the price of the underlying changes from at-the-money to one point in-the-money, the delta of the option may change from 0.50 to 0.95 because it surely looks good for the option to be in-the-money before it expires. Gamma estimates the rate of change.

For options which are far in-the-money (or far out-of-the-money), gamma probably does not matter much because the delta is already close to 1 (or close to zero for far out-of-the-money options). Just like a basketball game, if one team is leading by 30 points at the half, its chance of winning is very high. Whether it gains a couple of points or loses a couple of points in the second half shall not affect the result very much.
CHAPTER 12
MORTGAGE-BACKED SECURITIES

Mortgage-backed securities (MBS) are securities backed by mortgages. MBS can be privately issued or issued by quasi-government agencies. The most liquid and active MBS market is in the US, where there are over US$1.2 trillion worth of MBS outstanding (in 1992), and over US$300 billion of new MBS and mortgage loan pools issued each year.

MORTGAGE PASS-THROUGH SECURITIES

The traditional MBS are “mortgage pass-through” securities in which the lender bank pools mortgage loans with similar characteristics together, collects principal and interest payments every month, and passes through the principal and interest payments less the servicing and other fees to investors. Investors receive pro rata shares of the resultant cash flows.

Suppose an investor buys a pass-through MBS at par, backed by a pool of mortgage loans all with 10 percent interest rate fixed for 30 years. (30-year fixed rate mortgages are very common in the US.) Assume that interest rates drop by two percent after the purchase. A common misconception is that the market value of the MBS would go up just like other bonds. This is not the case for MBS. When rates drop, borrowers tend to refinance their mortgages. Instead of paying 10 percent mortgages fixed for 30 years, they can now refinance their loans at 8 percent. This is pretty bad for the MBS investor. Instead of seeing his investment goes up in value because of the rate drop, he gets his investment paid off at par. In addition, he has to reinvest his money at lower rates now. This is the “prepayment risk” of MBS.

On the other hand, if interest rates go up from 10 percent to 12 percent, borrowers would not rush to refinance their mortgages because they can enjoy paying lower rates (10 percent versus the market rate of 12 percent).
for the remaining life of their mortgages. The investor, who was expecting to get some of his money back (the regular amortisations, and normal prepayments based on an assumed prepayment speed) to invest at a higher rate, is not getting back as much as he expected. And the original investment horizon becomes longer now. This is the "extension risk" of MBS.

**Prepayment Characteristics of MBS**

The most important characteristic of MBS is prepayment. Prepayment is when borrowers prepay their mortgages before the maturity date. Although interest rate is the most important factor that influences prepayment pattern, prepayment always exists no matter how interest rates and other economic factors change. People tend to prepay their mortgages for various reasons: moving up to a bigger and better house, or relocating to a different location, etc. In California, statistics show that people tend to move every 5 to 7 years. For the whole nation, the average life is 7 years for 15-year mortgage loans and 12 years for 30-year loans. Therefore, when an investor invests in a 10 percent coupon MBS backed by a pool of 30-year loans, his investment horizon is not 30 years but more or less 12 years under a normal situation.

The prepayment characteristic is so important that when a collateral mortgage obligation (CMO), a more complex form of MBS, is priced, the average life and the yield of the bond are quoted based on an assumed prepayment speed. There are two common methods for measuring prepayment speed: Conditional Prepayment Rate (CPR) method and Public Securities Association (PSA) method. CPR represents the annualised percentage of the outstanding balance that is prepaid during the period. For example, 6 percent CPR means that 6 percent of the outstanding balance, net of scheduled amortisations, will be prepaid each year. PSA, on the other hand, assumes that unseasoned loans tend to be prepaid at slower rates. The base PSA (100 percent PSA) assumes that prepayments rise linearly from 0.2 percent CPR to 6 percent CPR over 30 months from the origination of the mortgage, and then remain constant at 6 percent CPR. A 150 PSA means that prepayment speed will rise to 9 percent (1.50 x 6 percent) over 30 months and then remain at 9 percent.
NEGATIVE CONVEXITY

For MBS, there is something called negative convexity. In short, it says that when rates continue to drop, the value of the security decreases rather than increases.

For most non-callable securities, such as treasury bonds, the price-to-yield curve is convex with respect to the X axis (the following price-to-yield graphs are adapted from “The Evolution of Mortgage-backed Securities” by Jess Lederman):

![Price-to-Yield Graph](attachment:image.png)

This means that as the yield decreases (moving from right to left in the above graph), price increases at a faster and faster rate, and as the yield increases, price decreases at a slower and slower rate. The price-yield curve is different for MBS. For MBS, there are two components. The first component is just like other non-callable bonds. The second component is actually an option transaction - the issuer of the security writes a prepayment option to the loan borrowers, and passes through the premium to the investor. This is one of the reasons that pass-through MBS are usually priced at more than 100 basis points over treasuries. During the life of the mortgage, a borrower can put the mortgage back to the lender at an advantageous situation to him, such as when the market mortgage rates are two percent lower than his existing mortgage rate.
When the market mortgage rates are higher than the existing mortgage rates in the loan pool, the value of the borrower's prepayment option is not worth much (the right-hand side of the graph). Borrowers are unlikely to refinance their mortgages (or to exercise their options and put the mortgages back to the lender). But if rates (and hence the yield) continue to drop (moving from right to left in the above graph), the prepayment option is changing from out-of-the-money to in-the-money. This is because when the market mortgage rates are lower than the mortgage rates in the loan pool (by approximately 2 percent depending on the cost of refinance), there is an advantage for the borrowers to refinance their mortgages. The value of the prepayment option increases. The value of the MBS is the combination of these two values - the long position (positive value) of the non-callable bond minus the short position (negative value) of the prepayment option. Therefore, it is difficult to predict the cash flows of a simple pass-through MBS.
**Multi-class MBS**

In 1983, Freddie Mac introduced multi-class collateralised mortgage obligations (CMO). A CMO usually has several classes (or tranches). It divides mortgages into a series of sequentially paying bonds with several different maturities. For instance, a $100 million CMO can be divided into many classes, four as in this example:

<table>
<thead>
<tr>
<th>Class</th>
<th>Principal</th>
<th>Expected Average Life</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class A</td>
<td>$30 million</td>
<td>2 years</td>
</tr>
<tr>
<td>Class B</td>
<td>$40 million</td>
<td>5 years</td>
</tr>
<tr>
<td>Class C</td>
<td>$25 million</td>
<td>7 years</td>
</tr>
<tr>
<td>Class D (residual class)</td>
<td>$5 million</td>
<td>20 years</td>
</tr>
</tbody>
</table>

Class A is entitled to the first 30 percent of the principal repayment of the collateral. It means that the first $30 million principal repayment (including the scheduled amortisations and all prepayments) received on the pool will go to Class A investors. All other classes will receive interest only. After Class A is paid off, Class B starts to receive the principal repayment, and so on.

Class A has most of the prepayment risk and not much extension risk. On the other hand, Classes C and D have most of the extension risk but not much prepayment risk. This helps to solve, to a great extent, the unpredictable cash flow problem of pass-through MBS. Investors can target certain specific maturities. This inevitably broadens the investor base. Additionally, unlike single-class MBS which are priced at a spread of, say 125 basis points over 10-year treasury, multi-class MBS can be priced at different treasury maturities. These two factors indeed tighten MBS to treasury spreads.

The above example is just the simplest form of multi-class MBS. Others are quite complex and innovative. Some of the recent developments in MBS become more mathematical and probably steer the products out of the...
normal financial path. For example, for a multi-class MBS with total tranches of 250, it is impossible to analyse the cash flows of these tranches using fundamental financial principles. Everything was done mathematically. There are also the "kitchen-sink securities". They are those latest tranches of MBS where even the issuer cannot figure out their cash flow patterns because there are too many uncertainties. They are grouped together and sold at a deep discount to speculative investors. The value of these securities is everybody's guess. With no surprise, most of the "kitchen-sink securities" investors lost big in 1994 when interest rates were rising.
CHAPTER 13
HEDGING WITH DERIVATIVES

What is a hedge? According to the Webster's Dictionary, a hedge is (1) a fence or boundary formed by a dense row of shrubs or low trees; or (2) a means of protection or defence as against financial loss. Hedging can reduce risk, but it seldom eliminates risk except that the hedging instrument is exactly the same as the instrument being hedged. Perfect hedges are rare, as a trader put it, they can only be found in Japanese gardens.

For example, a financial institution has just made a 5-year $50 million loan to one of its best borrowers. The interest rate on the loan is fixed at 7.0 percent. The Chief Executive is quite concerned about the interest rate risk of this transaction. He did not want to make this deal because of the interest rate risk. But he was afraid that he might lose this customer. He asked the Treasurer to fully hedge the interest rate risk. The Treasurer in turn gave the assignment to a financial analyst.

There are many ways to hedge this transaction, the young financial analyst thinks. The simplest way is to enter into a 5-year interest rate swap exchanging the fixed rate payments of the loan to floating rate. After examining the market swap rates, he finds that there is one problem: based on the current implied forward curve, the bank will pay the counterparty 6.0 percent for five years and receive floating payments based on a 3-month LIBOR rate adjusted quarterly. The current 3-month LIBOR rate is 5.0 percent. What this means is that at least for the first three months, the bank will have a negative net interest income on the swap - paying 6.0 percent and receiving 5.0 percent. He knows that the bank is under tremendous pressure to improve its earning growth. A negative net interest income on this swap certainly will not help.
The alternative is to buy an interest rate cap. But the premium for a long-term cap is very expensive. In addition, 5-year caps are not that liquid.

Another alternative, which the financial analyst thinks is the best, is to enter into a pay-floating-receive-fixed swap. We call this a reverse swap, because it reverses a regular pay-fixed-receive-floating swap that is normally used for the purpose of reducing interest rate risk. In this case, the bank will enter into a swap to pay floating rates, currently at 5.0 percent adjusted quarterly based on 3-month LIBOR rates, and receive a fixed rate of 6.0 percent. The beauty of this transaction is that the bank will have a positive net interest income at least for the first three months. As long as 3-month LIBOR rates do not go up by more than one percent, which he does not think it will, the positive net interest income will last for the duration of the transaction. Even if 3-month LIBOR rates rise higher than 6.0 percent, the bank has already put some money in the pocket during the early part of the transaction, and hopefully it will be enough to cover the future shortfall. So he checks the counterparty’s credit rating and enters into a $50 million reverse swap.

The young financial analyst reports the transaction to the Treasurer. The Treasurer happens to be very busy at that moment because the Dollar has just hit a 6-month high against the Yen, and the institution happens to have a large open position in US dollar. He does not have time to review the details of this swap transaction. On the other hand, it is a simple transaction. So he asks the financial analyst to inform the accounting department of the entire transaction and he himself reports to the Chief Executive that the entire loan exposure is hedged and everything is all right. Both are happy because the institution has just earned a handsome profit in the currency market, and the interest rate risk on the $50 million loan has been fully hedged.

The above example is a real case with a slight modification. It happened at a large problem bank in California several years ago. The bank put a $300 million pay-floating-receive-fixed swap on its book. At that time the yield curve was upward sloping, and this swap would increase the institution’s interest rate exposure if interest rates rise. The bank’s policy allowed
management to enter into swap and other derivative transactions only for the purposes of hedging or reducing the bank’s interest rate exposure. Just like other messy transactions, there were no documented analysis and record on this swap transaction. Management admitted that it was a mistake, and told the examiners that the analyst was no longer working for the bank and nobody knew the reasoning behind that transaction.

What happened to this transaction was amazing. In the early 90’s, the US short-term interest rates continued to drop. This reverse swap actually made a lot of money for the bank.

So the young analyst won his bet. But the question is - was it a hedge? The answer is no. This was a bet on interest rates. Management probably knew and endorsed the transaction, but was afraid that the regulators might criticise the institution of betting on interest rates. Therefore, no documented analysis was retained. This happened quite often during the banking crisis in the US several years ago because of the federal deposit insurance system – if the bet was right, the institution would be saved and management would be rewarded handsomely; if the bet was wrong, the government would have to pay for the damages.

Hedging is a complicated issue. To hedge a position can reduce risk, but it also implies foregoing of business opportunity and potential profit. For example, a back-to-back transaction can reduce your price risk to a minimum level. However, it also means that the institution will not be able to enjoy any gain. (Even a back-to-back transaction cannot eliminate risk entirely because it introduces additional credit risk and liquidity risk.)

How much risk a bank is willing to take depends on the institution’s capital level, business strategy, expertise, sophistication of systems, etc. In our example, if the institution leaves this $50 million loan totally unhedged, there may not be too much problem if the institution has a strong capital position which can tolerate this kind of risk, provided that proper analysis has been performed and documented.

Hedging with Derivatives
In reviewing a hedge transaction, examiners usually look at the entire process, the oversight by management, the analysis and the documentation. To hedge or not to hedge is a management decision. It should be part of the institution's entire asset/liability management process. It should be properly analysed and documented. In addition, the analysis should be reviewed and approved by management, and even by the board if the transaction is considered significant to the institution.

The current rules governing the accounting treatment for derivatives are quite weak. They do not adequately cover some of the most basic types of derivative products. Accounting for end-user hedging activities is the most problematic derivatives accounting issue. Accounting rules for these activities are incomplete and could easily be mis-applied. This situation exists in Hong Kong, the US and the UK.

Traditional accounting standards only cover certain derivatives instruments. For example, in the US, SFAS 52 covers foreign currency transactions, and SFAS 80 covers futures contracts. These accounting standards may not cover other derivatives transactions such as swaps, options, structured notes.

The traditional practice in hedge accounting is to treat a transaction as a hedge if it meets the following general criteria:

1. **The item to be hedged exposed the enterprise to price (or interest rate) risk.** In our example, there definitely is an interest rate risk. If interest rates rise, the institution will suffer a loss on this loan. Therefore, this criterion is met. To fulfil this requirement, certain analytical work must be performed and documented by management.

2. **The item being hedged and the hedging instrument are specifically identified by management and the relationship between them is designated as hedge.** This criterion is also met in our example. Again, proper documentation is required.

3. **The hedging instrument is expected to reduce such exposure effectively and continue to do so throughout the life of the**
transaction. For this criterion to be met, at the inception of the hedge and throughout the hedge period, high correlation of changes in (a) the market value of the hedging instrument and (b) the fair value of, or interest income or expense associated with, the hedged item shall be probable so that the result of the hedging instrument will substantially offset the effects of price and interest rate changes on the exposed item. However, the accounting standard falls short of saying what “high correlation” is. The “hedge” in our example does not meet this criterion because when interest rates rise, the values of both the hedging instrument and the instrument being hedged decrease.

For a transaction qualified as a hedge, the recognition of a change in the hedging instrument’s market value is not required until the reporting period in which the change in market value of the hedged item is ultimately recognised. This accounting treatment allows the delay of recognition of profits and losses for instruments designated as hedge, and opens the door for abuses by companies which want to hide their derivatives losses. Because the traditional accounting standards are incomplete, it is difficult to police abuses. On the other hand, it is not that difficult to find some correlation between two items in a multi-billion dollar assets and liabilities portfolios and call them a hedge, even though the so called “hedge” may not make any sense to the institution’s existing asset/liability structure.

Several international accounting bodies, including the Hong Kong Society of Accountants, are currently addressing this issue. Until the new standards become effective, policing accounting abuses in derivatives transactions remains a difficult job.
CHAPTER 14
CREDIT DERIVATIVES

One of the most popular topics in the derivatives and risk management circle these days is credit derivatives. This latest financial innovation may have tremendous impact on how banks and financial institutions operate in the future.

The most important characteristic of derivatives is its ability of "bundling" or "unbundling" risk and return. For example, buying an index futures contract means participating in the ups or downs of all the underlying stocks in the index. On the other hand, a pool of mortgage loans can be "unbundled" into several different tranches of mortgage-backed securities or collateral mortgage obligations (CMO) and sold to different types of investors who have different risk and return requirements. Credit derivatives are under the concept of "unbundling".

The return on any financial instrument depends on the risk level of the financial instrument. Many financial instruments have more than one type of risk. For example, a corporate bond has its credit, interest rate and liquidity risk components, and may even have additional tax and legal risk components. An investor may find that a particular corporate bond is suitable for his risk/return requirement except for the credit risk. In the past, he might just forget about buying that bond because there was no way for him to get rid of the credit risk component of this investment. With credit derivatives, he can now buy this bond and "unbundle" away the specific credit risk of the subject company.

There are three common forms of credit derivatives, namely, credit default swap, credit linked note and total return swap.

Credit Derivatives
Credit Default Swap

The simplest form of credit derivatives is credit default swap (or default option) in which Bank A (the protection seeker) pays a fee (usually in basis points) to Bank B (the protection provider) to protect the financial loss arising from the default or other credit event of the Company X bond (the reference asset). Bank B is usually a much stronger company than Company X, otherwise it makes no sense for Bank A to seek protection from Bank B.

<table>
<thead>
<tr>
<th>Bank A</th>
<th>Fee in bps per quarter</th>
<th>Bank B</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Protection Seeker)</td>
<td></td>
<td>(Protection Provider)</td>
</tr>
<tr>
<td>Company X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bond</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Under the terms of the contract, if a defined credit event or default occurs during the term of the contract, Bank B will pay Bank A the notional of the contract less any recovery value of the reference asset (usually 90 days after the defined event).

This arrangement is like an insurance policy, a guarantee or a letter of credit. But the key point is that the credit risk of this bond has been "unbundled" away from the bond. For example, under the credit default option contract, Bank A pays Bank B 12 basis points on a $10 million notional per quarter for five years. If a credit event occurs during the period, and the market price of the reference asset is 75 three months after the event, Bank A will get $2.5 million (the face value of $10 million minus the recovery value of $7.5 million) from Bank B.

Credit Linked Note

Bank A can also sell something called "credit linked note" to protect the loss arising from the default or credit event of the Company X bond. In the arrangement of a credit linked note, Bank A issues a note linked to the subject bond (the reference asset), and the note pays a specified fixed or
floating interest rate just like other notes. Bank B buys the note at par. If no default or defined credit event occurs during the term of the note, the note will mature at par. However, if a defined credit event occurs, the note will be redeemed for the recovery value of the reference asset (usually 90 days after the credit event). For example, Bank B purchased a $10 million credit linked note from Bank A and Company X's credit rating declined from BBB to BB during the term of the note and this rating decline is defined as a credit event. The subject bond's market value is $65 three months after the rating decline. The note will be redeemed for the recovery value of $6.5 million. Therefore, Bank A's gain of $3.5 million from the credit linked note transaction will offset the loss of $3.5 million due to its holding of a $10 million Company X bond.

### Total Return Swap

In a total return swap arrangement, Bank A (the protection seeker) agrees to pay Bank B (the protection provider) all contractual payments plus any appreciation in market value of the subject bond (the total return on the reference asset), and Bank B agrees to pay Bank A LIBOR plus specified basis points, say z bps, as well as any depreciation in market value of the reference asset during the term of the swap.
APPLICATION OF CREDIT DERIVATIVES

You may ask why Bank A wants to enter into these credit derivatives arrangements such as total return swap. It can simply invest in the inter-bank market or other markets to obtain the same return of LIBOR plus z basis points which Bank B would pay.

This analysis may be correct from a pure yield or return point of view. But banks have other things to consider. Bank A is concerned that Company X's credit standing may deteriorate in the long run, but it still wants to keep a good relationship with Company X. Therefore, it continues to supply Company X's financing needs. Credit derivatives allow Bank A to continue to have a good relationship with Company X without taking on the credit risk it does not want to take. (Bank A does not have to tell Company X that it has purchased a credit default option or sold a credit linked note relating to Company X.)

Another common application of credit derivatives is to reduce credit concentration on certain counterparties. For example, Bank A may want to reduce its exposure to Company X for certain loans or lines of credit which have already been on Bank A's book by entering into a credit derivative contract with a third party.

One important characteristic of credit derivatives is that Bank A, the protection seeker in the above examples, does not necessarily have to hold the bond of Company X (the reference asset) in order for it to participate in these arrangements. In fact, Bank A does not even have to have any relationship with Company X. Bank A simply speculates that an adverse credit event will occur to Company X and trades credit derivatives using the bond of Company X as a reference asset. Credit derivatives represent a new class of investment for professional investors.

REGULATORY IMPLICATION

Regulators need to ensure that banks have proper risk management tools which include expertise, systems and controls in place for their credit...
derivatives operations. Similar to other financial derivatives, banks need to manage related market risk, credit risk, liquidity risk, operational risk, legal risk and regulatory risk of credit derivatives.

On the other hand, credit derivatives bring up a new topic for regulators relating to the capital adequacy requirement regime. For credit default swaps, the protection seeker to a large extent reduces the original credit exposure. However, in the process, it acquires a new counterparty risk - the credit risk of the protection provider. How this improved credit exposure situation should be treated in terms of capital adequacy ratio (CAR) is a sensitive issue for regulators. For credit linked notes and total return swaps, banks get rid of some of the original credit risk but also acquire new price risk and counterparty risk. These are also CAR-related issues regulators have to deal with.

**POTENTIAL IMPACT OF CREDIT DERIVATIVES TO THE BANKING INDUSTRY**

To banks, credit derivatives are not just another financial innovation. They may alter the traditional way banks and financial institutions conduct their banking businesses. As we all know, at least two thirds (some even say 90 percent) of risks in banking activities relate to credit, and credit risk is extremely difficult to quantify and manage. Credit derivatives provide bankers with a genuine tool to deal with credit issues. For example, a bank can reduce its property exposure using credit derivatives if management thinks that the property exposure of the bank is too high.

Credit derivatives are in a way like mortgage banking business in the US where mortgage originators package pools of mortgage loans, unbundle them into pieces, and sell them to different types of investors in the secondary market. Mortgage originators collect the origination fees, keep the servicing right of these loans and earn a servicing spread. Similarly, credit derivatives unbundle the credit risk from a financial instrument. They give banks more options to diversify their portfolios, alter their asset/liability management strategies, maneuver their regulatory capital structures, etc. The mortgage banking business was an innovation in the 80s and later became an industry

*Credit Derivatives*
in the US. Equally innovative, credit derivatives are poised for further growth. Several years down the road, it will not be surprising to see a bank selling some or even most of its credit exposures in its asset portfolio and managing mainly the price risk component of these assets. It probably makes sense for some banks to adopt this strategy because it is easier to manage price risk than credit risk. Although this strategy reduces the yield of these assets, it can increase the volume of lending activities to compensate for the yield reduction. This is because this strategy may free up some of the bank's regulatory capital relating to credit risk.
In the very first chapter of this book, we touched on the concept of value at risk.

Several years ago, the concept of value at risk was still relatively new. Since then, it has gained a lot of publicity on both the market and the regulatory fronts.

From the participants’ point of view, value at risk is an extremely useful tool for measuring market risk. It summarises the market risk exposure of all financial instruments in a bank’s trading portfolio into a single number. Nowadays, if a dealer bank is not using value at risk or other similar methodologies to measure market risk for its trading activities, it will be perceived to be lagging behind the best practice standard.

The regulators also consider value at risk a useful tool in measuring market risk. The Basle Committee has issued an amendment to the 1988 Capital Accord to incorporate market risk in which value at risk is an acceptable and preferred method for determining the required capital level for a bank’s trading risk.

In the first chapter, we defined value at risk as “the expected loss from an adverse market movement with a specified probability over a period of time”. We also made a simple illustration to demonstrate the concept of value at risk. Although the concept of value at risk is quite simple and easy to understand, the implementation of value at risk is not an easy job. In this chapter, we will introduce some of the most commonly used value at risk approaches and discuss the advantages and shortcomings of using value at risk.
**The Variance-Covariance Method**

The trading portfolio of a bank usually includes more than one product and currency. It is therefore important to address the correlation factor. A commonly used method is the variance-covariance method.

Under the variance-covariance method, we need to collect the historical volatility data plus one more — the correlation between each pair of assets.

Assume that we have a two-asset portfolio this time, and some of the information about these two assets are as follows:

<table>
<thead>
<tr>
<th></th>
<th>Asset A</th>
<th>Asset B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current market price per unit</td>
<td>$50</td>
<td>$100</td>
</tr>
<tr>
<td>Number of units held</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Total market value</td>
<td>$5,000</td>
<td>$10,000</td>
</tr>
<tr>
<td>Historical volatility</td>
<td>1.0% (one day)</td>
<td>2.0% (one day)</td>
</tr>
</tbody>
</table>

Assume that we are calculating the market risk capital charge for these two assets using Basle Committee's Quantitative criteria — 99% confidence level (or 2.33 standard deviations for one day) and a 10-day holding period.

Value at risk of A = $5,000 \times 2.33 \times 1.0\% \times \sqrt{10} = $368.41

Value at risk of B = $10,000 \times 2.33 \times 2.0\% \times \sqrt{10} = $1,473.62

The number 2.33 is the number of standard deviation which corresponds with 99% confidence level. The number \( \sqrt{10} \) is the multiplication factor of the required holding period which is 10 days in this case. If the holding period is one year, the multiplication factor is square root of 252 because there are 252 trading days in one year.

The next step is to consider the correlation between these two assets. Again, we need to collect and analyse the historical correlation between each pair of assets. In order to make this analysis meaningful, we need a lot of observations - at least one year's data as required by the Basle Committee. And we need to use the familiar correlation formula:
Risk \( A + B = \sqrt{R_A^2 + R_B^2 + 2CR_AR_B} \)

where \( R_A \) and \( R_B \) are the value at risk of A and B respectively, and C is the correlation between A and B.

All correlation numbers lie between -1 and 1. Within this range, there are three critical correlation numbers: 1, 0 and -1. If the prices of these two assets always move perfectly together, the correlation is 1. We can simply add the two value at risk numbers together and derive the portfolio value at risk which is 1,842.03.

If the correlation is 0 between these two assets, which means that these two assets are completely independent of each other, the portfolio value at risk is:

\[ \sqrt{368.41^2 + 1,473.62^2 + 0} = 1,518.97 \]

If the correlation is -1, which means that they offset each other, the portfolio value at risk is:

\[ \sqrt{368.41^2 + 1,473.62^2 + 2 \times (-1) \times 368.41 \times 1,473.62} = 1,105.21 \]

Or you can simply subtract $368.41 from $1,473.62.

As we can see, the concept of the variance-covariance method is quite simple. But again, the implementation is quite complicated. We need to measure each asset's volatility and the correlations between each pair of assets based on historical data. For a two-asset portfolio, it is not very difficult. But for a portfolio which has thousands of positions, this is a big job.

The above example is a simple form of variance-covariance method. Each bank would have its own version in applying this method. A commonly used variance-covariance method in the market usually involves several steps:

1. Unbundle different types of risk from each asset or position based on market factors. For example, a foreign bond would be separated into two cash-flow components - principal and interest payment; and each of these two components will be further unbundled by different market factors such as interest rate and exchange rate factors. Therefore, each

Value at Risk
“cell” would have a cash flow exposed to only one type of market factor.

2. Group the cells with the same (or similar) characteristics together.

3. Calculate the value at risk for each cell group. Some make an assumption that the distribution is normal.

4. Calculate the portfolio value at risk using the variance-covariance matrix.

**THE HISTORICAL SIMULATION METHOD**

The historical simulation method is based on the assumption that history will repeat itself.

Assume that we have a portfolio of two assets and their current market values are $70 and $30 respectively. Next, we need to “re-value” these assets and come up with some “alternative values” based on their historical price movements. Assume further that we need 100 sets of these alternative values (some people call them observation points) to make the result meaningful.

We observe the market prices of these two assets for the past 100 trading days. Based on these observation points, we can establish a list of alternative values, denoted as $V_n$ and $W_n$, as follows:

<table>
<thead>
<tr>
<th>Observed market values $V_n$ and $W_n$ where $n = 0, \ldots, 100$</th>
<th>Observed portfolio value $P_n$ where $n = 0, \ldots, 100$</th>
<th>$\Delta$ in observed market value $\Delta P_n = P_n - P_{n-1}$ where $n = 0, \ldots, 100$</th>
<th>Alternative value $AV = P_n + \Delta P$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_0 = 70, W_0 = 30$</td>
<td>$P_0 = 100$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$V_1 = 68, W_1 = 22$</td>
<td>$P_1 = 90$</td>
<td>$\Delta P_1 = -10$</td>
<td>$90$</td>
</tr>
<tr>
<td>$V_2 = 70, W_2 = 25$</td>
<td>$P_2 = 95$</td>
<td>$\Delta P_2 = +5$</td>
<td>$105$</td>
</tr>
<tr>
<td>$V_3 = 73, W_3 = 27$</td>
<td>$P_3 = 100$</td>
<td>$\Delta P_3 = +5$</td>
<td>$105$</td>
</tr>
<tr>
<td>$V_4 = 71, W_4 = 30$</td>
<td>$P_4 = 101$</td>
<td>$\Delta P_4 = +1$</td>
<td>$101$</td>
</tr>
<tr>
<td>etc.</td>
<td>etc.</td>
<td>etc.</td>
<td>etc.</td>
</tr>
<tr>
<td>$V_{99} = 66, W_{99} = 25$</td>
<td>$P_{99} = 93$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$V_{100} = 67, W_{100} = 30$</td>
<td>$P_{100} = 97$</td>
<td>$\Delta P_{100} = +4$</td>
<td>$104$</td>
</tr>
</tbody>
</table>

*Value at Risk*
Assume that the portfolio’s average rate of return and standard deviation are 0% and 5% respectively, and the 100 alternative values are distributed normally as follows:

The distribution indicates that a lot of the alternative values (approximately 68 percent of them) fall in the range between 95 and 105. If we expand the range a little wider; say between 90 and 110, there are approximately 95 percent of the alternative prices falling in this range. If we expand this range wider again between 85 and 115, it covers almost all the alternative prices, 99.7 percent of them.

For value at risk, we are only concerned with the adverse price movement, or the “bad” side of the price range. Therefore, in our example and assuming normal distribution, the one-day one-standard deviation value at risk is $5, one-day two-standard deviation value at risk is $10, and one-day three-standard deviation value at risk is $15. These one-tailed probability numbers correspond to 84%, 97.7% and 99.86% confidence levels respectively.

With the historical simulation approach, the assumption of normal distribution can in fact be relaxed. The 100 sets of daily change in the portfolio value, \( \Delta P_n \), can be ranked from the day with the worst performance to the day with the best performance.

Value at Risk
Daily profit and loss ranked in ascending order:

<table>
<thead>
<tr>
<th>Rank</th>
<th>Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$15</td>
</tr>
<tr>
<td>2</td>
<td>$13</td>
</tr>
<tr>
<td>3</td>
<td>$12</td>
</tr>
<tr>
<td>4</td>
<td>$9.5</td>
</tr>
<tr>
<td>5</td>
<td>$9</td>
</tr>
<tr>
<td>6</td>
<td>$8.8</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>96</td>
<td>$7</td>
</tr>
<tr>
<td>97</td>
<td>$9</td>
</tr>
<tr>
<td>98</td>
<td>$9.3</td>
</tr>
<tr>
<td>99</td>
<td>$13</td>
</tr>
<tr>
<td>100</td>
<td>$14</td>
</tr>
</tbody>
</table>

A line can then be drawn at the 95th percentile to find the value at risk with 95% confidence level, one tailed. In our example, it would be the fifth worst performance or -$9.

Another advantage of using historical simulation is that since all data is already available, there is no need to care about correlation as they are already embedded in the historical data.

The concept of this method is easy to understand but its implementation is not so easy.

In order to make the calculation meaningful, we need a significant number of observation points or historical data. The Basle Committee requires a minimum data of one year for the market risk capital charge calculation. Sophisticated market participants usually use longer period (three to five years) of historical data. Therefore, the system capacity is also an issue.

**THE MONTE CARLO METHOD**

In forecasting the future, there are two distinct approaches. Models that assume a fixed relationship between the inputs and that the inputs lead to an unambiguous result are called deterministic. Models that depend on random or uncertain inputs which provide a distribution of probable results are called stochastic. This may sound a bit abstract. Mark Kritzman gave an excellent example to explain the difference between deterministic process and stochastic process: "a model that predicts an eclipse, for example, is deterministic, because it relies on known fixed laws governing the motions of the earth, the moon and the sun. You are unlikely to hear an astronomer say that there is a 30% chance of an eclipse next Wednesday. A model that predicts tomorrow's weather, however, is stochastic, because many uncertain

Value at Risk
elements influence the weather." The observatory is sometimes blamed for

telling people that there is only a slight chance of rain but it turns out
pouring right at lunch time. The observatory may not have done a poor job.
The reason is that the uncertain elements, which the observatory cannot
forecast, dominate the result of the forecast in this case.

**MONTE CARLO SIMULATION INVOLVES A STOCHASTIC PROCESS**

The concept of Monte Carlo method is quite simple. For value at risk in
a Monte Carlo simulation, the researcher needs to obtain a series of values
from changes in market factors. These values of changes in market factors
are then added to the current market value, and thus a series of alternative
values are derived just like the historical simulation method. However, the
main difference between these two methods lies in the way of obtaining the
series of changes in the market factors.

Unlike the historical simulation method, the Monte Carlo simulation method
does not rely on past price movements in forecasting future prices. The
stochastic process says that the forecast of future prices should be expressed
in terms of probability distribution and unaffected by the price one week
ago or one month ago. In other words, a company's share price of $241
a week ago has no more meaning than the fact that its price a week ago
was $241.

Although we say that the Monte Carlo process does not rely on past price
experience to predict the future, it does require the researcher to define
certain parameters based on past experience, such as volatility and
correlations between market factors.

The Monte Carlo method requires the researcher to derive a value or
values through the use of a sequence of random paths which are selected
from each of the market factors' *normal distribution*. The condition of normal
distribution means that the width of the distribution is based on variance

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*Value at Risk*
of the market factor. Through this method, the simulation can be done
many times and the results of each of the simulation processes are unrelated
to each other. That is, they follow the independence condition.

The theoretical foundation for stochastic process is that if “we sum or
average a group of independent random variables, which themselves are not
normally distributed, the sum or average will be normally distributed if the
group is sufficiently large.”

In layman’s term, a researcher simulates many times through a random
process to obtain a series of values from changes in market factors in a
stochastic process. Although we use the term random, the process actually
goes through certain precise mathematical processes. To simplify our
discussion, we could think that the researcher simulates the behaviour of
the current market price through a random process. In this random process,
the current market price goes through many random paths independent of
each other under certain defined parameters. By the end, the researcher
obtains a distribution of values.

How many times a researcher should repeat the simulation process or how
many paths he should use depends on how accurate he wants the outcome
to be and how powerful his computer is. Researchers usually use at least
one thousand paths in a Monte Carlo simulation process.

But this is just the value at risk of one instrument in the portfolio. If there
are 10,000 instruments in the portfolio, the researcher has to repeat the
above process 10,000 times. If 1,000 paths are being used for each instrument,
the researcher has to run the simulation 10,000,000 times. Therefore, running
a Monte Carlo simulation for value at risk purpose is quite time-consuming
and is seldom run on a full portfolio basis. It is usually run on option related
instruments and on a less frequent basis for management information purpose.


Value at Risk
Some Pro's and Cons about Value at Risk

The financial world is moving towards a direction of increasingly relying on quantitative methodology to manage risk. The value at risk method is based on sound mathematical foundation. Its result can be explained by statistical theories and is more accurate than other traditional risk measurement methodologies.

The most significant benefit of using value at risk to measure a portfolio's risk exposure is that all the exposures in the portfolio can be summarised into one single meaningful number and this number is tied directly to the P/L. Value at risk expresses the risk exposure of a portfolio in terms of how frequent a specific level of potential loss will be exceeded. Management only needs to review the bank's daily value at risk number to understand the risk exposure of the portfolio.

Nevertheless, there are some shortcomings in the various approaches of the implementation of value at risk. Here are some of them:

1. The variance-covariance models assume portfolio values are normally distributed, but usually they are not. Therefore, using standard deviation to measure potential loss would likely provide an inaccurate result.

2. The variance-covariance method usually applies the delta-gamma method to calculate the value at risk for portfolios which contain options. Delta is a linear measurement and is good only for a small change in the price of the underlying (or market factors). For large changes, delta is not accurate. Ironically, measuring large changes is what value at risk attempts to do. Even with enhanced models which incorporate gamma, "since the change in slope or curvature of the option value curve is not constant for different prices of the underlying, the risk measure including gamma will again provide an inaccurate measure of market risk for larger changes in the price of the underlying." Therefore, if a portfolio has a lot of options, it is more suitable to use Monte Carlo method.


Value at Risk
3. Most value at risk models use historical correlations to measure portfolio value at risk and assume that historical correlations are stable. However, historical correlations are not stable among market factors and financial instruments, especially during stress periods.

4. All value at risk models require a very large data base. To handle the calculation, there will be a great demand on the computer system capability, especially for Monte Carlo models. Updating data also requires human resources.

5. The use of different data could also generate different value at risk results. For example, Bank A uses one year of historical data and Bank B uses five years of historical data. Even if they try to measure the same portfolio, the results will be different.

6. Most value at risk models use a one-day holding period to measure the amount of value at risk because market participants expect that financial markets are liquid enough to enable positions to be closed out in one day. This is acceptable in normal situations. But in abnormal situations, a holding period of one day may be too optimistic. In other words, many value at risk models may understate the amount of value at risk. The Basle Committee requires a holding period of 10 days for the purpose of calculating market risk capital. The most convenient way for banks to comply with the Basle requirement is to apply the rule of square root of time - the resultant amount of value at risk times the square root of 10 or 3.1623. But this also has a problem because it implies that during this 10-day holding period, the bank will do nothing to manage this portfolio of positions. In addition, multiplying the square root of time may be acceptable for linear products but it will provide a distorted result for non-linear products such as options.

7. Both the historical simulation method and variance-covariance method rely heavily on historical data to forecast future prices. As we all know, the past cannot predict the future, especially under a stress situation.
Any risk measurement methodology is just a tool for management to better measure, understand, control and manage risk exposures. It depends on how management intelligently interprets the results and puts them in proper use. Some market participants even warn that if value at risk is not used with proper stress testing, it will certainly give management a false picture about the institution's true risk exposure because the value at risk method is more suitable for measuring risk exposure in normal circumstances. Also, every risk measurement methodology has its advantages and disadvantages and value at risk is no exception. Therefore, value at risk should be used with other traditional risk measurement methodologies to provide management with a complete set of tools for measuring risk.
Chapter 16

Hang Seng Index and HIBOR Derivatives

In Chapter 5, we talked about swaps, particularly interest rate swaps, and their use in managing financial institutions' asset/liability structures and interest rate risk. In this chapter, we will discuss some simple hedging strategies using Hang Seng Index Futures and Options, and HIBOR Futures.

Assume that you are a millionaire and invest heavily in the Hong Kong stock market. You have a well-diversified portfolio (that is, your portfolio has at least 20 stocks and these stocks represent all major market sectors in Hong Kong) of $10 million. Now you are skeptical about the current price level and think that there will be a market correction in the near future. You can sell all your stocks and subsequently buy them back when the correction is over. But there is a practical issue — the cost of selling and buying the stocks, even though you pay much less commissions than most of the others because you trade shares in thousands each time. In addition, to unload a huge amount of stocks in a short period of time is also practically difficult. The alternative is to use the Hang Seng Index Futures and Options.

The Hang Seng Index (HSI)

The Hang Seng Index consists of 33 blue-chip stocks. It has four sub-indices — Finance, Utilities, Properties, and Commerce & Industry. The index was first published in 1969 (the base date). The index and sub-indices are calculated using the weighted market capitalisation method:

\[
\frac{\text{Current Total Market Value of Constituent Stocks}}{\text{Total Market Value of Constituent Stocks at Base Date}} \times 100
\]

This is similar to how the consumer price index (CPI) is calculated. But there is one important characteristic of this index. Because the index is based on a
weighted average of market value, and market value is determined by the price of the stock multiplied by the number of shares outstanding, the impact on the index of a price change in any given stock will depend on the size of that company's market capitalisation. Share companies with higher market capitalisation have greater impact on the index than those with lower market capitalisation.

**Hang Seng Index Futures**

Buying or selling HSI Futures contracts allows you to participate in the overall price movement of the Hong Kong stock market, or more specifically, the 33 stocks in the index.

The value of each HSI Futures contract is calculated by the level of the index times $50. In other words, each index point is worth $50. For example, if the current level of the futures index is at 10,000, then the contract value is $500,000.

The HSI Futures are traded in the Futures Exchange of Hong Kong for future delivery, and are settled in cash for the difference of the contracted index value and the spot index value. Delivery months are the spot (current) month, the next calendar month, and the next two calendar quarter months. Margin deposits are required for all participants (both buyers and sellers).

**Hang Seng Index Options**

The HSI Options are European options. Please see an example below:

You want to buy an HSI put option which expires in June and has a strike price (or exercise price) of 10,000 index points. If the market declines to 9,000 on the expiry day, you can exercise your option (you will pay a small fee for that) or settle the difference in cash between the strike price and the official settlement price (which is the average of the quotations of the HSI taken at five-minute intervals during the expiry day and is very close to the HSI), provided that the strike price (which is 10,000) is higher than the current market level (or the official settlement price).
price) of 9,000. For this transaction, your profit for one contract is $50 \times 1,000 \text{ points or }$50,000 minus the premium you paid. It makes no sense for you to exercise if the strike price is lower than the official settlement price because your position is out-of-the-money.

In the earlier example, how are you going to hedge your stock portfolio if you think that the market will decline substantially in the near future?

There are two different strategies: (1) sell HSI futures, and (2) buy HSI put options and assume that the market declines by 10 percent from the 10,000 point level to the 9,000 point level and there is no transaction cost:

**Strategy 1:**
You sell 20 HSI futures contracts of June delivery with total contract value of $10.0 million.

$50 \text{ per index point} \times 10,000 \text{ points} \times 20 \text{ contracts} = $10.0 \text{ million}$

If the market declines to the 9,000 point level, you can buy back 20 contracts of June delivery at 9,000 to close out the original position, and gain $1.0 million.

$50 \text{ per index point} \times 20 \text{ contracts} \times (10,000-9,000) = $1.0 \text{ million}$

At the 9,000 index level, your stock portfolio is worth only $9.0 million. With the $1.0 million gain, your total investment value remains at $10.0 million. (You have to pay a small amount of margin deposit. However, you will get it back when you close out the account.)

**Strategy 2:**
Buy 20 June put option contracts at a strike price of 10,000 HSI points (an at-the-money option because at the time you buy these contracts, the market is at 10,000). Assume that the premium is 300 points.

If the market declines by 10 percent to the 9,000 point level, the value of your stock portfolio declines to $9.0 million. However, the put option contracts you bought bring you a profit of $700,000.

*Hang Seng Index and HIBOR Derivatives*
$50 per point \times 20 \text{ contracts} \times (10,000 - 9,000) = $50 \times 20 \times 300 \text{ premium points} = $700,000.

As shown above, because of the option premium, you only partially recover (or hedge) the loss by using options. That is why you often hear from financial treasurers that using options to hedge is very expensive. The main advantage of using options in this situation is allowing you to benefit from the upside potential. If your expectation is wrong and the index surges, you will gain from your stocks while your loss is the option fee of $300,000 you have paid.

**HIBOR Futures**

Banks and corporate treasurers may face another challenge — managing the company's interest rate risk. We have talked about using interest rate swaps to alter a company's asset/liability structure and manage its interest rate risk. Another commonly used method to hedge against interest rate risk is the use of futures. In Hong Kong, the 3-month Hong Kong Interbank Offered Rate (HIBOR) Futures introduced by the Hong Kong Futures Exchange in 1990 provide banks, corporate treasurers and investors with an important vehicle for hedging and speculating on interest rates.

All futures exchanges operate by providing a standardised contract basis for trading commodities and financial instruments for future delivery on margin deposits. The HIBOR Futures are no exception. The contract size is HK$1.0 million with future delivery in the months of March, June, September, December for up to two years. Each basis point (the tick size) is worth $25, and the contracts are settled in cash. The exchange delivery settlement price (EDSP) is used to determine the settlement price. The EDSP is derived from quotations for 3-month interbank offered rates randomly selected from 12 participating banks. The highest and the lowest two are discarded and the remaining eight averaged to an arithmetic mean.

HIBOR Futures are quoted at 100 minus the implied futures rate. For example, assuming that the HIBOR rates are at 6.0 percent (the spot rate)
and the June 3-month futures rate is at 6.25 percent (recall the pricing relation between spot and futures rates), the June 3-month HIBOR Futures price should be quoted at 93.75 (100 - 6.25).

Assume that you are a corporate treasurer and plan to borrow $100.0 million in June for three months, and you think that the rates will move up in the near future, increasing your borrowing cost. You can hedge this potential interest rate risk exposure using HIBOR futures:

You sell 100 HIBOR Futures at the current price of 93.75.

If your prediction is right and 3-month HIBOR moves up to 7.25 percent in June and the EDSP for the June contract is 92.75 (100 - 7.25), you can close out your short sale position by buying 100 futures contracts at 92.75 and have a gain of $250,000: \((93.75 - 92.75) \times 100 \text{ (basis points)} \times 25 \text{ per basis point} \times 100 \text{ contracts} = 250,000\).

This gain of $250,000 will be offset by the increase in borrowing cost of one percent for three months.

Although HIBOR Futures can be used as a hedging vehicle, they are trading very inactively. Similar to HSI Futures, HIBOR Futures participants are required to put up margins — both initial margin and maintenance margin. Margin requirements for HIBOR participants are usually minimal and are returned on the close-out.

In addition to HSI Futures, HSI Options and HIBOR Futures, there are also warrants, single stock options and futures traded in Hong Kong. However, they are more company specific and are less useful for hedging a portfolio.
In the previous chapters, we have talked about the nature and applications of financial derivatives. It should now be clear to everyone that derivative instruments are not associated with new risks. In this chapter, we will discuss how risks should be managed in banks.

**How derivatives can help in managing risk**

Derivatives actually help transform the risk nature from one to another. Going back to the Hang Seng Index (HSI) example in Chapter 16, the initial exposure is the stock portfolio you own. The choice of whether to use HSI Futures or HSI options depends on which risk profile you prefer. The former eliminates most of your risk as well as the upside potential while the more expensive option gives you both the downside protection and the upside potential.

Seeing the positive side of the coin, we should not forget the negative side as illustrated by the case of the $50 million loan hedge cited in Chapter 13. Indeed, improper use of derivatives may accentuate the interest rate risk or foreign exchange risk exposures of banks. Though undeservingly so, the word “derivatives” often appears in headlines associated with mismanagement and financial loss. Therefore, financial institutions are taking a closer look at the possible impact of reputation risk.

**Regulators’ viewpoint on risk management**

What is the role of the regulatory bodies? Our stance is to ensure that banks understand the underlying nature of derivatives and use them appropriately. The banking industry, just like every other businesses, inevitably

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1 This chapter was written by Mr Henry Cheng and Mr Adrian Pang.
needs to take the necessary business risk. What is important to a bank is its ability to manage the risk and to measure risk and profit properly.

Derivative in itself is only a tool either to manage risk or enhance earnings. Similar to home appliances, there should not be any problem to keep the fridge and washer at home so long as the former is used to keep the food and the latter is used to wash the clothes — and not vice versa. Even for simple tools like these, you are advised to test the machines, check the voltage settings, fill out the warranty certificates, read the user manuals and ask your children not to play with them improperly.

What the regulators would do is to understand how banks in Hong Kong are using derivatives to manage their risks and to ensure that they are using the tools properly. In order for us to achieve the goal, the HKMA issued the guideline 12.2 in 1996 to all authorised institutions in Hong Kong, which is reprinted in the Appendix of this book. This guideline serves to establish a risk management framework. The framework helps set a minimum standard — we would like to stress the words “minimum standard” — for us to evaluate the adequacy and quality of the risk management system in place. The document addresses four main areas.

First and foremost, the Board of Directors and senior management must fully understand the nature and risks involved in the institution’s activities. It is their duty to establish risk management framework to identify, measure, control and report such risks.

The next focus would be to look into the actual market risk and credit risk management system in place. To evaluate the quality in these two areas, the level of risk, complexity and volume of derivative activities would always be taken into account. By this, it means that the risk management system of a bank which is an active dealer in derivatives should be much more sophisticated than what one would expect from a bank which only uses derivatives for the purpose of asset/liability management.

Managing Risks in Banks
Operational risk management is another area of concern - a vital area in fact. In the past, cases of colossal financial loss were reported, and the media liked to attribute these losses to the trading of derivatives. In substance, the true villain in many of the cases was inadequate internal controls, lack of segregation of duties, improper procedures, human error, system failure or fraud.

**The Importance of Senior Management's Involvement**

Whilst the management of market risk, credit risk and operational risk have been widely discussed in the industry, we would discuss more about senior management oversight in the following section.

Earnings, earnings per share to be more exact, is very important to a bank. Thus, it is not surprising that when senior management receive the management reports, the first thing, if not the only thing, they look at are the profit and loss figures.

However, there are at least two more basic issues which the senior executives should pay attention to. Is the profit generated from activities which they and the shareholders approve? Is the profit a real and normal one? These two seemingly easy questions are, in reality, great challenges to the senior executives - especially when it comes to derivative activities.

The first rule to successful risk management is for the Board of Directors and senior management to realise that it is their duty to fully understand the nature and risks involved in the institution's activities, and to establish a risk management framework to identify, measure, control and report such risks. In the previous chapters, we have only talked about market risk and credit risk. However, real life is much more complicated and management need to oversee other types of risk which are difficult to quantify. Examples are regulatory risk, legal risk, liquidity risk, reputation risk and operational risk.

The establishment of a set of comprehensively written policies and procedures is always the starting point for high quality senior management oversight. In
brief, the policies and procedures should lay out the scope of business activities, the organisation structure showing clear reporting line, authority and responsibility for each business activity indicating the segregation of duties, the framework of risk management system demonstrating the risk identification process, risk measurement methodology and the risk reporting mechanism.

Our experience is that most banks have some kind of policies and procedures, but many of them are either too brief or not updated. For some banks, their policies and procedures have remained unchanged for years even though the banks may have gone through several organisational changes. And in some cases, the policy is so brief that the operational staff do not have a clear idea about how the policy should be properly implemented.

Policies and procedures are like the rules of the volleyball game. Everyone involved in the game, including the referees, should know all but "not some" of the rules. Therefore, policies and procedures should be written as clearly as possible and all the staff involved should be asked to read and understand the rules. However, unlike volleyball game, the game of derivatives changes rapidly and it is important to constantly review the rules to make sure that they are still applicable.

The next issue is the establishment of a risk management system. This is not the duty of the risk manager but the senior management. The Board of Directors and senior management are the ones responsible for allocating the resources. If the senior management decide to engage in derivative activities, they should first think about the resources needed to establish a good risk management system. These are the necessary steps for conducting derivatives business, similar to renting an office and furniture, hiring a branch manager and operating staff before opening a branch. What we wish to point out here is resource commitment. We have seen some banks which hurried into the derivatives market, yet the senior management were reluctant to set up the necessary infrastructure, like the installation of appropriate risk management system and the recruiting of experienced back office and middle office staff.

Managing Risks in Banks
Another point to ponder on is the effectiveness of the risk management system. A good risk management system should accurately identify, measure and report all the risks involved. The system should also be able to give early warning signals. This issue is a rather technical one and may have to be designed differently for different products. In most cases, stress testing and scenario analysis have to be conducted in addition to a carefully set risk limit structure. Questions like “what is the impact on my profit and loss account and cash flows if the stock market crashes like the one in 1987?” and “what will happen to my profit and loss account and cash flows if the liquidity of the swap market suddenly dries up?” should always come to the minds of the senior management.

Some market participants argue that it is almost impossible to design a perfect early warning system. In response to such argument, Dominic Casserley wrote in his book - Facing Up to the Risks, “no one warning system works for all risks, but those without any warning system will be the last in a market to spot trouble before it arrives, and may go on investing after it is clearly time to stop.”

Internal audit is another area we often emphasised, the importance of which arises from the need to assess the soundness and adequacy of the risk management system. For more sophisticated market participants, the pricing and revaluation models should also be independently validated. Internal audit should also test the compliance with the authorised institution’s policies and procedures.

Audit is one of the effective warning systems which the senior management should really listen to. However, sometimes the senior management simply assume everything would be followed up and rectified - until maybe a year later when they read the next audit report and see the same findings under the section “follow up of last audit findings.”

Finally, we would like to discuss the new products approval policy. This is an area to which senior management probably have not paid enough attention.

*Managing Risks in Banks*
The derivatives industry can be compared to any other industry, the manufacturing of cars for instance. A manufacturer who has been making sedans wants to go into the market of sports cars. What does he need to think about? The answer would be a long list - to conduct market analysis, install new production line (or modify the existing one), source new components, plan for the production volume and inventory level and formulate the pricing strategies.

Business planning in the derivatives market is no different. If a bank used to trade in the G-7 foreign exchange market and the treasurer suggests that the bank should go for the trading of Asian currencies, what do the senior management need to think about? The list should be as long as that of the car manufacturer. What are the risks associated with trading Asian currencies - market risk, credit risk or liquidity risk? What is the incremental risk to our existing activities? Do we need to have different operational procedures? Shall we improve the limit structure and reporting system to address, say, the liquidity risk? What are the regulatory, legal and tax implications? Do we have the expertise in the Asian markets?

Without a comprehensive policy on new products approval, a bank may start trading in the Asian currencies without careful planning, because “the nature is similar to the G-7 currencies” according to some bankers. However, the consequences may be quite different.

CONCLUDING REMARKS

To conclude, we have seen in this book a variety of derivative products and their uses. This book is not for market experts and there are many complex derivative products that we have not covered. However, we hope you have grasped the concepts of basic building blocks such as options, futures and forwards. Once you have a good understanding of the fundamentals, it is not very difficult to analyse more complex products.

Derivatives are not monsters. They are just tools to transfer risks from one format to another. In fact, they can be very useful tools for asset/liability
management in banks if properly used. However, entering into derivative transactions without understanding their natures could be fatal. Therefore, bankers and treasurers need to understand the inherent risks of the product, establish trading limits and review the risk exposures regularly. The Appendix includes the minimum requirements that the HKMA expects banks to have when conducting derivatives business.

After reading this book, we hope you will have a better understanding of derivatives and risk management. As the derivatives market is evolving rapidly and new products are developed from time to time, continuing reading about the subject is essential to keep abreast of the market developments.
INTRODUCTION

1. The Monetary Authority (MA) issued in December 1994 a guideline on “Risk Management of Financial Derivative Activities” to set out the basic principles of a prudent system to control the risks in derivatives activities. These include:

a) appropriate oversight by the board of directors and senior management;

b) adequate risk management process that integrates prudent risk limits, sound measurement procedures and information systems, continuous risk monitoring and frequent management reporting; and

c) comprehensive internal controls and audit procedures.

2. This Guideline supplements the December 1994 Guideline by providing additional guidance relating to specific aspects of the risk management process. It has taken account of observations from, and weaknesses identified in, the surveys and treasury visits conducted by the MA since December 1994; the findings of the review of internal control systems in respect of trading activities carried out by authorized institutions in March 1995 in response to the MA’s request following the collapse of Barings; the recommendations of the Group of Thirty and the lessons learned from the cases of Barings and Daiwa Bank having regard in particular to the official reports on the Barings collapse issued in the UK and Singapore. While this Guideline is relevant to the trading of financial instruments in general, it concentrates particularly on the trading of derivatives. This reflects the rapid growth in these instruments, the

Guideline on Risk Management of Derivatives and Other Traded Instruments
opportunities for increased leverage which they offer and the complexity of some derivatives products which may complicate the task of risk management. The present guideline should be read in conjunction with the December 1994 Guideline.

3. It should be emphasized right at the outset that the problems of Barings and Daiwa Bank arose to a large extent from a failure of basic internal controls, such as lack of segregation of duties. The valuation and measurement challenges posed by complex derivatives products should not distract institutions from the need to ensure that the basic controls are in place.

4. This Guideline applies to all authorized institutions and to the subsidiaries of all locally incorporated authorized institutions which engage in trading activities. Trading in this context includes market-making, position-taking, arbitrage and trading on behalf of customers. Broadly speaking, institutions which trade in derivatives can be classified into two main categories: dealers and end-users. Dealers market derivatives products to customers and usually also trade for their own account. This group can be further subdivided into dealers who provide quotes to other market professionals (as well as to customers) and other dealers who provide quotes only to customers or are less active. End-users trade only for their own account. They are divided into active position-takers who trade frequently for their own account and take large positions, and limited end-users who are characterised by smaller portfolios, less complex products, and lower transaction volume. The actual risk management processes that should be put in place should be commensurate with the nature, size and complexity of individual institutions’ trading activities. An institution which is an active dealer or position-taker will require a more elaborate system of risk management. The MA will, during the course of its supervision of institutions’ derivatives activities, classify institutions into the categories mentioned above (i.e. active dealers, dealers, active position-takers and limited end-users) and will communicate this classification to the institutions concerned. It will assess the adequacy of institutions’ risk management systems against this classification.
RISK MANAGEMENT AND CORPORATE GOVERNANCE

5. As the Barings case illustrated, the overall quality of risk management within an authorized institution cannot be divorced from the overall quality of its board and senior management, organizational structure and culture. It is particularly vital with potentially complex products such as derivatives that the board and senior management should understand the nature of the business which they are supposed to be controlling. This includes an understanding of the nature of the relationship between risk and reward, in particular an appreciation that it is inherently implausible that an apparently low risk business can generate high rewards. As in the case of Barings, unusually high reported profitability may be a sign that excessive risks are being taken (or that there may be false accounting).

6. The board and senior management also need to demonstrate through their actions and behaviour that they have a strong commitment to an effective control environment throughout the organization. This will be shown in part by the risk management policies which they approve (see paragraphs 12 to 15 below). However, it is important to ensure that these policies do not simply exist on paper, but are also applied in practice. This will depend on such factors as the managerial and operational resources which are actually devoted to risk management within the institution, the support and back-up which are given to internal audit and to the risk control unit (if it exists) and the action which is taken to deal with breaches of policies, procedures and limits. These are areas which are subject to examination by the MA.

7. The board and senior management should avoid giving conflicting signals to employees by appearing to advocate prudent risk management while at the same time awarding large bonuses which are directly linked to short-term trading performance. This may encourage excessive risk-taking and at worse, deliberate falsification of positions and concealment of losses. In general, steady earnings from low risk positions are of higher quality than volatile earnings from high risk positions and should be awarded accordingly. Where bonuses are paid, management should
consider how the possible adverse effects can be minimized, e.g. by relating bonuses to longer-term trading performance or risk adjusted performance, or by paying the bonuses over a period of time.

8. It is also the duty of the board and senior management to ensure that the organization of the institution is conducive to managing risk. It is necessary to ensure that clear lines of responsibility and accountability are established for all business activities, including those which are conducted in separate subsidiaries.

9. A number of banks have adopted a system of "matrix management" whereby their various business operations around the world report to product managers or function managers who have responsibility for products or particular business activities on a global or regional basis. This is combined with reporting to local country managers who should have an overview of the business as a whole within their particular geographical areas. Such a system was operated by Barings.

10. The matrix system can be helpful in ensuring that the risks arising in the same product around the world are aggregated and centrally managed, thus making it easier to apply common standards and to manage the risks. However, if applied inappropriately, it can suffer from two main flaws, both of which were evident in the case of Barings:

a) it can result in confused reporting lines and blurred responsibilities where the local operation is reporting to a number of different product managers. This may lead to lack of responsibility and control at the senior management level for the operation in question; and

b) the local country manager may be either unwilling or unable (e.g. because of lack of a clear mandate) to exercise supervision over the business activities conducted within his jurisdiction.

11. Experience has shown that it is difficult to control a trading operation from a distance. The central risk control function at the head office should
ensure that there is sufficient awareness of the risks and the size of exposure of the trading activities conducted in overseas operations. The local country manager also needs to have sufficient understanding of the business in his territory and the formal authority to ensure that proper standards of control are applied (including segregation of duties between the front and back offices). This is also necessary so that he can communicate effectively with the local regulators. In the case of Hong Kong, the chief executive of the local branch of a foreign bank is fully accountable to the MA for the conduct of all the business conducted by the branch in Hong Kong, even if he is not functionally responsible for certain parts of the business.

**Board and Senior Management Oversight**

12. Consistent with its general responsibility for corporate governance, the board should approve written policies which define the overall framework within which derivatives activities should be conducted and the risks controlled. The MA's observations over the last year are that a comprehensive set of such policies have been lacking in some institutions. This should be rectified if it has not already been done.

13. The policy framework for derivatives approved by the board may be general in nature (with the detail to be filled in by senior management). But the framework should, among other things:

a) establish the institution's overall appetite for taking risk and ensure that it is consistent with its strategic objectives, capital strength and management capability. (Appetite for risk can be expressed in terms of the amount of earnings or capital which the institution is prepared to put at risk, and the degree of fluctuation in earnings, e.g. from position-taking, which it is willing to accept);

b) towards this end, define the approved derivatives products and the authorized derivatives activities, e.g. market-making, position-taking, arbitrage, hedging. (The nature of such exposure should be carefully defined to ensure, for example, that activities described as arbitrage do not in practice involve the taking of outright positions);

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c) detail requirements for the evaluation and approval of new products or activities. (This requires the board to approve the definition of what is meant by a “new” product, e.g. a change in the underlying instrument and hence in the risk, or a change in the capacity in which the institution trades the product, e.g. as dealer or end-user);

d) provide for sufficient staff resources and other resources to enable the approved derivatives activities to be conducted in a prudent manner;

e) ensure appropriate structure and staffing for the key risk control functions, including internal audit;

f) establish management responsibilities;

g) identify the various types of risk faced by the institution and establish a clear and comprehensive set of limits to control these;

h) establish risk measurement methodologies which are consistent with the nature and scale of the derivatives activities;

i) require stress testing of positions; and

j) detail the type and frequency of reports which are to be made to the board (or committees of the board).

14. The type of reports to be received by the board should include those which indicate the levels of risk being undertaken by the institution, the degree of compliance with policies, procedures and limits, and the financial performance of the various derivatives and trading activities. Internal and external audit reports should be reviewed by a board level Audit Committee and significant issues of concern should be drawn to the attention of the board. More detailed information should be supplied to senior management, including that which splits risk exposure, positions and profitability by regions, business units and products and which analyses exposure to the various market variables (interest rates, exchange rates etc.).
15. Branches of foreign banks which trade in derivatives in Hong Kong should operate within policies and procedures which are approved by head office and which are consistent with those approved by the board for the bank as a whole. Regular reports on risk exposure, positions and profitability should be submitted to head office.

**The identification of risk**

16. Institutions should identify the various types of risk to which they are exposed in their derivatives activities. As set out in the December 1994 Guideline, the main types of risk are:

- credit risk
- market risk
- liquidity risk
- operational risk
- legal risk

Definitions of these are set out in Annex A.

17. Operational risk, involving the risk of loss from inadequate systems of control, was a key feature of the Barings and Daiwa Bank cases. The Daiwa Bank case also demonstrated how an initial loss arising from failure of controls can be compounded by regulatory risk, i.e. the risk of loss arising from failure to comply with regulatory or legal requirements, and reputation risk, i.e. the risk of loss arising from adverse public opinion and damage to reputation. In this context, institution should promptly inform the MA of any fraud or trading malpractices by staff, particularly those which could result in financial or reputational loss by the institution concerned.

Reputation risk and appraisal of counterparties

18. The complexity of some derivatives products and the amount of leverage involved (which increases the potential for loss as well as profit) may expose authorized institutions to an additional element of reputation risk.
risk if counterparties who have lost money on derivatives contracts complain publicly that they were misled about the risks or take legal action. The authorized institution may also be exposed to credit risk if the counterparty fails to meet his financial obligations under the contract. This risk can arise in respect of both corporate and personal customers (particularly in the private banking area). The MA has come across a number of the latter cases in 1995.

19. For the institution’s own protection, the board should approve clear written policies to address the issues of selection and appraisal of counterparties, risk disclosure and handling of disputes and complaints. Such policies and procedures were lacking in a number of authorized institutions whose controls were reviewed in 1995. The objective of such policies and procedures is prudential in nature: to protect an authorized institution against the credit, reputation and litigation risks that may arise from a counterparty’s inadequate understanding of the nature and risks of the derivatives transaction. Such counterparties may not fully understand their obligations under the derivatives contracts and therefore may be unable to anticipate and plan for the risks these obligations entail. This gives rise to a higher than normal risk of default and a greater potential for litigation and damage to the authorized institution’s reputation. As in the case of an ordinary credit facility, the MA expects that, as part of its credit analysis, an authorized institution will:

a) analyze the expected impact of the proposed derivatives transaction on the counterparty;

b) identify whether the proposed transaction is consistent with the counterparty’s policies and procedures with respect to derivatives transactions, as they are known to the institution; and

c) ensure that the terms of the contract are clear and assess whether the counterparty is capable of understanding the terms of the contract and of fulfilling its obligations under the contract.
20. Where the institution considers that a proposed derivatives transaction is inappropriate for a counterparty, it should inform the counterparty of its opinion. If the counterparty nonetheless wishes to proceed, the institution should document its analysis and its discussions with the counterparty in its files to lessen the chances of litigation in case the transaction proves unprofitable to the counterparty. If the institution considers that the counterparty may be financially incapable of meeting its obligations, or that undue reputation risk may arise from adverse publicity if the counterparty loses money, the institution should consider very carefully whether it should enter into the transaction at all. Institutions should exercise extra care in respect of complicated derivatives transactions in view of the additional credit, reputation and litigation risks to which they may give rise.

21. It is important that the institution understands clearly the nature of its relationship with the counterparty and the obligations which may flow from that. The issue of whether the transaction is an appropriate one for the counterparty to undertake does not generally arise in respect of transactions where the institution acts on the instructions of the client in the capacity of broker or agent. For transactions which the institution entered into on a principal-to-principal basis, it is recognized that the transaction is essentially on an arm's length basis and that counterparties are ultimately responsible for the transactions they choose to make. However, as noted in paragraph 19 above, the MA considers that internal policies and procedures are still required to guard against the credit risk that may arise from the counterparty's inadequate understanding of the nature and risks of the transaction and to protect the institution against complaints or litigation on the ground of misrepresentation in respect of any information which it chooses to provide to the counterparty. For transactions where an institution has agreed to assume the role of an advisor, the institution needs to be aware that it owes the client a duty to tender its advice fully, accurately and properly.
22. Authorized institutions should also be aware that the degree of complexity of the transaction and the level of sophistication of the counterparty are factors which a court may take into account in considering whether the institution has in practice assumed an advisory role in relation to the counterparty (even if no explicit agreement to that effect has been entered into). A wider duty of care may be allowed by the courts in a case involving a highly sophisticated transaction and a relatively unsophisticated counterparty. In those circumstances, there is a possibility that the courts may be more likely to accept evidence that an authorized institution had assumed a responsibility to advise the counterparty on issues such as risk and suitability. It is also noted that where an institution provides information to enable its counterparties to understand the nature and risks of a transaction, it should:

a) ensure that the information is accurate;

b) ensure that information in any economic forecast is reasonable, based on proper research and reasonable grounds; and

c) present the downside and upside of the proposal in a fair and balanced fashion.

23. To guard against the possibility of misunderstandings, particularly with private banking customers, all significant communications between the institution and its customers should be in writing or recorded in meeting notes. Where it is necessary for an account manager to speak to the customer by telephone, such conversations should be tape-recorded.

24. Institutions should establish internal procedures for handling customer disputes and complaints. They should be investigated thoroughly and handled fairly and promptly. Senior management and the Compliance Department/Officer should be informed of all customer disputes and complaints at a regular interval. Cases which are considered material, e.g. the amount involved is very substantial, should be reported to the board and the MA.
RISK MEASUREMENT

25. Having identified the various types of risk, the authorized institution should as far as possible attempt to measure and aggregate them across all the various trading and non-trading activities in which it is engaged.

26. The risk of loss can be most directly quantified in relation to market risk and credit risk (though other risks may have an equally or even greater adverse impact on earnings or capital if not properly controlled). These two types of risks are clearly related since the extent to which a derivatives contract is “in the money” as a result of market price movements will determine the degree of credit risk. This illustrates the need for an integrated approach to the risk management of derivatives. The methods used to measure market and credit risk should be related to:

a) the nature, scale and complexity of the derivatives operation;
b) the capability of the data collection systems; and
c) the ability of management to understand the nature, limitations and meaning of the results produced by the measurement system.

27. The MA has observed that the risk measurement methodologies of a number of authorized institutions are relatively simple and unsophisticated despite the fact that they are quite active market participants. In particular, the use of notional contract amounts to measure the size of market or credit risk (and to set limits) is insufficient in itself and should be confined to limited end-users (and even then only on a temporary basis until a more sophisticated risk measurement system has been devised). It should be noted however that although more sophisticated methodologies measure risk more accurately, they also introduce added assumption and model risk. In particular, the assumption in “value-at-risk” models (see below) that changes in market risk factors (such as interest rates) are normally distributed, may not hold good in practice.
Mark-to-market

28. The measurement process starts with marking to market of positions. This is necessary to establish the current value of positions and to record profits and losses in the bank's books. It is essential that the revaluation process is carried out by an independent risk control unit or by back office staff which are independent of the risk-takers in the front office, and that the pricing factors used for revaluation are obtained from a source which is independent of the front office or are independently verified. A number of authorized institutions have not adopted this practice. (Ideally, the methodologies and assumptions used by the front and back offices for valuing positions should be consistent, but if not there should be a means of reconciling differences.) For active dealers and active position-takers, positions should be marked to market on a daily basis. Where appropriate, intra-day or real-time valuation should be used for options and complex derivatives portfolios (this may be performed by dealing room staff provided that the end-of-day positions are subject to independent revaluations).

29. To ensure that trading portfolios are not overvalued, active dealers and active position-takers should value their trading portfolios based on mid-market prices less specific adjustments for expected future costs such as close-out costs and funding costs. Limited end-users may use bid and offer prices, applying bid price for long positions and offer price for short positions.

Measuring market risk

30. The risk measurement system should attempt to assess the probability of future loss in derivative positions. In order to achieve this objective, the system should attempt to estimate:

a) the sensitivity of the instruments in the portfolio to changes in the market factors which affect their value (e.g. interest rates, exchange rates, equity prices, commodity prices and volatilities); and
b) the tendency of the relevant market factors to change based on past volatilities and correlations.

31. The common methodologies used by authorized institutions in Hong Kong to measure market risk include notional amounts, month-million, duration and price value basis point. These methods generally fail fully to satisfy both the criteria specified in the previous paragraph. The approach which is best suited for this purpose is "value at risk" which is recommended by both the Group of Thirty and the Basle Committee. The value-at-risk approach measures the expected loss in a position or portfolio that is associated with a given probability and a specified time horizon. The above methodologies are summarized in Annex B.

32. Active dealers and active position-takers in derivatives are recommended to adopt the value-at-risk approach, although it is recognized that it will take time to install the necessary systems. Institutions which trade derivatives in a different capacity (particularly limited end-users) may use less sophisticated methodologies but should adopt correspondingly more conservative trading strategies and limits.

33. Statistical models used to calculate value at risk may use a variety of different approaches (e.g. variance/covariance, historical simulation, Monte Carlo simulation). The choice is a matter for the institution concerned, but where models are to be used for measuring capital adequacy for supervisory purposes, the Basle Committee has specified that common minimum standards should be adopted (including a 99% one-tailed confidence interval and a minimum holding period of 10 days). The Basle standards are summarized in the attached Annex C.

34. The MA will have regard to these standards in evaluating the value-at-risk models used by authorized institutions in Hong Kong for managing their trading risk. It is recognized that models used for this purpose may incorporate assumptions which are different from those recommended by the Basle Committee. In particular, it is common to
use a holding period of only one day for the measurement of potential changes in position values. This assumption will however only hold good for liquid instruments in normal market conditions. For instruments or markets where there is significant concern about liquidity risk, a longer holding period should be used (e.g. 10 days) or more conservative limits should be adopted.

35. The assumptions and variables used in the risk management method should be fully documented and reviewed regularly by the senior management, the independent risk management unit (if it exists) and internal audit.

Stress tests

36. Regardless of the measurement system and assumptions used to calculate risk on a day-to-day basis, institutions should conduct regular stress tests to evaluate the exposure under worst-case market scenarios (i.e. those which are possible but not probable). Stress tests need to cover a range of factors that could generate extraordinary losses in trading portfolios or make the control of risk in these portfolios very difficult. Stress scenarios may take account of such factors as the largest historical losses actually suffered by the institution and evaluation of the current portfolio on the basis of extreme assumptions about movements in interest rates or other market factors or in market liquidity. The results of the stress testing should be reviewed regularly by senior management and should be reflected in the policies and limits which are approved by the board of directors and senior management.

37. All institutions which are active in derivatives in Hong Kong are recommended to conduct regular stress testing of their portfolios. This should be carried out both by local risk managers and on a consolidated basis by the head office risk control function. A significant number of institutions have not previously done so.
Options

38. The measurement of the market risk in options involves special considerations because of their non-linear price characteristics. This means that the price of an option does not necessarily move in a proportionate relationship with that of the underlying instrument, principally because of gamma and volatility risk. (A description of these risks and the other risks in options is given in Annex D.) Measurement of risk exposure of an options portfolio may therefore require the use of simulation techniques to calculate, for example, changes in the value of the options portfolio for various combinations of changes in the prices of the underlying instruments and changes in volatility. The risk exposure would be calculated from that combination of price and volatility change that produced the largest loss in the portfolio. Other more elaborate simulation techniques may be used. In general, given the additional complexity of risk measurement and management of options, the MA would expect active trading in options to be confined to the more sophisticated authorized institutions.

Measuring credit risk

39. The credit risks of derivatives products have two components: pre-settlement risk and settlement risk. They should be monitored and managed separately. A number of authorized institutions have not done this in respect of settlement risk.

40. Pre-settlement risk is the risk of loss due to a counterparty defaulting on a contract during the life of a transaction. It varies throughout the life of the contract and the extent of loss will only be known at the time of default. To measure pre-settlement risk, authorized institutions should not rely solely on the notional amounts of derivatives contracts which provide only an indication of the volume of business outstanding and bear little relation to the underlying risk of the exposure. That risk is conditional on the counterparty defaulting and the contract having positive mark-to-market value to the institution at the time of default. However,
even contracts which presently have a zero or negative mark-to-market value to the institution (and where there is thus no current loss exposure) have potential credit risk because the value of the contract can become positive at any time prior to maturity as a result of market movements.

41. All authorized institutions are encouraged to calculate pre-settlement risk by summing the current exposure of a contract (i.e. the mark-to-market value, if positive) and an estimate of the potential change in value over the remaining life of the contract (the “add-on”). Where legally enforceable netting agreements are in place, the current exposure for a given counterparty may be calculated by netting contracts with that counterparty which have negative mark-to-market value against those which have positive value. The Guideline on Amendment to the 1988 Capital Accord for Bilateral Netting issued by the MA in February 1995 sets out the conditions under which the MA will be prepared to recognize netting arrangements for capital adequacy purposes.

42. Active dealers and active position-takers may use their own simulation techniques to measure potential future exposure, or else may use the add-ons specified by the Basle Committee for capital adequacy purposes. A less sophisticated approach is to measure the total pre-settlement risk by multiplying the notional amount of the contract by percentage factors which depend on the numbers of years of the contract (the “original exposure” method). This method is not recommended for authorized institutions.

43. Settlement risk arises where securities or cash are exchanged and can amount to the full value of the amounts exchanged. In general, the time-frame for this risk is quite short and arises only where there is no delivery against payment.

LIMITS

44. A comprehensive set of limits should be put in place to control the
market, credit and liquidity risk of the institution in derivatives and other traded instruments. These should be integrated as far as possible with the overall institution-wide limits for these risks. For example, the credit exposure for a particular counterparty arising from derivatives should be aggregated with all other credit exposures for that counterparty and compared with the credit limit for that counterparty. As noted earlier, the aggregate limits for the amount of risk to be incurred by the institution in its derivatives activity and the broad structure of the limits should be approved by the board. The aggregate limits can then be allocated and sub-allocated by management. The system of limits should include procedures for the reporting and approval of exceptions to limits. It is essential that limits should be rigorously enforced and that significant and persistent breaches of limits should be reported to senior management and fully investigated.

**Market risk limits**

45. Market risk limits should be established at different levels of the institution, i.e. the institution as a whole, the various risk-taking units, trading desk heads and individual traders. It may also be appropriate to supplement these with limits for particular products. In determining how market risk limits are established and allocated, management should take into account factors such as the following:

a) past performance of the trading unit;

b) experience and expertise of the traders;

c) level of sophistication of the pricing, valuation and measurement systems;

d) the quality of internal controls;

e) the projected level of trading activity having regard to the liquidity of particular products and markets; and

f) the ability of the operations systems to settle the resultant trades.
46. Some commonly used market risk limits are: notional or volume limits, stop loss limits, gap or maturity limits, options limits and value-at-risk limits. These are described in Annex D. The selection of limits should have regard to the nature, size and complexity of the derivatives operation and to the type of risk measurement system. In general, the overall amount of market risk being run by the institution is best controlled by value-at-risk limits. These provide senior management with an easily understood way of monitoring and controlling the amount of capital and earnings which the institution is putting at risk through its trading activities. The limits actually used to control risk on a day-to-day basis in the dealing room or at individual trading desks may be expressed in terms other than value at risk, but should provide reasonable assurance that the overall value-at-risk limits set for the institution will not be exceeded. Regular calculation of the value at risk in the trading portfolio should therefore be conducted to ensure that this is indeed the case.

47. It should be emphasized that no means of expressing limits can give absolute assurance that greater than expected losses will not occur. Even the value-at-risk approach, while recommended for active dealers and active position-takers, has its own limitations in providing protection against unpredictable events. Limits set by the institution on this basis should therefore cater for such events, taking into account the results of the stress tests run by the institution (see above). Other types of limits are less sophisticated than value at risk and are generally not sufficient in isolation (unless only a limited and conservative trading strategy is being pursued), but they may be useful for certain purposes and when used in conjunction with other measures.

48. Stop loss limits may be useful for triggering specific management action (e.g. to close out the position) when a certain level of unrealized losses are reached. They do not however control the potential size of loss which is inherent in the position or portfolio (i.e. the value at risk) and which may be greater than the stop loss limit. They will thus not necessarily prevent losses if the position cannot be exited (e.g. because of market illiquidity).
Consideration must be given to the period of time over which the unrealised loss is to be controlled: too long a period (e.g. a year) may allow large unrealized losses to build up before management action is triggered. Limits for shorter periods may be advisable (e.g. on a monthly basis).

49. Limits based on the notional amount or volume of derivatives contracts do not provide a reasonable proxy for market (or credit) risk and thus should not generally be acceptable on a stand-alone basis. (A number of authorized institutions have been relying solely on notional limits.) Volume limits can however have some use in controlling operational risk (i.e. as regards the processing and settling of trades) and also liquidity and concentration risk. Such a risk might arise for example, as it did in the case of Barings, from having a substantial part of the open interest in exchange-traded derivatives (particularly in less liquid contracts.) The Barings case also illustrates that for activities such as arbitrage, it is necessary to set limits on the gross as well as the net positions in order to control over-trading and limit the amount of funding which is required for margin payments. (A number of authorized institutions have not been monitoring the growth of gross positions.)

50. It may be appropriate to set limits on particular products or maturities (as well as on portfolios) in order to reduce market and liquidity risk which would arise from concentrations in these. (Some institutions have not been doing this.) Similarly, options risk can be controlled by concentration limits based on strike price and expiration date. This reduces the potential impact on earnings and cash flow of a large amount of options being exercised at the same time.

Credit limits

51. Institutions should establish both pre-settlement credit limits and settlement credit limits (not all have been doing this). The former should be based on the credit-worthiness of the counterparty in much the same way as for traditional credit lines. The size of the limits should take into account the sophistication of the risk measurement system: if
notional amounts are used (which is not recommended), the limits should be correspondingly more conservative.

52. It is important that authorized institutions should establish separate limits for settlement risk. The amount of exposure due to settlement risk often exceeds the credit exposure arising from pre-settlement risk because settlement of derivatives transactions may involve the exchange of the total value of the instrument or principal cash flow. Settlement limits should have regard to the efficiency and reliability of the relevant settlement systems, the period for which the exposure will be outstanding, the credit quality of the counterparty and the institution's own capital adequacy.

Liquidity limits

53. The cash flow/funding liquidity risk in derivatives can be dealt with by incorporating derivatives into the institution's overall liquidity policy and, in particular, by including derivatives within the structure of the maturity mismatch limits. A particular issue is the extent to which institutions take account of the right which may have been granted to counterparties to terminate a derivatives contract under certain specified circumstances, thus triggering an unexpected need for funds. (The results of the MA's survey conducted in early 1995 suggested that a significant proportion of institutions do not take account of such early termination clauses in planning their liquidity needs.)

54. As the Barings' case demonstrates, it is also necessary for institutions to take into account the funding requirements which may arise because of the need to make margin payments in respect of exchange-traded derivatives. The institution should have the ability to distinguish between margin calls which are being made on behalf of clients (and monitor the resultant credit risk on the clients) and those which arise from proprietary trades. Where the institution is called upon to provide significant funding in respect of derivatives activities undertaken in a subsidiary, the institution should carefully monitor the amount involved against limits for that subsidiary and investigate rapid growth in the subsidiary's funding needs.
55. As noted earlier, the market or product liquidity risk that arises from the possibility that the institution will not be able to exit derivatives positions at a reasonable cost, can be mitigated by setting limits on concentrations in particular markets, exchanges, products and maturities.

INDEPENDENT RISK CONTROL

56. There should be a means within each authorized institution of independently monitoring and controlling the various risks in derivatives (and other trading activities). The precise way in which the risk control function is organized in each institution will vary depending on the nature, size and complexity of its derivatives operation. Different types of risks may be monitored and controlled by different departments and units. For example, the credit risk in derivatives may be subject to the oversight of that department of the institution which monitors its credit risk as a whole. As noted earlier, however, the inter-relationship between the different types of risks needs to be taken into account. (An Asset and Liability Committee of the board may be a suitable forum for doing this.)

57. Institutions which are active dealers or active position-takers in derivatives should maintain a separate unit which is responsible for monitoring and controlling the market risk in derivatives. This should report directly to the board (or Asset and Liability Committee) or to senior management who are not directly responsible for trading activities. Such management should have the authority to enforce both reductions of positions taken by individual traders and in the bank’s overall risk exposure. Where the size of the institution or its involvement in derivatives activities does not justify a separate unit dedicated to derivative activities, the function may be carried out by support personnel in the back office (or in a “middle office”) provided that such personnel have the necessary independence, expertise, resources and support from senior management to do the job effectively.

58. Whatever form the risk control function takes, it is essential that it is distanced from the control and influence of the trading function. In particular, it is unacceptable for risk control functions of the type described
59. The minimum risk control functions which should be performed include the following:

a) the monitoring of market risk exposures against limits and the reporting of exceptions to management outside the trading area;

b) the marking-to-market of risk exposures and the performance of reconciliation of positions and profit/loss between the front and back offices;

c) the preparation of management reports, including daily profit/loss results and gross and net positions; and

d) the monitoring of credit exposures to individual counterparties against limits and the reporting of exceptions to management outside the trading area (as noted earlier this function may be performed by the credit department).

60. For institutions which are active traders in derivatives, and in particular those which wish to satisfy the Basle Committee's criteria for the use of internal models to measure the capital requirements for market risk, the risk control function should also be actively involved in the design, implementation and ongoing assessment of the institution's risk management system, and particularly its internal model. This will typically be done at head office level (perhaps with the assistance of local risk managers) and will include the following:

a) the development of risk management policies (including policies to ensure system security) and limits for approval by the board and senior management;

b) the design and testing of stress scenarios;

c) the regular back-testing of the measure of market risk (e.g. that generated by the internal value-at-risk model) against actual daily...
changes in portfolio value;

d) the review and approval of pricing and valuation models used by the
front and back offices, and the development of reconciliation
procedures if different systems are used; and

e) the generation of reports for the board and senior management
covering such aspects as trends in aggregate risk exposure, the
adequacy of and compliance with policies and risk limits and risk/return information.

61. The risk management system and the effectiveness and independence of
the risk control unit should themselves be subject to regular review by
internal audit.

**OPERATIONAL CONTROLS**

62. Operational risk arises as a result of inadequate internal controls, human
error or management failure. This is a particular risk in derivatives
activities because of the complexity and rapidly evolving nature of some
of the products. The nature of the controls in place to manage operational
risk must be commensurate with the scale and complexity of the
derivatives activity being undertaken. As noted earlier, volume limits
may be used to ensure that the number of transactions being undertaken
does not outstrip the capacity of the support systems to handle them.

**Segregation of duties**

63. Segregation of duties is necessary to prevent unauthorized and fraudulent
practices. This has a number of detailed aspects but the fundamental
principle is that there should be clear separation, both functionally and
physically, between the front office which is responsible for the conduct
of trading operations and the back office which is responsible for
processing the resultant trades. Institutions must avoid a situation where
the back office becomes subordinate to the traders as was the case with
Barings. This gave rise to the situation where the head trader of the

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Singapore futures operation was able both to initiate trades and to control the way in which they were recorded and settled.

64. The MA has come across a number of cases in authorized institutions where segregation of duties is incomplete. For example:

a) the mark-to-market process is performed by the front office instead of the back office (or separate risk control unit);

b) the data used for marking to market are not obtained from sources independent of the front office or are not independently verified;

c) reconciliation of the back office position reports to the front office records are not reviewed by personnel independent of the front office operations;

d) incoming confirmations of deals are received in the first instance by dealers instead of the back office;

e) dealing reports and profit/loss reports are either prepared by dealers or routed via dealers to senior management;

f) limit monitoring is not carried out by personnel who are independent of the dealing room; and

g) there is a lack of physical separation of the front and back offices.

65. The MA considers that such practices are unacceptable and has requested the institutions concerned to take remedial measures. In some cases, it has been argued that the deficiencies are not high risk because of the existence of compensating human and other controls and because of conservative trading strategies. While this may be true under normal circumstances, the lack of proper systems controls does create loopholes which can be exploited by unscrupulous individuals. The Barings and Daiwa Bank cases show that trust placed in key individuals may be abused and that it is dangerous to assume that a fundamental weakness in controls can be mitigated by other, more superficial, checks and balances. Shortages of physical space or skilled personnel should not be used as an excuse to override normal control considerations.

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66. A basic and essential safeguard against abuse of trust by an individual is to insist that all staff should take a minimum period of annual leave (say 2 weeks) each year. This makes it more difficult to conceal frauds in the absence of the individual concerned. All institutions are recommended to follow this practice.

Policies and procedures

67. Policies and procedures should be established and documented to cover the internal controls which apply at various stages in the workflow of processing and monitoring trades. Apart from segregation of duties, these include:

- trade entry and transaction documentation
- confirmation of trades
- settlement and disbursement
- reconciliations
- revaluation
- exception reports

68. A checklist of some of the key controls under these headings is given in Annex E. One important aspect of reconciliations as revealed by the Barings case is that major unreconciled differences (e.g. between margin payments paid to a futures exchange by the institution on behalf of clients and payments received from clients, or between the institution's balances/positions as recorded in its own accounts and in those of the exchange) should be fully and promptly investigated.

69. Some of the deficiencies identified by the post-Barings review of institutions' internal controls by auditors and the MA's treasury visits include:

a) lack of formally documented procedures that cover all aspects of internal controls for both the front office and back office;

b) no tape recording of telephone calls made by the dealers;

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c) dealing slips were not pre-numbered or time stamped, and there was no record of the nature of each trade to provide an audit trail;
d) no formal lists of authorized counterparties (and limits for such counterparties) and brokers; and
e) reconciliation of daily positions to nostro bank statements was not documented.

Contingency plan

70. Plans should be in place to provide contingency systems and operations support in the case of a natural disaster or systems failure. These should include emergency back-up for dealing functions as well as critical support functions. Contingency plans should be reviewed and tested on a regular basis.

INTERNAL AUDIT

71. Internal audit is an important part of the internal control process. Among the tasks of the internal audit function should be:

a) to review the adequacy and effectiveness of the overall risk management system, including compliance with policies, procedures and limits;

b) to review the adequacy and test the effectiveness of the various operational controls (including segregation of duties) and staff's compliance with the established policies and procedures; and

c) to investigate unusual occurrences such as significant breaches of limits, unauthorized trades and unreconciled valuation or accounting differences.

72. The greater the size, complexity and geographical coverage of the derivatives business, the greater the need for experienced internal auditors with strong technical abilities and expertise. The MA considers that some internal audit functions of authorized institutions have not possessed these qualities in relation to derivatives.
73. It is essential that the internal audit function should have the necessary status within the organization for its recommendations to carry weight. The head of internal audit should if necessary have direct access to the board, audit committee and the chief executive. Line management must not be able to water down the findings of internal audit reviews.

74. In preparing internal audit reports, major control weaknesses should be highlighted and a management action plan to remedy the weaknesses should be agreed with a timetable. As the Barings case illustrates, it is essential that major weaknesses are remedied quickly (the dangers posed by the lack of segregation of duties in Singapore had been identified in an internal audit review carried out in mid-1994, but the situation had not been rectified by the time of the collapse). While implementation is the responsibility of management, internal audit should conduct follow-up visits within a short space of time in the case of significant weaknesses. Failure of management to implement recommendations within an agreed timeframe should be reported to the Audit Committee.

Hong Kong Monetary Authority
March 1996

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1. **Credit risk**

Credit risk is the risk of loss due to a counterparty's failure to perform on an obligation to the institution. Credit risk in derivative products comes in two forms:

- **Pre-settlement risk** is the risk of loss due to a counterparty defaulting on a contract during the life of a transaction. The level of exposure varies throughout the life of the contract and the extent of losses will only be known at the time of default.

- **Settlement risk** is the risk of loss due to the counterparty's failure to perform on its obligation after an institution has performed on its obligation under a contract on the settlement date. Settlement risk frequently arises in international transactions because of time zone differences. This risk is only present in transactions that do not involve delivery versus payment and generally exists for a very short time (less than 24 hours).

2. **Market risk**

Market risk is the risk of loss due to adverse changes in the market value (the price) of an instrument or portfolio of instruments. Such exposure occurs with respect to derivative instruments when changes occur in market factors such as underlying interest rates, exchange rates, equity prices, and commodity prices or in the volatility of these factors.

3. **Liquidity risk**

Liquidity risk is the risk of loss due to failure of an institution to meet its funding requirements or to execute a transaction at a reasonable price. Institutions involved in derivatives activity face two types of liquidity risk: market liquidity risk and funding liquidity risk.
Market liquidity risk is the risk that an institution may not be able to exit or offset positions quickly, and in sufficient quantities, at a reasonable price. This inability may be due to inadequate market depth in certain products (e.g. exotic derivatives, long-dated options), market disruption, or inability of the bank to access the market (e.g. credit down-grading of the institution or of a major counterparty).

Funding liquidity risk is the potential inability of the institution to meet funding requirements, because of cash flow mismatches, at a reasonable cost. Such funding requirements may arise from cash flow mismatches in swap books, exercise of options, and the implementation of dynamic hedging strategies.

4. Operational risk

Operational risk is the risk of loss occurring as a result of inadequate systems and control, deficiencies in information systems, human error, or management failure. Derivatives activities can pose challenging operational risk issues because of the complexity of certain products and their continual evolution.

5. Legal risk

Legal risk is the risk of loss arising from contracts which are not legally enforceable (e.g. the counterparty does not have the power or authority to enter into a particular type of derivatives transaction) or documented correctly.

6. Regulatory risk

Regulatory risk is the risk of loss arising from failure to comply with regulatory or legal requirements.

7. Reputation risk

Reputation risk is the risk of loss arising from adverse public opinion and damage to reputation.

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Annex B

RISK MEASUREMENT METHODOLOGIES

1. Notional amount or volume of contracts

This simply refers to the notional amount of the contract and is the most basic form of risk measurement. The main advantage of this measure is its simplicity which allows net and gross positions to be computed easily and quickly. It is useful as one of the means for limiting business volume, and liquidity and settlement risks.

However, the notional amount only provides an indication of the volume of business outstanding and bear little relation to the underlying risks of the exposure as it does not take account of cash flows, price sensitivity or price volatility. Also, for sophisticated institutions, the nominal measurement method does not allow an accurate aggregation of risks across all instruments. This method should not be used on a stand-alone basis.

2. Month-million

This is the product of the notional amount of the contract expressed in millions and the remaining term of the contract expressed in number of months. For example, the month-million of an interest rate contract with an amount of $60 million and a remaining term of three months is calculated as follows:

\[ 3 \text{ months} \times 60 \text{ million} = 180 \text{ month-million}. \]

This method is commonly used by market participants for measuring exposure in interest rate products. It is simple in nature and is better than the notional amount as it also takes account of the remaining maturity of the contract which is a relevant factor in assessing the market risk of interest rate products. However, similar to the nominal measurement method, it does not take account of the underlying instrument’s cash flow, price sensitivity or price volatility.
Furthermore, contracts with the same month-million may have significantly different risk exposures. For example, an interest rate contract with an amount of $60 million and a remaining term of three months ($3 \text{ months} \times $60 \text{ million} = $180 \text{ month-million}) has the same month-million of another interest rate instrument with an amount of $3 million and a remaining term of five years (60 \text{ months} \times $3 \text{ million} = $180 \text{ month-million}). Although these two instruments have the same month-million, their risk profiles (short-term vs long term) are quite different and should be managed differently.

This method should not therefore be used on a stand-alone basis by active derivatives participants.

3. **Duration**

Duration is a measure of the sensitivity of the present value or price of a financial instrument to a change in interest rates. Conceptually, duration is the average time to the receipt of cash flows weighted by the present value of each of the cash flows in the series. This measurement technique calculates price sensitivities across different instruments and converts them to a common denominator. Duration analysis can estimate the impact of interest rate changes on the present value of the cash flows generated by a financial institution's portfolio. For example, if the modified duration (duration divided by 1 + yield) of a security is 5, the price of the security will decrease by 5 percent approximately, if the related yield increases by one percent.

The **Price Value Basis Point (PVBP)** measurement is a common application of the duration concept. This methodology assesses the change in present value of a financial instrument or a portfolio of instruments due to a one basis point change in interest rates. PVBP is calculated by multiplying the price of the instrument by its modified duration and then by a factor of 0.0001. For example, a one basis point increase in yield would decrease the price of a bond with a modified duration of 5 from 100 to 99.95. PVBP is a useful tool for sensitivity analysis of a position or a portfolio. It also provides a quick tool for traders to evaluate their profit and loss due to a basis point movement in interest rates.
However, the duration method also has certain limitations. Duration methods focus on sensitivity analysis but not probability analysis. They do not tell how the value of a security or a portfolio of securities would be likely to change based on past experience. Also, for large rate movements (by more than one percent), duration tends to provide inaccurate results as the true relationship between a change in price and a change in interest rate is not linear. This can be remedied to some extent by combining duration measures with convexity measures (measuring the rate of change of duration as yield changes).

4. Value at Risk

This is a sophisticated method increasingly used by major market participants to assess the risk of their whole trading book. The “value at risk” (VAR) approach uses probability analysis based on historical price movements of the relevant financial instruments and an appropriate confidence interval to assess the likely loss that the institution may experience given a specified holding period. It combines both probability analysis and sensitivity analysis. The following is a simplified illustration of the concept:

A bank has an open USD/DEM position of $1 million. The historical data indicates that the one-day volatility during an adverse USD/DEM exchange rate movement is 0.08 percent. The value at risk based on one standard deviation is:

\[ \$1 \text{ million} \times 1(0.08 \text{ percent}) = \$800 \]

The value at risk based on three standard deviations is:

\[ \$1 \text{ million} \times 3(0.08 \text{ percent}) = \$2,400 \]

This example can be interpreted that there is an approximately 16 percent probability (one standard deviation) based on the past price movement experience that the bank may lose $800 or more overnight, and approximately 0.14 percent probability (three standard deviation) the bank may lose $2,400 or more. Additionally, the longer the holding period that is used, for example, five or ten days instead of overnight, the larger the value at risk.
There are three main VAR approaches: variance/covariance, historical simulation and Monte Carlo simulation. Under the variance/covariance approach, an institution uses summary statistics on the magnitude of past price movements in the relevant market factors (interest rates, exchange rates, etc.), the estimated sensitivity of the positions/portfolio to movement in market factors, and correlations between price movements to estimate likely potential losses in its portfolio of trading book positions. Under the historical simulation approach, an institution bases its expectation of potential future losses on calculations of the losses that would have been sustained on that book in the past using data on past price movements. Under the Monte Carlo simulation approach, an institution uses models to generate many scenarios randomly in order to obtain the distribution of portfolio values to estimate the potential future losses.

To derive the value at risk, the institution needs to determine the confidence interval, minimum holding period and minimum sample period for calculating volatilities and correlations. The Basle Committee has specified the standards that should be adopted by banks which use internal models for calculating the capital requirements under its market risk regime. These are set out in Annex C.
Minimum Quantitative Standards Specified by the Basle Committee for Models Used to Calculate Market Risk Capital Requirements

1. Quantitative standards

- Value at risk (VAR) should be computed daily.
- A 99% one-tailed confidence interval should be used.
- Minimum holding period (or liquidation period) would be ten trading days. However, banks may use the VAR numbers calculated according to shorter holding periods scaled up to ten days. In the case of options positions or positions that display option-like characteristics, the scale-up approach is allowed as an interim measure only. Banks with such positions are expected to ultimately move towards the application of the minimum holding period of ten trading days. In allowing banks to use the scale-up approach for options positions, supervisory authorities may require these banks to adjust their capital measure for options risk through other methods, e.g. periodic simulations or stress testing.
- The minimum sample period for calculating volatilities and correlations is one year. For banks that use a weighting scheme or other methods for the historical observation period, the “effective” observation period must be at least one year (i.e. the weighted average time lag of the individual observations cannot be less than six months).
- Volatilities and correlations data should be updated at least quarterly and whenever market prices are subject to material changes.
- Correlation may be used to offset VAR both within and across broad risk categories (e.g. interest rates, exchange rates, equity prices and commodity prices).
• Options risk should be captured; risk associated with volatilities of the rates and prices (vega risk) should be accounted for. For complex option portfolios, term structures of volatilities should be used as the risk factors.

• Each bank must meet, on a daily basis, a capital requirement as the higher of (i) its previous day's VAR number and (ii) an average of the daily VAR of the preceding sixty business day multiplied by a multiplication factor (of at least 3) set by its supervisor.

Separate capital charge to cover specific risk of traded debt and equity securities, to the extent that this risk is not incorporated into the models, is required.

2. Specification of Market Risk Factors

An important part of a bank's internal market measurement system is the specification of an appropriate set of market risk factors, i.e. the market rates and prices that affect the value of the bank's trading positions. The risk factors used in the internal risk management model should be sufficient to capture the risks inherent in an institution's portfolio of on- and off-balance sheet trading positions. In specifying the risk factors, institutions should take into account the following:

Interest rate based instruments

• The yield curve should be divided into various maturity segments to capture the variation in the volatility of interest rates along the curve.

• There will typically be one risk factor per segment. For exposures to interest rate movements in the major currencies and markets, a minimum of six risk factors (i.e. six maturity segments) is recommended. However, the number of risk factors should ultimately be driven by the nature of the institution's trading strategies.

• The system must incorporate separate risk factors to capture spread risk, e.g. difference between bonds and swaps, at various points along the yield curve.
Exchange rate based instruments

• There should be one risk factor (i.e. the foreign exchange rate against the domestic currency) for each currency in which the bank has a significant exposure.

Equity based instruments

• There should be a risk factor corresponding to each equity market in which the bank holds significant positions.

• The minimum standard is to have one broad-based equity index as a risk factor in a market, and use “beta-equivalents” to relate it to individual stocks. However, more than one index could be used (for example sector indices) in a single market.

• The level of sophistication of the modelling technique should correspond to the bank’s exposure to the overall market as well as its concentration in individual equity issues in that market.

Commodity based instruments

• For limited positions in commodity-based instruments, it might be acceptable to use a single risk factor for a relatively broad class of commodities (e.g. a single risk factor for all class of oils).

• For more active trading, the model must account for the variation in the “convenience yield” (i.e. the benefits from direct ownership of the physical commodity e.g. the ability to profit from temporary market shortages) between derivatives positions such as forwards and swaps and cash positions in the commodity.
COMMONLY USED MARKET RISK LIMITS

1. NOTIONAL OR VOLUME LIMITS

Limits based on the notional amount of derivatives contracts are the most basic and simplest form of limits for controlling the risks of derivatives transactions. They are useful in limiting transaction volume, and liquidity and settlement risks. However, these limits cannot take account of price sensitivity and volatility and say nothing about the actual level of risk (in capital or earnings terms) faced by the institution. Derivatives participants should not therefore use these limits as a stand-alone tool to control market risk.

2. STOP LOSS LIMITS

These limits are established to avoid unrealized loss in a position from exceeding a specified level. When these limits are reached, the position will either be liquidated or hedged. Typical stop loss limits include those relating to accumulated unrealized losses for a day, a week or a month.

Some institutions also establish management action trigger (MAT) limits in addition to stop loss limits. These are for early warning purposes. For example, management may establish a MAT limit at 75 percent of the stop loss limit. When the unrealized loss reaches 75 percent of the stop loss limit, management will be alerted of the position and may trigger certain management actions, such as close monitoring of the position, reducing or early closing out the position before it reaches the stop loss limits.

The above loss triggers complement other limits, but they are generally not sufficient by themselves. They are not anticipatory; they are based on unrealized losses to date and do not measure the potential earnings at risk based on market characteristics. They will not prevent losses larger than the stop loss limits if it becomes impossible to close out positions, e.g. because of market illiquidity.
3. Gap or maturity band limits

These limits are designed to control loss exposure by controlling the volume or amount of the derivatives that mature or are repriced in a given time period. For example, management can establish gap limits for each maturity band of 3 months, 6 months, 9 months, one year, etc. to avoid maturities concentrating in certain maturity bands. Such limits can be used to reduce the volatility of derivatives revenue by staggering the maturity and/or repricing and thereby smoothing the effect of changes in market factors affecting price. Maturity limits can also be useful for liquidity risk control and the repricing limits can be used for interest rate management.

Similar to notional and stop loss limits, gap limits can be useful to supplement other limits, but are not sufficient to be used in isolation as they do not provide a reasonable proxy for the market risk exposure which a particular derivatives position may present to the institution.

4. Value at risk limits

These limits are designed to restrict the amount of potential loss from certain types of derivatives products or the whole trading book to levels (or percentages of capital or earnings) approved by the board and senior management. To monitor compliance with the limits, management calculates the current market value of positions and then uses statistical modelling techniques to assess the probable loss (within a certain level of confidence) given historical changes in market factors (details are set out in Annex B).

The advantage of value at risk (VAR) limits is that they are related directly to the amount of capital or earnings which are at risk. Among other things, they are therefore more readily understood by the board and senior management. The level of VAR limits should reflect the maximum exposures authorized by the board and senior management, the quality and sophistication of the risk measurement systems and the performance of the models used in assessing potential loss by comparing projected and actual results. One drawback in the use of such models is that they are only as good as the
assumptions on which they are based (and the quality of the data which has been used to calculate the various volatilities, correlations and sensitivities).

5. **Options limits**

These are specifically designed to control the risks of options. Options limits should include Delta, Gamma, Vega, Theta and Rho limits.

**Delta** is a measure of the amount an option’s price would be expected to change for a unit change in the price of the underlying instrument.

**Gamma** is a measure of the amount delta would be expected to change in response to a unit change in the price of the underlying instrument.

**Vega** is a measure of the amount an option’s price would be expected to change in response to a unit change in the price volatility of the underlying instrument.

**Theta** is a measure of the amount an option’s price would be expected to change in response to changes in the option’s time to expiration.

**Rho** is a measure of the amount an option’s price would be expected to change in response to changes in interest rates.
Recommendations on Operational Controls

This Annex sets out recommended best practices in the following major areas of operational controls:

A. Segregation of duties
B. Trade entry and transaction documentation
C. Confirmation procedures
D. Settlement and disbursement procedures
E. Reconciliation procedures
F. Revaluation procedures
G. Exceptions reports
H. Accounting procedures

A. Segregation of duties

- There should be clear segregation, functionally and physically, between the front office and back office.

- Job descriptions and reporting lines of all front office and back office personnel should support the principle of segregation of duties outlined in the institution’s policies.

- The process of executing trades should be separated from that of confirming, reconciling, revaluing, or settling these transactions or controlling the disbursement of funds, securities or other payments, such as margins, commissions, fees, etc.

- Individuals initiating transactions should not confirm trades, revalue positions for profit and loss calculation, approve or make general ledger entries, or resolve disputed trades.

- Access to deal recording, trade processing and general ledger systems should be restricted by using physical access controls e.g. user ID and password codes and terminal access controls.

Guideline on Risk Management of Derivatives and Other Traded Instruments
• There should be a unit independent of the trading room responsible for reviewing daily reports to detect excesses in approved trading and credit limits.

B. TRADE ENTRY AND TRANSACTION DOCUMENTATION

• Management should ensure that procedures are in place to provide a clear and fully documented audit trail of derivatives transactions. These procedures should be adequate to inform management of trading activities and to facilitate detection of non-compliance with policies and procedures. The information on derivatives transactions should be in a format that can be readily reviewed by the institution’s management as well as by internal and external auditors.

• There should be sufficient accounting and other records that capture and record on a timely basis and in an orderly fashion every transaction which the institution enters into to explain:
  - its nature and purpose (e.g. trading or hedging);
  - any asset and/or liability, actual and contingent, which respectively arises or may arise from it; and
  - any income and/or expenditure, current and/or deferred, which arises from it.

• All derivatives transactions should be sequentially controlled (e.g. the use of prenumbered dealing slips), timed and tracked by tape recording of dealers' telephones to ensure that all deals are accounted for and to provide an audit trail for deals effected. Sequence of the prenumbered forms should be reviewed and accounted for periodically. Tape recording equipment should not be accessible by the dealers and should remain under the control of management.

• To establish valid contracts, records of original entries should capture sufficient details, including:
  - Time and date of execution.
  - Name of dealer executing transactions.
  - Name of staff entering transaction data (if different from dealer).
- Name of counterparty.
- Type of instrument, price, and amount.
- Settlement or effective date.
- Payment or settlement instructions.
- Brokers’ fees or commissions and other expenses.

- Dealers should maintain a position sheet for each product traded and continuous position reports in the dealing room. Dealers’ position reports should be submitted to management for review at the end of each trading day.

- Daily position report should be prepared from the institution’s processing system/general ledger by back office personnel. The reports should include all transactions and be reconciled daily to the dealer’s position reports.

- Every transaction should be updated (i.e. mark to market) in the calculation of market and credit risk limits.

- There should be sufficient transaction documentation to support limit reporting and a proper audit trail. A unit independent of the front office should be responsible for reviewing daily reports to detect excesses of approved trading limits.

- There should be an approved list of brokers, counterparties and explicit policies and procedures for dispute resolution.

- Dealers should adhere to stated limits. If limit excesses arise, management approval should be obtained and documented prior to execution of the transaction. There should be adequate records of limit excesses.

- Deals should be transacted at market rates. The use of off-market rates as a base for the renewal of maturing derivatives contracts should be on an exception basis and subject to the following conditions:
  - it is permitted in accordance with stated policies and procedures of the institution and the justification and approval of such transactions are documented;
- the customer had specifically requested it;
- it was known to the institution that the customer did so with full internal authority, being aware of the possibility that a loss could be concealed thereby; and
- the relevant contracts will be marked to market so that the discounted value of the contract and the loss arising from using the off-market rate can be shown in the institution’s accounts and its returns to the MA.

C. Confirmation Procedures

- The method of confirmation used should provide a documentation trail that supports the institution’s position in the event of disputes.

- Outgoing confirmations should be initiated no later than one business day after the transaction date. Any use of same-day telephone confirmations should be taped-recorded and followed with written confirmations. Oral confirmation will be accepted only if the lines are taped and agreed with counterparty in advance.

- Outgoing confirmations should contain all relevant contract details and be delivered to a department independent of the trading unit of the counterparty. Follow-up confirmations should be sent if no corresponding, incoming confirmation is received within a limited number of days after the contract is effected. The accounting/filing system should be able to identify booked contracts for which no incoming confirmations have been received. Records of outstanding unconfirmed transactions should be kept and reviewed by management on a regular basis.

- Incoming confirmations should be delivered to the designated personnel who are responsible for reconciling confirmations with trading records and not to trading personnel.

- All incoming confirmations should be verified with file copies of contracts/dealing slips and for authenticity. All discrepancies should be promptly identified and investigated by an officer independent of the trading
function for resolution. They should also be tracked, aged, and reported to management. Trends by type should be identified and addressed.

**D. SETTLEMENT AND DISBURSEMENT PROCEDURES**

- Specific procedures should be established for the initiation of, and authority for, fund transfer.

- No one person in a fund transfer operation (e.g. SWIFT) should be responsible for the processing, verifying and approving of a request. Only authorised persons with appropriate segregation of duties should have access to fund transmission systems, cash books, account information, and terminal facilities.

- Reasons underlying requests for funds should be analysed and documented. Settlement staff should be alert to any unusual transactions and immediately report them to management. They should distinguish between payments made on behalf of the institution and those on behalf of clients.

- Institutions must determine the authenticity of fund transfer requests before payments are released. This may include direct telephone confirmation with the counterparty in addition to the verification of test keys.

- In case test keys are used to verify the authenticity of requests for transfer of funds, such test keys should be separated into two parts (fixed and variable) and reset with the counterparty on at least a yearly basis. Each part should be kept by a different staff. No test key holders should be allowed to access the telex room.

- Payments should be properly authorised prior to disbursement of funds. Dual approvals should be required for large payments to help ensure validity and correctness, whether released manually or via SWIFT, tested telex or similar transmission systems. Access to the transmission system should be properly approved and granted on a need-to-perform basis and periodically reviewed by line management. In addition, adequate procedures should be established to control password maintenance,
addition and deletion of operators, and other system changes.

- Institutions should retain logs recording transfer request information, assign sequential numbers to incoming and outgoing messages, and copies of all messages received on fund transmission systems. At the end of each business day, request forms should be compared to the actual transfer to ensure that all transfers are properly authorised and carried out.

- There should be clear policy on the appropriateness of accepting requests for "third-party payment", i.e. payment instructions to the account of an individual, institution or corporation other than that of the counterparty to the transaction. To ensure the accuracy and authenticity of all payment instructions for payments to and from counterparties, in particular those involving third party names, management may adopt various measures including:
  - Requiring an authenticated confirmation of the payment instruction on the transaction date;
  - Requiring the counterparty to submit a list of individuals authorised to transact business and to confirm deals;
  - Confirming by telephone all deals on the settlement date directly with the counterparty; and
  - Rejecting payment instructions to account numbers without corresponding names.

- Daily independent reconciliation of transferred funds with nostro accounts and general ledger is an essential control for detection of errors or misapplications of funds.

E. Reconciliation procedures

- All pertinent data, reports, and systems should be reconciled on a timely basis to ensure that the institution's official books agree with dealers' records. At the minimum, the following reports should be reconciled:
  - Dealer’s positions to operational database.
  - Operational database to general ledger (including suspense accounts).
- Dealer’s profit and loss statement to profit and loss account.
- General ledger to regulatory reports.
- For exchange traded products, brokers’ statements (or the exchange’s statements) to general ledger and the income statement.

• The reconciliation of front office positions should be performed by an individual independent of dealing function. Internal auditors should be responsible for ensuring that reconciliation procedures are properly performed.

• The frequency of the reconciliations should be commensurate with the scale, significance and complexity of the trading operation. Active dealers should reconcile dealer’s positions and profit and loss statements to the operational database and general ledger on a daily basis.

• Unusual items and any items outstanding for an inordinately long period of time should be investigated.

• There should be adequate audit trail to ensure that balances and accounts have been properly reconciled. Reconciliation records and documentation should be maintained and independently reviewed. Such record should be kept for an appropriate period of time prior to their destruction.

F. Revaluation procedures

• The revaluation procedures should cover the full range of derivatives instruments included in the institution’s trading portfolio.

• Revaluation rates should be obtained from or verified by a source (or different sources in the case of OTC derivatives) independent of the dealers, representative of the market levels and properly approved. Revaluation calculations should be independently checked.

• Revaluation of accounts should be performed at least monthly. For active market participants, revaluations should be performed on a daily basis.
• Profits and losses resulting from revaluation should be posted to the
genial ledger at least once a month and positions should be marked-
to-market regularly for risk control and MIS purposes.

• If models are used to derive or interpolate specific market factors,
assumptions and methodologies used should be consistent and
reasonable, and should be reviewed periodically by the independent
risk control unit. Any changes of the assumptions and methodologies
should be justified and approved by management.

• Revaluation rates and calculations should be fully documented.

G. EXCEPTIONS REPORTS

• To track errors, frauds and losses, the back office should generate
management reports that reflect current status and trends for the
following items:
  – Outstanding general ledger reconciling items.
  – Failed trades.
  – Off-market trades.
  – After-hours and off-premises trading.
  – Aging of unconfirmed trades.
  – Suspense items payable/receivable.
  – Brokerage payments.
  – Miscellaneous losses.

• The management information system/reporting system of the institution
should enable the detection of unusual patterns of activity (i.e. increase
in volume, new trading counterparties, etc.) for review by management.

H. ACCOUNTING PRINCIPLES

• Institutions should have written accounting policies relating to trading
and hedging with derivatives instruments, which are in conformity
with generally accepted accounting principles and approved by senior
management.
• Transactions should be categorised according to whether they were entered into for trading purposes or whether they were entered into to hedge existing assets, liabilities, other off-balance sheet positions or future cash flow. Adequate evidence of intention to hedge should be established at the outset of the hedging transaction and there should be clearly defined procedures in place for identifying such transactions.

• Trading transactions should be marked to market. Hedging transactions should be valued on the same basis as the related assets, liabilities, positions or future cash flows.

• The setting up and use of suspense accounts should be properly controlled.

• Institutions should report derivatives transactions in regulatory reports and annual accounts in conforming with their established accounting policies.

• For financial instruments which are netted for financial reporting and regulatory reporting, institutions should ensure that the relevant netting agreements conform with the criteria issued by the MA or other relevant authorities permitting such setoff.
This book is due for return or renewal on the date shown unless previously recalled. Fines may be incurred for late return.

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