Value at Risk: An Approach to Calculating Market Risk

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1. Introduction

This paper will discuss market risk in banks as the basis for determining capital adequacy, focusing on the variety of bank risks associated with volatility of market rates and prices. The purpose of the paper is to identify the best approach to calculating market risk for Indonesian banks and to provide guidelines for banks' management in the choice of the most appropriate internal model. Additionally, the results of this study will be used as additional input in the analysis of supervisory tools available to the central bank of Indonesia and to assist in the design of capital adequacy regulation with respect to market risk.

Most banks in Indonesia may not be very sensitive to foreign exchange risk. However, capital adequacy with respect to market risk is still necessary for Indonesian banks if we anticipate the further development of banks, which are involved in cross-border operations where the host countries apply capital adequacy assessment with respect to market risk. Additionally, there are many foreign banks in Indonesia, which have been assessed using market risk by their home country authorities. If we examine banks individually, probably there will be some which are in fact sensitive to market risk. To clarify this issue, this study will conduct an empirical investigation to examine market risk in the largest banks in Indonesia.

This chapter is organised in the following way: Section 2 discusses the basic procedure for calculating market risk; Section 3 describes the regulatory approach to market risk (BIS); Section 4 discusses value at risk as an alternative method to assess market risk; Section 5 concludes the discussion.

2. Basic Procedure to Assess Market Risk

2.1. General Overview

In general, the procedure for calculating risk in banking begins with a calculation of the market value of the positions and continues with an estimation of the future value of the positions as a result of estimation of changes in rates and prices. Risk is the probability associated with the value of banks in the future. Therefore, to calculate the market risk of banks we need to: (1) calculate the value of the current positions (as defined above); and (2) estimate the value of the positions in the future (next day, next week, or at some point in the future). This study will adopt this procedure to calculate banks' market risks (for further details, see Figure 3).

There are a variety of approaches to calculating market risk. In general, we can distinguish two categories: the regulatory approach and alternative approaches. Banks normally use both categories. The adoption of the regulatory approach is necessary to comply with regulation and the adoption of an alternative approach (i.e. internal models) is necessary to manage risk in an optimal way. In fact, the regulatory authorities usually allow banks to use alternative methods to calculate minimum capital adequacy requirements with respect to market risk under certain guidelines. For these reasons, this study will embrace both regulatory and alternative methods.

2.2. Identification of Exposures

Before calculating the risk of a certain position, we need to identify the exposure of the position on a certain day when the risk is calculated. In general, the position consists of spot and forward elements. The identification of exposure for a spot position is straightforward: multiply the accounting value of the position by the market value or spot rate. In case of forward positions, we will adopt the theory of economic value. Based on this theory, the value of the current position (economic value) is the net present value of the future cash flows. Technically, the process to identify the future cash flows of the positions is called mapping. However, there are some factors, which influence the present value of forward positions such a discount factors, exchange rates, and prices. This study will use the volatility of each relevant factor to calculate the present value of cash flows. For instance, if there are two cash in-flows of £100 for one and two months ahead, the present value is calculated based on the volatility of one-month and two-month yields.

In general, this study will adopt the valuation theories of financial instruments to calculate the current values of positions. Cash flow identification is the first step in risk valuation for forward positions. The objective of this process is to identify the risk factors (i.e. volatility and correlation) to which the cash flows are sensitive. The next step is to calculate the current exposures by discounting the future cash flows with current market rates. In the absence of interest rate references, such as LIBOR, SIBOR, etc., the current exposure can be derived by discounting future cash flows using a zero coupon rate. The following section discusses in detail each step using some examples.

In general, bank positions, which are sensitive to market risk can be classified into four broad categories: fixed income (i.e. income is based on interest rate income), foreign exchange, equities and commodities. However, only fixed income and foreign exchange exposures are relevant for banks in Indonesia[2]. The discussion below is thus limited to a consideration of fixed income and foreign exchange exposures.

2.2.1. Fixed Income Exposures

Earnings from a fixed income position depend on the amount to be paid, the period of repayment, and the performance of the payer (i.e. credit quality). In the discussion below, we exclude the performance of the payer. Banks normally use one of the following methods in order to identify the distribution of cash flows over time: (1) duration map; (3) principal map; and (3) cash flow map.

The duration map approach was invented by Macaulay (1938). This approach calculates an exposure by using the weighted average life of coupons and principal payments. The approach recognises the risk exposure according to duration. The principal map assumes that the exposure occurs at the payment date of the principal. Before the payment occurs, this position only appears in the off-balance sheet book. Earnings and risks are expressed by using the accrual basis of valuation. When interest rates are volatile, this approach fails to represent the true earnings and risks. The cash flow map calculates the exposure based on the future stream of cash flows. However, this approach assumes that the expected flows are stable (i.e. no callable or putt able bonds).

To show the difference between the three maps, let us consider the position of a 10-year bond issued on 1 January 1994 with £1000 of nominal, 4.75% of half-yearly coupons, 11.44% of accrual yield to maturity and a market price of £900. From the above information, we can rewrite:

C=£47.5 (i.e. 4.75% x £ 1,000) , F=£1000, P_0=£900, R=11.44% per year or 5.72% per half year and N=20 (half-year periods), where C is coupon, F is future value, P_0 is current market value, R= yield (return) per year, N= the period.

Duration can be calculated as follows:

2 Banks in Indonesia are not allowed to perform transactions in equities or commodities.

$$D = \frac{C\left[\frac{(1+R)^{N+1} - 1(1+R) - RN}{R^2(1+R)^N}\right] + \left[\frac{F \times N}{(1+R)^N}\right]}{P_0} \quad (1)$$

$$= \frac{47.5\left[\frac{(1+0.0572)^{21} - 1(1+0.0572) - (0.0572 * 20)}{0.0572^2(1.0572)^{20}}\right] + \left[\frac{1,000 * 20}{(1.0572)}\right]}{900}$$

$$= 12.68 \text{ semi - annual periods, or } 6.34 \text{ years}$$

This method identifies that the exposure occurs in 6.34 years' time. The cash flow map identifies the exposure according to the future cash flows over time to expiration. Based on the above example, cash flows consist of £47.5 each half-year up to 9½ years and £1,047.5 at the maturity date. The principal map recognises the exposure only at the maturity date. Figure 9.1 shows the difference in risk exposure under the three approaches.

Figure 1. A

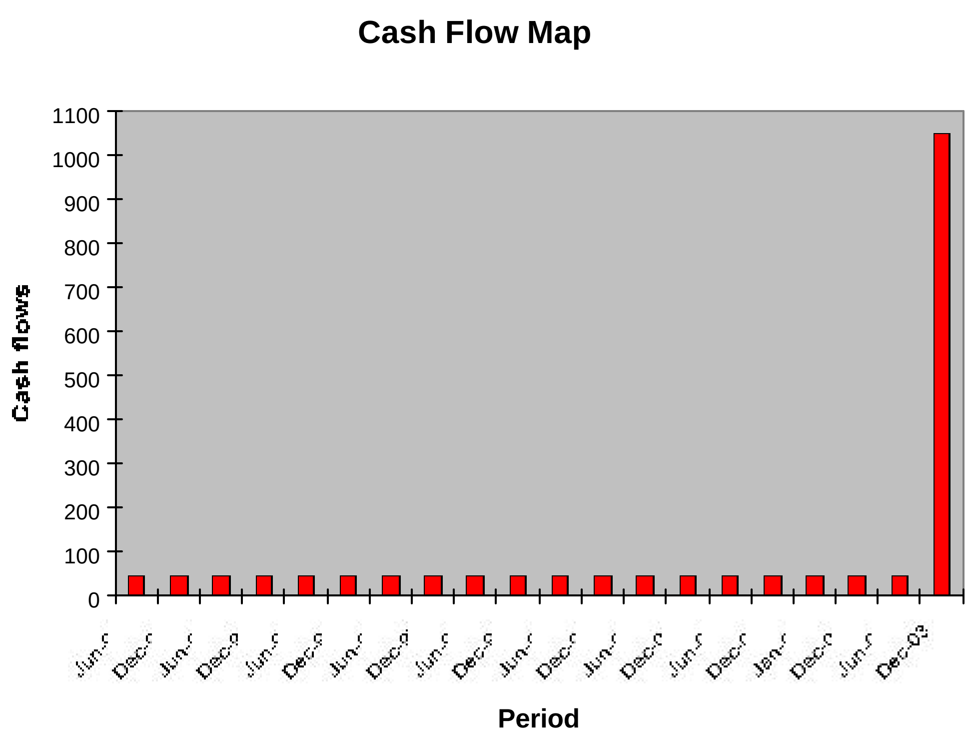


Figure 1. B

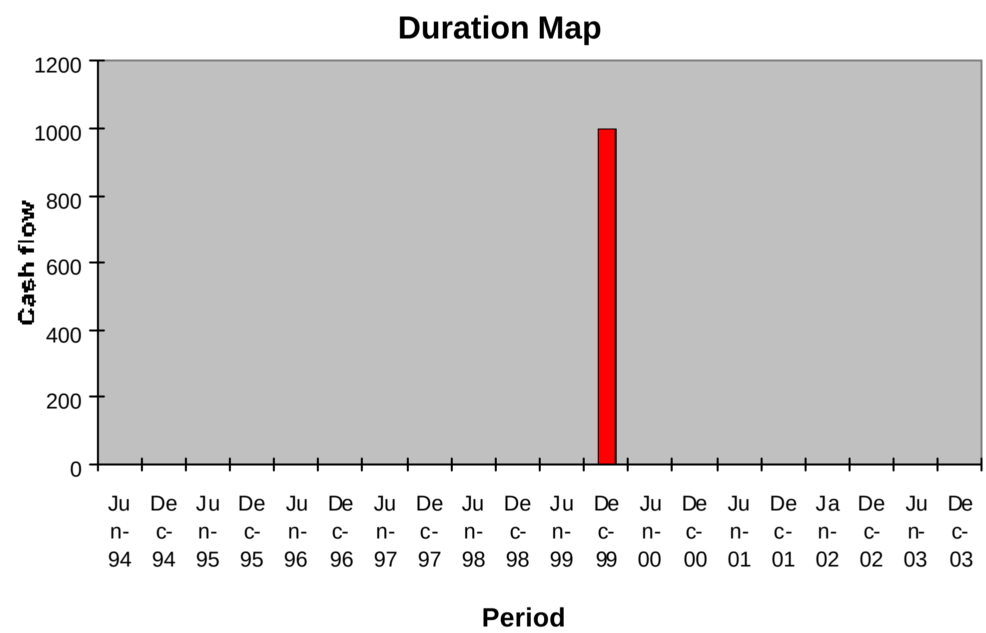
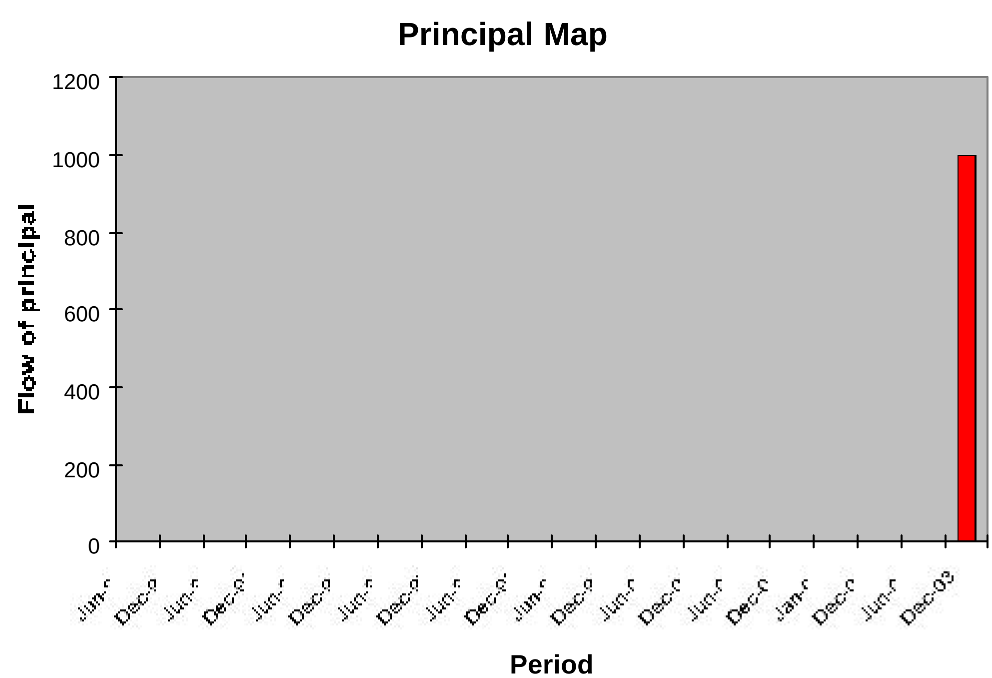


Figure 1.C



The cash flow approach provides the most accurate measure of risk (J.P. Morgan, 1994, pp.106-110). The risk of a related position is calculated by multiplying the market value of the position with the prices' or rates' volatilities and correlations.

2.2.2. Exposures Arising From Foreign Exchange Positions

To re-value foreign exchange positions, all positions must be calculated in the base currency (Indonesian Rupiah or IDR). This section will discuss how to construct spot and forward foreign exchange positions. The coverage of foreign exchange positions includes all foreign exchange positions (i.e. both in the banking and trading books). A spot foreign exchange position is converted into IDR by using the spot rate on the day when the risk is calculated.

Forward foreign exchange positions cover all positions in forward agreements, which exchange a certain amount of one currency for another at a future date. To calculate the market value of the position, we ignore the transaction cost and risk premia. Holdings of purchased forward foreign exchange contracts represent long positions in the purchased currency and short positions in other currencies; in other words, lending a purchased currency and borrowing another currency. For example, purchasing a one year currency forward of 10 million US$/IDR means borrowing IDRs and lending US$ in one year's time. To map the position, we need to know the IDR equivalent of USD 10 million on the maturity date using the forward rate. A forward rate is a term used to describe the market expectation about what the spot rate will be at the maturity date. One of the methodologies to estimate the forward rate is interest rate parity. This approach suggests that the forward rate depends on the interest rates of the two currencies and the spot exchange rate (Klopfenstein, 1993, p. 120). In mathematical form, the forward rate can be shown by the following equation:

$$f_{T,t} = S_t \frac{(1 + r_{T,t}^{Foreign})}{(1 + r_{T,t}^{Domestic})} \qquad (2)$$

where,

$f_{T,t}$ = the forward rate observed at time t, which locks in a spot rate at some future time T

S_t = the spot rate observed at time t

$r_{T,t}^{Foreign}$ = the foreign interest rate, observed at time t, for the time interval T-t

$r_{T,t}^{Domestic}$ = the domestic interest rate, observed at time t, for the time interval T-t

To provide more detail concerning the forward rate, we can use the example below. Let us assume that the following information is given:

(The following information is the basic data for buying USD100,000 forward)

a. The spot rate of USD/IDR: 2,500 with price volatility of 0.975%

b. USD yield per year: 6.0% with daily yield volatility of 1.25%

c. IDR yield per year: 10,0% with daily yield volatility of 2.5%

d. Maturity: 1 year

e. Nominal: USD 100,000

f. Risk correlation: see the following table

Table 1
Risk Correlation Matrix

	USD/IDR	**USD 1 year**	**IDR 1 year**
USD/IDR	1	0.0025	0.0050
USD 1 year	0.0025	1	0.10
IDR 1 year	0.0050	0.10	1

Using the above information, mapping can be performed by using the following procedure:

a. Calculating The Present Value Of The Future Cash Inflow Of USD 100,000

Based on the spot rates, the one-year yield of the two currencies, and the maturity, we can calculate the 1year forward rate of USD/IDR= $2500\left[\frac{(1+0.06*1)}{(1+0.1*1)}\right] = 2.623.76$

b. Calculating The Future IDR Position

IDR= 100,000 x 2623.76 =262,376,000

c. Calculating Price Volatility

Price volatility of 1 USD:

= Volatility of USD yield * Present value of interest on 1 USD received next year

= Volatility of USD yield * USD yield*{term/(1+USD yield * term)}

$$= 1.25\% \ x \, 0.06 \, x \frac{1}{(1.06 * 1)} = 0.0708\%$$

Price volatility of IDR is calculated by using the same formula:

$$= 2.5\% \, x \, 0.1 \, x \frac{1}{(1.1 * 1)} = 0.2273\%$$

d. Identifying The Positions

Risk in this transaction consists of four risk factors: the forward USD/IDR exchange rate, the USD yield volatility, the IDR yield volatility and correlations between these three. Each of the risks is associated with an exposure. The following table shows the exposures of the risk factors:

Table 2
Mapping of a Forward Foreign Exchange Position

Risk	Position	Present Value (Current Exposure)	Price Volatility
USD/IDR 1 year forward	(262,376,000) *	262,376,000x(1/1.1) = 238,523,636	0.975%
USD 1 year	100,000	100,000x(1/1.06) = 94,339	0.0708%
IDR 1 year	(262,376,000) *	262,376,000x(1/1.1) = 238,523,636	0.2273%

Note: *) Short position

e. Calculating Risk

Risk of each risk factor is the product of price volatility and the current exposure. Based on the example above, risk of each risk factor and diversified risk is as set out in the following table:

Table 3
Risk of a Forward Foreign Exchange Position

Position	Calculation	Risk
USD/IDR 1 year forward	(-238,523,636)*(0.975/100)	2,325,605.45
USD 1 year	94,339*(0.0708/100)*2623.76	175,246.21
IDR 1 year	(-238,523,636)*(0.2273/100)	542,164.22
	DeaR	3,043,015.88
	Diversified Risk	2,327,179.39

Ignoring the risk correlation, the risk of the positions is IDR 3,043,015.88[3]. By employing risk correlations, the diversified risk is IDR 2,327,179.39. The following discussion concerns the theory of risk in portfolio positions.

The variance of a portfolio is defined as the expected value of the squared deviations of the returns for the portfolio from its mean expected return. Example: r_1 = is the return for asset 1, r_2 = is the return for asset 2, r_p = is the return of the portfolio, w_1 is the investment in asset 1 and w_2 is the investment in asset 2.

$$s_p^2 = E[r_p - E(r_p)]^2 = \left[[w_1 r_1 + w_2 r_2] - [w_1 E(r_1) + w_2 E(r_2)]\right] \quad (3)$$

Grouping terms for the individual securities and factoring out the weights yields:

$$s_p^2 = \left(\{w_1[r_1 - E(r_1)]\} + \{w_2[r_2 - E(r_2)]\}\right)^2$$

Multiplying out, we obtain:

$$s_p^2 = w_1^2[r_1 - E(r_1)]^2 + w_2^2[r_2 - E(r_2)]^2 + 2w_1w_2[r_1 - E(r_1)][r_2 - E(r_2)]$$

where,

3 The risk exposure is calculated by summing the risks arising from the risk factors, whatever the sign (i.e. negative or positive).

$\left[r_1 - E(r_1)\right]$ = the standard deviation of expected returns on investment in asset 1 or $\boldsymbol{r}_1$

$\left[r_2 - E(r_2)\right]$ = the standard deviation of expected returns on investment in asset 2 or $\boldsymbol{r}_2$

$\left[r_1 - E(r_1)\right]\left[r_2 - E(r_2)\right]$ = the covariance between expected returns on investments in assets 1 and 2 or $Cov(r_1 r_2)$.

We can therefore express the equation above in the following form:

$$s^2 = w_1^2 s_1^2 + w_2^2 s_2^2 + 2 w_1 w_2 Cov(r_1, r_2) \qquad (4)$$

We can measure the strength of covariance between two returns by using the correlation coefficient $\left(p_{1,2}\right)$:

$$p_{1,2} = \frac{Cov(r_1, r_2)}{s_1 s_2} \rightarrow Cov(r_1, r) = p_{1,2} * s_1 s_2$$

Finally, the portfolio variance for a two asset model, can therefore be restated as follows:

$$s_p^2 = w_1^2 s_1^2 + w_2^2 s_2^2 + 2 w_1 w_2 p_{1,2} s_1 s_2 \qquad (5)$$

The variance of a three-security portfolio is:

$$s_p^2 = (w_1^2 s_1^2 + w_2^2 s_2^2 + 2 w_1 w_2 p_{1,2} s_1 s_2) + (w_1^2 s_1^2 + w_3^2 s_3^2 + 2 w_1 w_3 p_{1,3} s_1 s_3) + (w_2^2 s_2^2 + w_3^2 s_3^2 + 2 w_2 w_3 p_{2,3} s_2 s_3)$$

We can simplify into the following equation:

$$s_p^2 = \sum_{i=1}^{3} \sum_{j=1}^{3} \left(W_i^2 s_i^2 + W_j^2 s_j^2 + 2 r_{ij} s_i s_j W_i W \right) \qquad (6)$$

From the exercise above, we obtain evidence that the result for diversified risk is lower than the result of the sum of individual risks (by assuming that risk correlation is +1). See section 3.6.4 for detail.

3. Regulatory Approaches

3.1. General Overview

The discussion below begins by reviewing the risk calculation approach, which was introduced by the BIS in 1988. To calculate credit risk, the Committee on banking supervision, operating under the auspices of the BIS, (from now on this study will use the phrase “the Committee”) set out its approach in the Basle Capital Accord of 1988 (“the Accord”). One of the purposes of the Accord was to reduce the inequality of treatment via capital adequacy regulation to help provide the same competitive opportunities for international banks. This approach has been applied by most countries in the world including Indonesia. However, this approach has attracted many criticisms. According to Hall (1994), the Accord contains many weaknesses. Golding (1994) suggests that the ratios stipulated in the Accord are unrelated to true risks.

The Committee was aware of some of the deficiencies in the Accord’s attempt to address practical and universal needs. The Committee also recognised that many risks apart from credit risk may occur in banks. Therefore, the Committee agreed from the beginning to eventually capture market risk.

In April 1993, the Committee introduced a capital adequacy proposal to accommodate market risk in addition to credit risk. The proposal was revised several times and the final revision was released in January 1996. This revision actually represents an attempt to accommodate the industry’s requests and comments concerning the adoption of internal models. The discussion below contains the framework, risk components and risk valuation methodologies of the BIS proposal for capital regulation with respect to market risk.

3.2. Framework

The proposal contains methodologies on how to measure market risk, define capital and calculate minimum capital requirements for banks. The proposal adopts the following framework[4]:

- separating the “trading” from the “banking” books
- breaking the market risk into interest rate risk, foreign exchange risk, equity risk and commodities risk, and the treatments of derivatives
- calculating foreign exchange risk arising from both the “trading” and “banking” books
- adopting the “building block” approach where each market risk is calculated from specific risk and general market risk
- aggregating the risk in each component in order to get the total risk
- suggesting a treatment for option derivatives

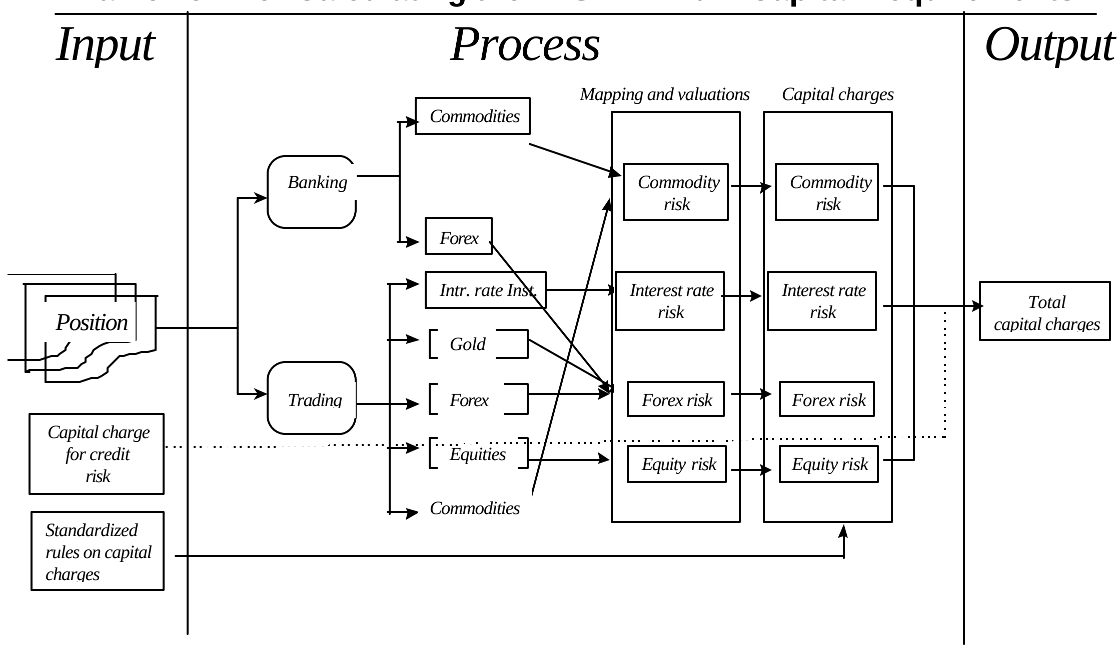
4 Information in this section is mainly derived from BIS’ proposals with respect to market risk (April 1993 and January 1996). See also Hall, 1995 and 1996.

According to the Committee, the trading book is defined as:

> "*the positions in financial instruments which are intentionally held for short-term resale and/or which are taken on by the bank with the intention of benefiting in the short-term from actual and/or expected differences between their buying and selling prices, or from other price or interest-rate variations, and positions in financial instruments arising from matched principal brokering and market making, or positions taken in order to hedge other elements of the trading book*". (BIS 1996, p.1)

There are some circumstances where non-trading instruments or off-balance sheet positions, which are used to hedge trading activities and trading positions are used to hedge the banking book. The proposal excludes these transactions from the market risk capital charge and subjects them, instead, to the credit risk charge as proposed in the Accord. The framework for calculating minimum capital requirements using the standardised methodology is shown in figure 2.

Figure 2
Framework for Calculating the BIS Minimum Capital Requirements



Note:
1. The derivative instruments are classified according to the underlying assets (interest rate, Forex, commodity or equity).
2. The standardised rules on capital charges in this case are just for market risk.

As mentioned in the previous section, the standardised methodology adopts the "building-block" approach in which specific risk and general market risk are calculated separately.

As shown in Figure 2, market risk is the accumulation of market risks, which occur in the banking book (i.e. foreign exchange risk and commodity risk) and the trading book (foreign exchange risk, interest rate risk, commodity risk and equity risk). Finally, we can identify that the overall minimum capital charge under the BIS's standardised methodology comprises the following items: (1) The minimum capital charge calculated by using the original Accord of 1988 (this calculation excludes debt securities in the trading book and all positions in commodities; however it includes counterparty risk deriving from all over-the-counter derivatives, regardless of whether they are in the trading or the banking book). (2) The arithmetical summation of the minimum capital charges for market risk.

3.3. Components of Risk

The previous discussion mentions that the proposal recognises interest rate risk, foreign exchange risk, commodity risk and equity risk. The discussion below covers in more detail the calculation of exposures, risk valuation methods, and capital charges.

3.3.1. Interest Rate Risk

Interest rate risk may occur in debt securities and other interest rate related instruments in the trading book (e.g. interest rate derivatives, forward rate agreements, other forward contracts, bond futures, interest rate and cross-currency swaps and forward foreign exchange positions). Sometimes, we find difficulty in distinguishing between debt securities and equities such as convertible bonds. The Committee uses the way the instruments are traded as the basis for determining whether the securities are debt or equities securities. If the instruments are traded as debt securities, banks can classify the instruments as debt securities and if the instruments are traded as equities, they can classify the instruments as equities. The calculation of interest rate risk differs amongst debt securities, interest rate- related derivatives and options. The treatment of options will be discussed in a separate section. The following discussion contains the risk calculation methods for debt securities and interest rate derivatives.

3.3.1.1. Debt Securities

According to the Committee, the regulatory authorities will require a minimum capital charge derived as the sum of weighted positions associated with specific and general market risk on debt securities. The specific risk is calculated based on percentages (weights) of either long or short positions. The purpose of specific risk capital charges is to prevent banks from losses as a result of adverse movements in the prices of individual securities because of factors related to individual issuers. Specific risk charges vary depending on the categories of bond issuers and the residual terms to final maturity. Appendix 1 provides more detail concerning the calculation of specific risk. The general market risk is designed to capture the risk of loss arising from changes in market interest rates. Banks may use either a “maturity” method or a “duration” method to calculate the exposure. There are 13 time bands in the “maturity” method and 15 time bands in the duration method. To slot each security into a specific time band, the proposal uses the residual maturity and the coupon as criteria. The proposal also classifies the time bands into 3 “zones”. These zones are designed to identify the capital charges as a result of off-settings among the bands and within the zones. The Committee employs assumptions concerning changes in yields and assigns risk weights to the time bands. Tables 4 and 5 show in detail the calculation of general market risk using the maturity method and the duration method respectively.

The general market risk is calculated according to the following steps: (1) slot the positions into corresponding time bands; (2) apply general market risk weights for each time band based on an assumed change of yields; (3) set-off the long and short positions within each time band (vertical off-setting) and apply a 10% “disallowance” to off-setting components; (4) set-off the long and short positions between time bands and apply 40% or 30% disallowances for off-setting components; (5) set-off the long and short positions between zone 1 and zone 2 on the one hand and zone 2 and 3 on the other, and apply a 40% disallowance for off-setting components; (6) apply a 100% risk charge to the remaining position.

According to the proposal, the exposure in bonds is assumed to be the same as the nominal amount outstanding in bonds. This assumption violates the fact that the nominal exposure is the sum of money received in the future and the current exposure must be calculated by discounting the nominal bond using discount factors. Additionally, the approach also assumes that all bonds are zero coupon bonds. In fact, there are many private bonds with coupons. Therefore, the current exposure of bonds is the present value of future cash flows, which consists of both coupons and principal repayments.

The interest rate risk is represented by the yield volatility over time to expiration. The regulatory approach uses percentages to proxy the yield volatility based on experience and agreement among member countries. This approach also ignores risk correlation among risk factors such as the risk correlation between yield volatility and foreign exchange volatility. This may lead to less accurate estimates of bank risk.

3.3.1.2. Interest Rate Derivatives

Unlike debt security positions, interest rate-related derivatives require the valuation of positions before employing capital charges. Interest rate derivatives include forward rate agreements (FRAs), other forward contracts, bond futures, interest and cross-currency swaps and forward foreign exchange positions. The calculation approaches vary according to the type of instrument. In general, we need to convert the derivatives into positions in the relevant underlying instruments. For futures and forward contracts, including forward rate agreements, the positions are calculated as combinations of long and short positions in the underlying instruments. Holding a three-month interest rate future that takes effect next month is calculated as a short position in the underlying instrument for one month and a long position in the underlying instrument for four months. Interest rate and currency swaps, FRAs, forward foreign exchange contracts and interest rate futures will not be subject to a specific risk charge. This exemption also applies to futures on an interest rate index (e.g. LIBOR). However, when the underlying instrument is a debt security, or an index representing a basket of debt securities, a specific risk charge will apply according to the credit risk of the issuers (which has been discussed in the previous section). The various categories of derivative instruments should be slotted into the maturity ladders and treated according to the rules identified for the treatment of debt securities in order to obtain general market risk charges for derivative instruments.

Swaps positions will be split into two positions: long floating and short fixed or long fixed and short floating. In a plain vanilla interest rate swap, one of the payments is floating interest against the receipt of fixed rate interest. In this case, the position will be split into

Table 4
Debt Securities' Risk Weights Under the BIS Proposals Using Maturity Method

Time-band	Time-band for coupon 3% or more	Time-band for coupon < than 3%	Assumed change in yields*	% risk weight	Horizontal Offsetting/disallowance (%)		
					Within the zone	Between adjacent zones	Between zones 1 and 3
	Zone I						
1	Up to 1 month	up to 1 month	1.00	0.00			
2	1 to 3 months	1 to 3 months	1.00	0.20	40		
3	3 to 6 months	3 to 6 months	1.00	0.40			
4	6 to 12 months	6 to 12 months	1.00	0.70			
	Zone 2					40	
5	1 to 2 years	1 to 1.9 years	0.90	1.25			
6	2 to 3 years	1.9 to 2.8 years	0.80	1.75	30		100
7	3 to 4 years	2.8 to 3.6 years	0.75	2.25			
	Zone 3					40	
8	4 to 5 years	3.6 to 4.3 years	0.75	2.75			
9	5 to 7 years	4.3 to 5.7 years	0.70	3.25			
10	7 to 10 years	5.7 to 7.3 years	0.65	3.75			
11	10 to 15 years	7.3 to 9.3 years	0.60	4.50			
12	15 to 20 years	9.3 to 10.6 years	0.60	5.25	30		
13	over 20 years	10.6 to 12 years	0.60	6.00			
		Zero coupon bond:					
		12 to 20 years	0.60	8.00			
		Over 20 years	0.60	12.50			

Note: *Assumed change in yield which is designed to cover about two standard deviations of one month's yield volatility in most major markets.

Source: Basle Committee on Banking Supervision, "Amendment to The Capital Accord to Incorporate Market Risks", January 1996.

Table 5
Debt Securities' Risk Weights Under the BIS Proposals Using Duration Method

No	Time-band	Duration weight	Assumed change in yields	Risk weight (%)	Vertical disallowance (%)	Horizontal offsetting /disallowance (%)		
1	2	3	4	5		Within the zone	Between adjacent zones	Between zone 1 and 3
	Zone I			**Column 5 = (4*3)**				
1	Up to 1 month	Duration *	1	Duration x 1	5			
2	1 to 3 months	Duration *	1	Duration x 1	5	40		
3	3 to 6 months	Duration *	1	Duration x 1	5			
4	6 to 12 months	Duration *	1	Duration x 1	5			
	Zone 2						40	
5	1 to 1.9 years	Duration *	0.9	Duration x 0.9	5			
6	1.9 to 2.8 years	Duration *	0.8	Duration x 0.8	5	30		100
7	2.8 to 3.6 years	Duration *	0.75	Duration x 0.75	5			
	Zone 3						40	
8	3.6 to 4.3 years	Duration *	0.75	Duration x 0.75	5			
9	4.3 to 5.7 years	Duration *	0.7	Duration x 0.7	5			
10	5.7 to 7.3 years	Duration *	0.65	Duration x 0.65	5			
11	7.3 to 9.3 years	Duration *	0.6	Duration x 0.6	5			
12	9.3 to 10.6 years	Duration *	0.6	Duration x 0.6	5	30		
13	10.6 to 12 years	Duration *	0.6	Duration x 0.6	5			
14	12 to 20 years				5			
15	Over 20 years	Duration *	0.6	Duration x 0.6	5			

Note: *) Duration is calculated using modified duration for each instrument

Source: Basle Committee on Banking Supervision, "Amendment to The Capital Accord to Incorporate Market Risks", January 1996.

A short position with maturity equivalent to the period until the next re-pricing of the interest rate and a long position with maturity equivalent to the residual life of the swap.

However, there are some interest rate swaps, which are related to stock indices. In this case, interest rate risk components will be slotted into maturity ladders and the equity risk components will be included in the equity framework. Similarly, for a cross-currency swap, which contains interest rate risk and foreign exchange risk, the exchange risk will be reported in the foreign currency framework.

Additionally, banks are allowed to offset their positions and exclude them from the interest rate maturity framework, both for specific risk and general market risk, since the positions are identical. For futures, the underlying instruments to which the futures contracts relate must be for identical products and mature within seven days of each other. Swaps and FRAs can be offset since they contain the same references of floating rate positions and the coupons are closely matched. Swaps, FRAs and forwards can be off-set since the residual maturity of the next interest re-fixing date or the maturity of fixed coupon or forwards must correspond within the following limits: (1) less than one month hence: same day; (2) between one month and one year hence: within seven days; (3) over one year hence: within 30 days.

The treatment of positions for derivatives instruments is similar to debt securities. The proposal does not employ the conversion of future cashflows into present value terms (i.e. only employs a notional amount) before employing proxies for specific and general market risk. Additionally, a position of a derivative instrument may not only be sensitive to the change of one risk factor, but may be sensitive to other risk factors simultaneously (e.g. exchange rate risk and interest rate risk). With the above treatment, we can identify the following deficiencies: (1) we are unable to obtain information on the whole risk from a position in a derivative instrument; (2) the total risk of the derivative instrument is calculated by summing the risk factors (i.e. ignores risk correlation among risk factors); (3) positions which are slotted into maturity ladders are not current exposure, but values which are received in the future. In fact, the current exposure of a forward rate agreement can be calculated by using the following procedure: (1) calculate the future cash flows for both currencies at the maturity date by using the forward rate; (2) calculate the present value of those future cash flows by using zero coupon rates.

3.3.2. Equity Position Risk

The aim of the capital charges for equity positions is to provide a cushion for losses as a result of adverse price movements in equity markets. The long or short positions of equities must be calculated on a mark-to-market basis. The coverage of equity position risk includes equity securities, the derivatives products, such as stock indices and arbitrages, and other off-balance sheet positions, which are sensitive to the volatility of equity prices. The capital charge for equity position risk consists of a specific risk charge for gross positions and a general market risk charge for the "net overall position". The Committee assigns an 8% specific risk capital charge for ordinary positions and a 4% capital charge for liquid and well-diversified positions. The Committee also assigns an 8% capital charge for general market risk. Furthermore, a 2% specific risk capital charge applies to the net long or short position in an index contract consisting of a diversified portfolio of equities. This additional capital charge also applies to futures-related arbitrage strategies.

3.3.3. Foreign Exchange (FX) Risk

The aim of the capital charges for FX risk is to provide a cushion for losses, which arise as a result of adverse movements in exchange rates. The Committee includes gold positions in the FX risk measure on the grounds that the volatility of gold prices is more similar to that of foreign currencies than commodities and because banks manage gold positions in a similar manner to foreign currencies. The coverage of FX risk includes the net position of each currency both in the banking and trading books. The net open position is calculated as the sum of: (1) the net spot position of each currency including accrued interest; (2) the net forward position of each currency including futures and the principal on currency swaps which are not included in the spot transaction; (3) guarantees and similar positions which are certain to be called; (4) net future income /expenses which have not yet accrued but are already fully hedged; (5) profit or loss in foreign currencies and; (6) the net delta-based equivalent of the total book of foreign currency options.

The nominal amount or net present value of net open positions in each currency and in gold is converted into domestic currency by using the spot rate before calculating the capital charge. The capital charge for FX risk is 8% of the sum of either the net short positions or the net long positions, whichever is greater, plus the net position (short or long) in gold, regardless of sign.

The Committee provides national authorities with the flexibility to exempt banks from FX capital requirements if their foreign currency business does not exceed 100% of their capital base and their overall net open position does not exceed 2% of their capital base. The foreign exchange risk calculation is illustrated in Table 6.

The proposal converts nominal forward foreign exchange positions into domestic currency by using the spot rate. The following example may provide a clear illustration of how the proposal treats a forward foreign exchange position. Assume a UK company holds a forward buying position of US$ 1.5 million in one year's time and that the spot rate of £/US is 1.5. The proposal treats this position as a long position of US$1.5 million and a short position of £1 million. This author believes that this approach is not very accurate because the cash-inflow of US$1.5 and cash-outflow of £1 million are the amounts which will be received and paid next year. In other words, the present value of the cash flows differs from the future cash flows. The present value of money received in the future must be derived by discounting the future cash flows using a zero yield coupon bond. The risk of the forward position is the product of the current exposure and the volatilities of risk factors.

Therefore, four risk factors exist in this position: (1) the yield volatility of the current exposure of one year's future cash inflow worth US$1.5 million; (2) the yield volatility of the current exposure of one year's future cash outflow worth £1 million; (3) the volatility of the GB£/US$ forward conversion rate; (4) the correlation between the one year yield volatility of US$ and GB£. Finally, the risk calculation under the BIS proposal cannot capture all possible risks, especially the volatility of the forward exchange rate and the risk correlation among risk factors.

Table 6
Illustration of Capital Charges for Foreign Exchange Rate Risk Under the BIS Proposals

Yen	DM	GB£	FFR	US$	Gold
(1,000)	-	(1,000)	(40)	(1,000)	(80)
1,200	100	1,300	52	1,100	88
800	200	(600)	(24)	600	48
(1,000)	(300)	(1,300)	(52)	(700)	(56)
4,000	(4,000)	200	8	(8,000)	(640)
300	1,000	(700)	(28)	1,300	104
200	1,200	1,400	56	(1,400)	(112)
(100)	1,000	(1,100)	(44)	900	72
100	800	700	28	900	72
(1,000)	1,000	(1,000)	(40)	-	-
3,500	1,000	(2,100)	(84)	(6,300)	(504)
Sum of longs			**4,500**		
Sum of shorts			**(8,484)**		

Gold		
		(504)
Capital charge:	**(8% x 8,484) + (8% x 504) = 719**	

Note: (.) shows negative positions

Source: Basle Committee on Banking Supervision, "Amendment to The Capital Accord to Incorporate Market Risks", January 1996.

In mathematical form, we can express the risk of FX forward positions in the following equation:

$$\boldsymbol{Risk}_{\boldsymbol{f}} = \sqrt{\sum_{\boldsymbol{i=1}}^{\boldsymbol{N}} s_{\boldsymbol{i}}^{\boldsymbol{2}} + s_{\boldsymbol{j}}^{\boldsymbol{2}} + \boldsymbol{2}\, r_{\boldsymbol{ij}} s_{\boldsymbol{i}} s_{\boldsymbol{j}}} \qquad (7)$$ where,

s_i = the risk of risk factor i
s_j = the risk of risk factor j
$?_{ij}$ = the risk correlation between risk factor i and j
i = the risk factors of a forward buying position (i = 1,2,3..... ......N)

In the example above, the risk factors include: the volatility of sterling yield (s_1); the volatility of US dollar yield (s_2); the volatility of £/US$ forward rate (s_3); and the correlation risk between those risk factors ($r_{12}; r_{23}; r_{31}$).

3.3.4. Commodity Risk

The aim of commodity risk capital charges is to provide a cushion against losses as a result of volatility in the prices of commodities. All commodities, which are traded in secondary markets, such as agricultural products, minerals and precious metals, are covered. In spot commodity trading, the change in the spot price is the most important risk. In forward and derivative contracts, there are three possible risks: basis risk (i.e. volatility of price of the commodity as a result of the relationship between the prices of similar commodities); interest rate risk (i.e. the risk of a change in the cost of carry for forward positions and options); and, forward gap risk (i.e. the risk that the forward price may change for reasons other than the change in interest rates). The proposal assigns a 1.5% capital charge to capture these risks. How the proposal applies capital charges will be outlined in the following discussion.

According to the proposal, three models are available to calculate capital charges; a maturity ladder approach, a simplified approach and an internal model. The maturity ladder approach adopts the following procedures: (1) convert all commodity positions into standard units of measurement (i.e. barrels, kilos, etc); (2) calculate the net position in each commodity and convert at current spot rates into a reporting currency; (3) slot the position of each commodity into separate maturity ladders (physical stock has to be slotted into the first time band of the maturity ladders.) The sum of short and long positions which are matched will be multiplied first by the spot price for the commodity, and then by the appropriate spread rate (see Table 7) for the time band in order to capture forward gap and interest rate risk within a given time band; (4) offset the residual net positions from nearer time-bands and apply a 0.6% charge to matched positions carried forward; (5) apply a 15% capital charge to the final long or short position. Detailed outline of this approach is shown in Table 8.

Table 7
Time Bands and Spread Rate of Maturity Ladder Approach For Commodities

Time-Band	Spread Rate
0 - 1 month	1.5 %
1 - 3 months	1.5%
3 - 6 months	1.5%
6 - 12 months	1.5%
1 - 2 years	1.5%
2 - 3 years	1.5%
Over - 3 years	1.5%

Source: Basle Committee on Banking Supervision, "Amendment to The Capital Accord to Incorporate Market Risks", January 1996.

Table 8
Example of Maturity Ladder Approach for Commodities Risk
Under the BIS Proposals

Time-band	Position	Spread Rate	Capital Calculation	Capital Charge
0 - 1 month	-	1.5%		
1 - 3 months	-	1.5%		
3 - 6 months	Long £ 800 and short £ 1,000	1.5%	1. Matched position: (£ 800 long + £ 800 short) x 1.5% 2. £ 200 short carried forward to 1-2 year band, capital charge: 200 x 2 x 0.6% *)	£ 24.00 £ 2.40
6 - 12 months	-	1.5%		
1 - 2 years	Long £ 600	1.5%	1. Matched position: (£ 200 long + 200 short) x 1.5% 2. £ 400 long carried forward to over 3 years, capital charge: 400 x 2 x 0.6%	£ 6.00 £ 4.80
2 - 3 years	-	1.5%		
Over 3 years	Short £ 600	1.5%	1. Matched position: (£ 400 long + 400 short) x 1.5% 2. Net position: 200, capital charge: 200 x 15%	£ 12.00 £ 30.00
			Total capital charge	£ 79.20

Note: *a capital charge of 0.6% is applied for the net position carried forward in respect of each time-band
Source: Basle Committee on Banking Supervision, (1996), “Amendment to The Capital Accord to Incorporate Market Risks”, January.

Commodity derivatives and off-balance sheet positions should be included in the commodity risk calculation in accordance with the following guidelines: (1) futures and forward contracts relating to individual commodities are to be slotted into the maturity ladders according to their expiry dates; (2) commodity swaps where one leg is a fixed price and the other is the current market price should be incorporated as a series of positions equal to the notional amount of the contract, with one position corresponding with each payment on the swap and slotted into the maturity ladder accordingly; (3) commodity swaps where the legs are in different commodities are to be incorporated in the relevant maturity ladders.

The Committee also allows reporting banks to adopt a simplified approach. The procedure for calculating capital charges against basis risk, interest rate risk and forward gap risk is similar to the maturity ladder approach. In the simplified approach, we add an additional charge of 3% of the bank's gross positions (i.e. long plus short positions based on current spot prices) for each commodity.

When banks have been using internal models for internal risk management purposes, the Committee allows them to use internal models as a basis for capital adequacy calculation with respect to market risk. However, they must comply with the minimum standards outlined in Appendix 2.

3.4. Treatment of Options

The valuation of positions and the calculation of capital charges for options are more complicated than for other instruments. Appendix 3 shows how to calculate position risk for debt securities and equity options. The capital charges for options have to be added to the capital charges for the relevant categories. The proposal suggests four methods for calculating the capital charges for options, namely: the simplified approach, the delta-plus method, the scenario approach and alternative approaches (i.e. internal models). The simplified approach is designed solely for banks, which contain purchased options in their positions, and banks which contain purchased and written options in their positions are expected to use either the delta-plus method, the scenario approach or the alternative methods.

3.4.1. Simplified Approach (Carved-out Approach)

The previous discussion mentions that the simplified approach is designed just for purchased option positions where the risk is lower than for written options. It implies that the positions of banks will be either long puts or long calls, with some additional cash positions if the options are in the money. The capital charge is calculated in accordance with the following guidelines: (1) if the options are in the money (i.e. either long put or long call), the capital charges will be calculated as the multiplication of the market value of the underlying security and the sum of specific and general market risk charges; (2) if the position only contains a long call or long put, the capital charge will be the lesser of the market value of the underlying security multiplied by the sum of specific and general market risk charges and the market value of the option.[5] The percentage capital charge for specific risk is 8% and for general market risk is 8%. Therefore, the capital charges for the

5 Options are not subject to specific risk when the underlying is an interest rate, a currency or a commodity. However, the options will be subject to a specific risk charge when the underlying is a corporate debt or corporate bond index, an equity or stock index.

options and the associated underlying assets, cash or forward, in the simplified approach are not subject to the standardised methodology. They are carved-out and subject to a separate capital charge calculation. (i.e. 8% for specific risk and 8% for general market risk).

3.4.2. Delta-plus Method

This approach allows banks to include written option positions in the relevant standardised methodology by multiplying the market value of the underlying assets by the delta[6]. Since the delta is not enough to cover all the risks of options, a bank will also be required to measure the gamma (the sensitivity of the change in the delta to the change in the price of the underlying assets) or the vega (the sensitivity of the change of option value to the change in volatility of the prices of the underlying assets). The specific risk capital charge results from the multiplication of the delta equivalent by the specific risk weight set out in the standardised methodology. The results of the gamma and vega calculations have to be added to the capital charge (i.e. without multiplying by the risk weight) because the volatility of the underlying (VU) has been included in the calculation. The detailed procedures of the delta, gamma and vega calculations are outlined in Appendix 4.

Sometimes options use interest rate futures as underlying instruments. If this is the case, the two-legged approaches apply in the calculation of the position of these options, where one leg is the time until the option takes effect and the other leg is the time until the option matures. The same treatment is applied to written options. Floating rate instruments with caps or floors will be treated as a combination of floating rate securities and a series of European-style options[7]. For example, a position consisting of a two-year floating rate bond indexed to three months LIBOR with a cap of 8% will be treated as: (1) a debt security that re-prices in three months; and, (2) a series of eight written call options on a FRA with a reference rate of 8%, and each with a negative sign at the time the underlying FRA takes effect and a positive sign at the time the underlying FRA matures. The delta-weighted position is also applied for equity options, foreign exchange options and gold options. These positions will be incorporated into the relevant market risk measurement

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6 Delta is the coefficient which represents the sensitivity of option price to the change in the underlying asset's price. For example, a 0.6 delta coefficient means the price of a call option will change GB£0.6 for each GB£1 change in the price of underlying assets. To fully hedge, we need to write 100 calls for every 60 units of the asset held (Tucker, 1994, p.457).

7 Example: A position of a three-year floating rate bond indexed to six month LIBOR with a cap of 15% will create two positions: (1) a debt security with maturity in six months; and (2) a series of five written call options on a FRA with a reference rate of 15%, each with a negative sign at the time the underlying FRA takes effect and a positive sign at the time the underlying FRA matures.

within the standardised methodology (i.e. multiply by 8% for equities, 8% for foreign exchange and gold, 15% for commodities) in order to calculate capital charges.

Additionally, the Committee requires banks to calculate gamma and vega risk when they use the delta-plus method for option positions. The procedure to calculate capital charges for gamma risk will be based on the following guidelines: (1) Calculate the volatility of the price of the underlying instruments (VU) by multiplying the market value of the underlying by the risk weights set out in the standardised methodology (ie, 8% for equities, 8% for foreign exchange and 15% for commodities); (2) The gamma is then calculated using the Taylor expansion series:

$$Gamma\,impact = \frac{1}{2} * gamma * VU \qquad (8)$$

Given data on the exercise price, the market value of the underlying asset, the risk-free rate of interest, and the implied volatility of the option, we can calculate the value of the delta, gamma and vega by employing the Black-Scholes model as shown in Appendix 4.

The proposal also requires that the capital charge for vega risk be calculated by multiplying the vegas for all options on the same underlying by a proportional shift in volatility of 25%. Vega is the sensitivity of the change of option value to the change in volatility of the price of the underlying assets. This proposal assumes that the shifting volatility is up to 25%. If we assume that the implied volatility is 15%, using the Black-Scholes model, we get a vega of 180. It means that for a change of volatility of 1% the price of the option price will shift by 1.8 units.

This figure is derived from:

$$\boldsymbol{Vega = \frac{\Delta price}{\Delta volatility} \rightarrow 180 = \frac{\Delta price}{1\%} \rightarrow \Delta price = 1.8}$$

To shift the volatility into 25%, we need to add 10% more volatility. The capital charge for vega risk can be calculated as:

1.8*10 =18

Other option price volatility measures, such as *rho* and *theta,* are not part of the proposal. However, their inclusion within the capital adequacy measurement is possible if the reporting banks wish to do so.

The regulatory approach for options still uses weights as proxies for the volatilities of risk factors. It is unclear, however, how to decide on the weights to be used. With this approach, there is no guarantee that the result represents true risk in the banks. Under the delta plus method, the result is more accurate than the result of the simplified method because the delta plus method considers many more parameters such as Greek letter volatility measures. However, the proposal still simplifies the calculation of some risk factors, such as the volatility of the option's underlying price or rate.

3.4.3. Scenario approach

The Committee also suggests that sophisticated banks can calculate the options and associated hedging positions by using scenario matrix analysis since they are capable of doing so. This approach can be performed by specifying a fixed range of changes in the option portfolio's risk factors and calculating the value of the option portfolio at various points along the "grid". The banks will re-value the option portfolio using matrices for simultaneous changes in the option's underlying rate or price and in the volatility of the rate and price. An individual matrix is used for one underlying instrument. The procedure for employing the scenario approach is described below.

First, the range of changes in interest rates or prices must be consistent with the changes assumed in the standardised methodology. The highest figure of the assumed change in yields for each time band for interest rate options is the same as set out in the standardised methodology. Similarly for other options, the assumed change of prices or rates is £ 8% for equities, foreign exchange and gold and £ 15% for commodities. The equal spacing of intervals in each range can be calculated from the range (-8% to +8%) by observation, which consists of at least seven observations. Second, the maximum range of changes in volatility of the underlying rates or prices (vega in Greek letters) equals a shift in volatility of ± 25%. However, national discretion is permitted in respect of the choice of range of the volatility. Finally, we can get a matrix of each cell, which contains the net profit or loss of the option and the underlying hedge instrument. The capital charge is identical with the largest loss appearing in the matrix. The Committee also allows banks to adopt a different scenario analysis, subject to supervisory consent.

3.5. Stress Testing, External Validation And Back Testing

The adoption of internal models needs many tools to ensure that the model is conceptually sound. Three are suggested by the Committee: stress testing, external validation and back testing. These three activities must be conducted continuously to ensure that all factors used to calculate risk remain valid.

Stress testing is used to identify the events, which could generate significant losses or gains under a range of scenarios. The objective of conducting stress tests is to evaluate the capacity of the banks' capital to absorb potential losses and to identify strategies to reduce the risk or to conserve capital. Banks' stress tests may be in the form of satisfying both quantitative and qualitative criteria, which relate to banks' exposure. There are three types of stress tests: (1) comparing the capital charges derived from using an internal model to the largest losses during the reporting period to get a picture of how many days of peak day losses can be covered by a given value-at-risk estimate; (2) testing the current portfolio against past periods of significant disturbance such as the 1987 equity crash to evaluate the sensitivity of market risk exposure to changes in the volatility and correlation assumptions; (3) conducting stress tests by using relevant adverse movements in the characteristics of their portfolios, such as examining the impact of the adverse movement of oil prices on investment portfolios in certain markets.

Back-testing is just simply comparing measurement of risk with trading outcomes in order to evaluate the performance of banks' risk models. In other words, back tests will observe whether the outcome is consistent with the confidence level used in the models (e.g. 99% or 95%). The 99% confidence level of daily risk measures means that the model will cover 99 out of 100 trading outcomes and leave just one outcome as an exception (error). However, this back testing attempts to compare static portfolio risk with a more dynamic revenue flow because most modelling in risk assumes that there is no change in the composition of the portfolio during the holding period.

Additionally, the Committee also requires external validation of the accuracy of the model. Prior to approval from the regulatory authority, banks, which intend to use internal models are required to satisfy several sets of minimum qualitative and quantitative standards (see Appendix 2). The ability of banks to comply with the qualitative standards will influence choice of the multiplication factors in the calculation of the capital charge. These qualitative standards are designed to ensure that the internal model is accurate and consistent for the measurement of bank risk.

3.6. Some Pitfalls In The BIS's Proposal

To examine whether the proposal contains deficiencies, this study will adopt the ideal capital adequacy standard suggested by Taylor (1993). According to Taylor, an ideal capital standard should satisfy the following criteria: (1) ensure that there is sufficient equity capital to cover most losses in order to reduce the probability of failure; (2) impose a minimum regulatory burden on banks and minimise the regulatory barriers to entry; (3) cover all the financial risks which banks may encounter; (4) consider portfolio effects (i.e. require more capital for concentrated risk); (5) treat risk consistently in relation to capital; (6) provide reward for accurate risk measurement (i.e. lower risk and good management deserve to have less capital); (7) it must be durable and flexible, in the sense of not requiring frequent update and flexible enough to accommodate financial developments. The discussion below adopts these criteria in order to evaluate the BIS proposal.

3.6.1. Amount of Required Capital

By introducing a minimum capital adequacy requirement with respect to market risk under the amendment to the Basle Accord, total required capital will increase. However, there is no assurance that those banks, which meet the minimum capital requirement, will not encounter financial problems in the future. Failure may still occur for one or more of the following reasons: (1) the BIS proposal ignores the risk relationship among risk factors; (2) there are many possible risks which are not covered, such as operational risk and fraud risk.

3.6.2. Comprehensiveness

The proposal includes only market risk in the trading book. Levonian (1994) suggests that the proposal should cover interest rate risk arising from the banking book, such as loans and deposits. Additionally, the uncertain distinction between the banking and trading book in certain circumstances may provide an incentive for banks to shift positions from the trading to the banking book or the other way round depending on what benefit the bank is looking for. This criticism was raised by the Institute of International Finance (IIF) which represented 177 banks in the US (Shirreff, 1994)

3.6.3. Regulatory Constraints

Many banks have been implementing more accurate risk management models for internal purposes for some times. The proposal still requires banks to generate additional capital (a multiplication factor) to cover unanticipated shocks. This may result in banks running two models (standardised and internal models) for the same purpose (White, 1995). This condition limits banks' efficiency.

3.6.4. Portfolio Effects

The BIS proposal calculates total portfolio risk by summing the individual risk factors. The proposal thus implicitly assumes that risk factors in the portfolio positions are perfectly positive correlated (+1). The following equation is the expression in mathematical form of this assumption (Section 2.2.2.e shows the detailed mathematical explanation of this theory):

$$R_{AB} = \sqrt{A^2 s_A^2 + B^2 s_B^2 + 2 r_{AB} s_A A s_B B} \qquad (9)$$

where,

R_{AB} = the risk of investment in asset A and asset B

s_A = the risk of investment in asset A

s_B = the risk of investment in asset B

A = the current exposure of investment in asset A

B = the current exposure of investment in asset B

r_{AB} = the correlation of risk between investment in asset A and asset B

If r_{AB} =+1, then

$$\begin{aligned} R_{AB} &= \sqrt{A^2 s_A^2 + B^2 s_B^2 + 2(1)\ s_A A s_B B} \\ &= \sqrt{(A s_A + B s_B)^2} \\ &= A s_A + B s_B \end{aligned}$$

In fact, the correlation among risk factors is not always +1. There may even be negative correlations.

3.6.5.Equivalent Treatment of Risks

The BIS proposal adopts universal capital charges for foreign exchange risk (8%), equity risk (8%) and commodity risk (15%). In fact, the volatility of one currency differs from another, and similarly for equities and commodities (Economic Bulletin, 1994, pp.63-8).

3.6.6.Rewarding Precision in Risk Management

Some multinational banks normally adopt risk calculation models that contain an embedded solution of the deficiencies in the BIS proposal as discussed in point 3.6. In other words, these banks have implemented more prudent risk management models than ordinary banks, which have not adopted any risk management models. However, these banks are treated similarly (i.e. no reward) to ordinary banks, which apparently simply adopt the BIS proposal in their risk management. This treatment discourages banks from developing and adopting better and more accurate risk calculation models.

3.6.7. Durability

In general, the BIS proposal is unable to accommodate the risk valuations arising from derivative instruments, especially options (i.e. non-linear relationship between the price and risk factors). On the other hand, the development of derivative instruments in terms of the percentage of banks' operations has increased rapidly. The BIS proposal fails to accurately measure risk for the options. Finally, the approach adopted by the BIS would seem to be out of date and fails to accommodate the needs of advanced financial risk management. However, the proposal can be applied widely in any other countries as a result of its simplicity and practicality. This reflects a belief that universal and practical considerations are the most important characteristics of international capital regulation, especially for traditional banks.

4. Risk Measurement Models Using Value At Risk (Var)

4.1.General Overview

The regulatory approach which has been discussed in the previous section measures risk from various components, such as foreign exchange, interest rates, equities and commodities. This approach will generate total risk of overall positions from each component. For example, a position in US treasury bonds of a UK bank will be accommodated in the assessment of interest rate risk of debt securities and foreign exchange risk. The risk of a US treasury bond is the summation of interest rate risk and foreign exchange risk. When a bank has thousands of transactions which consist of various positions in financial instruments, the BIS proposal fails to cover the risk of each financial instrument position. Although the purpose of measuring risk is to find the risk of each position by considering risk factors in the calculation, measuring risk from the components of risk and summing into one risk measure has the following drawbacks: (1) the approach ignores the correlation among the risk factors; (2) the approach provides complicated information concerning the risk in bank positions but less information for bank supervisors to help them identify the sources of risk (i.e. identify overall risk for each transactions); (3) the information is less valuable for banks' management for internal control purposes (Chew, 1996, pp.201-4).

In the banking industry, many banks have implemented models to calculate risks. However, there is no agreement on which method provides the most accurate result. The only approach recognised by the BIS is value at risk (VaR) which is included in the template to calculate market risk capital charges. For this reason, this study focuses on VaR in discussing internal models.

4.2. Definition of VaR

The VaR approach became more popular for bankers, regulators, consulting firms and academicians after the BIS Committee recognised it as one alternative for calculating banks' risk for capital adequacy purposes. Taylor (1993) defines VaR as the maximum amount that an institution can expect to lose on a given position during a given period or potential closeout period with a predefined probability. Chew (1996), Boudoukh (1997) and Hendricks (1996) define VaR as an approximation to the profit or loss generated by an institution due to changes in the market prices of underlying assets in a certain time horizon. Based on this definition, VaR contains the following features: (1) a position of underlying assets; (2) an estimate of the price volatility of underlying assets; (3) a time horizon or holding period.

In mathematical form, the risk of a position in a financial instrument is the following:

$$VaR_{t+1|t} = V_t s_{t+1|t} \quad (10)$$

where,

$VaR_{t+1|t}$ = risk at time "t"

V_t = market value of the position at time "t"

$s_{t+1|t}$ = volatility of risk factors at time "t" for the period "$t+1$"

The equation above shows that the value of instruments is linearly related to the change of prices or rates. When the price of the underlying asset decreases by 2%, the value of the instrument decreases by 2%. However, the value of a financial instrument may not always be linear with the change of prices. The best example of this are options. The value of an option depends on the delta and the change of price of the underlying asset. Assuming the position is not linear and has a delta 0.5, when the price decreases by 2%, the value of the instrument decreases by 2% x 0.5=1%. Finally, the mathematical form of VaR for a non-linear position is the following:

$$VaR_{t+1|t} = V_t s_{t+1|t}(d) \quad (11)$$

where d is the delta of the option.

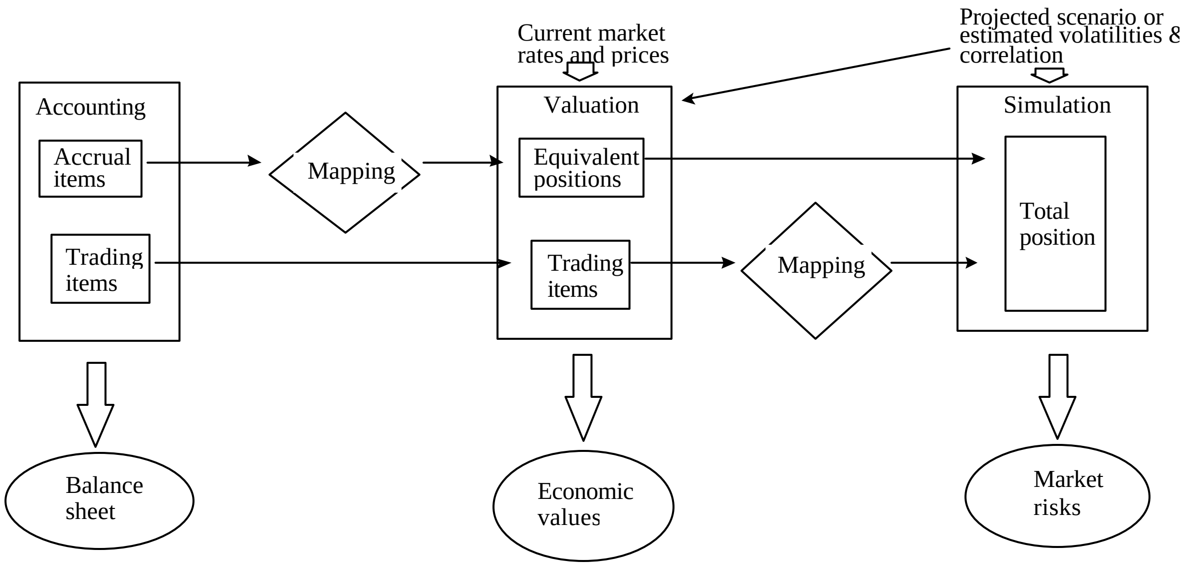
We need to go further to define the estimate of price volatility, the value of underlying assets, and the time horizon. Different parameters used in these three areas will produce different results.

We can also distinguish between Daily Earnings at Risk (DEaR) and VaR. DEaR is defined as an estimation of losses on a given portfolio that can be expected to be incurred over a single day, such as the next 24 hours, with a certain probability. VaR measures maximum estimated losses in market value of a given position that can be expected to be incurred until the position can be neutralised or reassessed. If the time horizon is one day with a given probability level, then the VaR equals the DEaR.

Value at risk defines income as the net value of assets (i.e. after marking-to-market) and contracts held by a bank. The volatility of price or rate of an asset in the market (i.e. the net value of assets) may influence profit and loss. As defined in the previous section, the main purpose of VaR is to measure the maximum loss of a given portfolio in a certain time horizon at a given probability level. In VaR , we are just concerned with the probability of suffering loss. The crucial step in calculating VaR is to measure the loss which is derived from income volatility.

As part of risk management techniques, the banks' managements tend to adjust their portfolios based on estimates of the changes of prices and rates. Therefore, risk estimation needs to follows two steps: (1) calculate the sensitivity of a portfolio to changes in underlying prices or rates; (2) estimate the potential changes in rates or prices. This sensitivity estimation is more important when the holding period of the VaR is longer. Figure 3 shows the procedure for calculating VaR.

Figure 3
Value at Risk Calculation Procedures



Sources: J.P. Morgan (1994)

4.3. VaR Methodology

According to Chew (1996, p.208) there are three methods to calculate volatility: the correlation method (i.e. variance/covariance matrix method), sometimes called the parametric method; historical simulation; and Monte Carlo simulation.

The correlation method calculates the change in the value of positions by combining the sensitivity of each asset to price changes which are estimated by using variance/covariance matrices of the various component's volatilities and correlations. This method uses the statistical assumption that volatility (the change) of prices or rates is normally distributed. This study will adopt this method as the model is practical, and data is available from various data providers. Section 4.4 discusses in detail the parametric approach.

Simons provides a wider dimension of VaR by differentiating between simple historical and historical simulation as well as parametric (mean-variance analysis) and Monte Carlo simulation (Simons, 1996). The simple historical simulation method calculates the change in the value of positions by identifying the lowest returns (for example: 1 %) from the range of returns in historical data and then multiplying the identified of the lowest returns with the current market value of a portfolio. The period of historical analysis plays a critical role in the accuracy of the results. A shorter period may not capture the whole variety of movements in prices or rates. The 1% of lowest returns is derived by establishing a rank of daily historical returns. The 1% of probability returns means that VaR is calculated using a

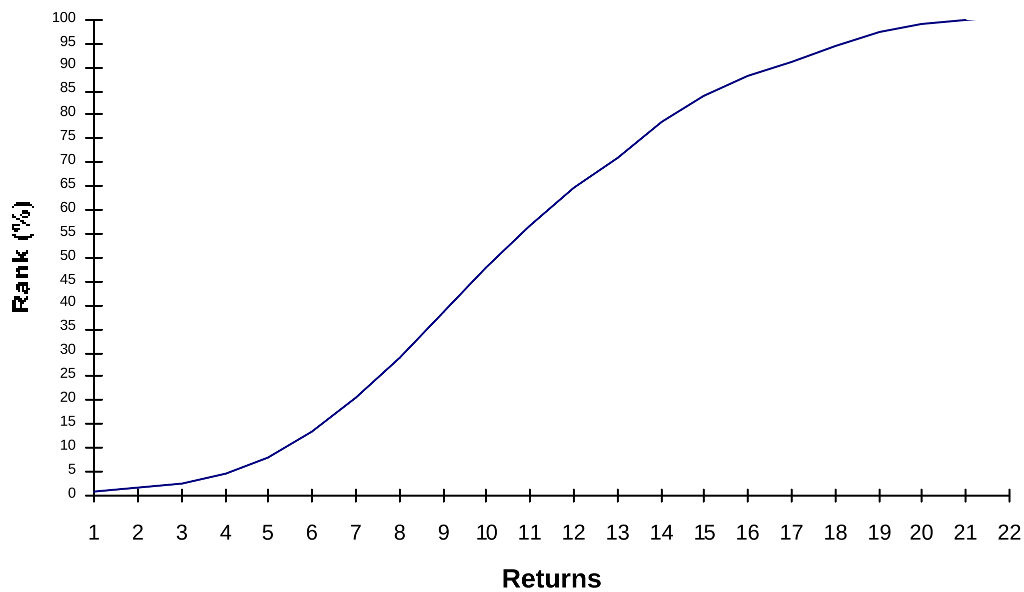
1% cut-off point from the lowest returns. According to Figure 4 the VaR of the 1% confidence interval is around 1.5%. This method is less complicated than the other methods. However, we need to establish a huge data base for all portfolio of risk factors and maintaining all the data is impractical. The problem is that not all the risk factor data is available. For example, a position of a forward exchange rate will entail volatility in the forward rate, yield volatility of currency 1, yield volatility of currency 2 and correlation of yield volatility of currencies 1 and 2.

Historical simulation calculates VaR by simulating the actual values of risk factors (interest rates, prices or exchange rates) in the past into current portfolio composition. By comparing the value of current portfolios and the value of portfolios derived from historical simulation, we can get the distribution of returns. The VaR can be calculated by employing confidence intervals identical to those defined in simple historical simulation. In historical simulation, we simulate the past portfolio returns by using the actual value of risk factors and the current portfolio composition instead of looking at the volatility of the actual portfolio returns.

The Monte Carlo simulation method calculates the change in the value of positions by using a random sample generated by price scenarios. Instead of using the past value of risk factors as mentioned in historical simulation, Monte Carlo simulation generates models to estimate the risk factors from past portfolio returns by specifying the distributions and their parameters (i.e. volatility and correlation). Using these distributions and parameters, we can generate thousands of hypothetical scenarios for risk factors and, finally, we can determine future prices or rates based on hypothetical scenarios. VaRs can be derived from the cumulative distribution of future prices or rates for given confidence levels.

After studying the arguments, it is hard to say if one approach is better than the others without considering the specification of the position, the availability of data and information technology.

Figure 4
The Rank of Daily Returns



To determine which method is most appropriate, J.P. Morgan (1995, p.14) focuses on the answers to two questions. The first is whether the future price and rate movements are normally distributed. If the future rate and price movements can be described in a statistical fashion by using simplifying parameters of a normal distribution, the volatilities and correlation method can be used. However, if market movements are not normal (e.g. for unexpected sharp changes) the scenario approach will be appropriate. The second is whether the value of positions changes linearly with changes in rates and prices. If the change in the value is linear, we can use the position's sensitivity to rate and price change (parametric). An option is an example of an instrument, which contains a non-linear relationship between the change in the value and rate or price. As we know, the value of an option will be determined by whether the option is in or out of the money, and the future implied volatility is used in the pricing formula instead of the price or rate of the underlying asset. The scenario simulation, or full valuation approach, is more appropriate for non-linear positions. Based on the discussion above, there are two things that we need to consider in determining the ideal approach to calculating VaR: the distribution of portfolio returns and the linearity of the relationship between the value of the portfolio and the changes in rates and prices.

This study will focus on the parametric approach in calculating VaR because: (1) Most likely, the volatility of interest rates and foreign exchange rate returns up to July 1998 will follow a normal distribution as the government in Indonesia adopts a managed floating exchange rate policy. Additionally, the domestic currency interest rate is relatively stable. (2) The valuation of option positions will assume that their value changes linearly with changes in rates or prices (i.e. by using the measurement of Greek letters).

4.4. Parametric Approach (Delta Valuation Method)

In order to estimate price changes in the future, we need to characterise market movements statistically and derive a measure of estimated future "adverse" movement. Then, we apply the adverse movement to positions and compute the estimated resulting changes in market value.

From a series of daily historical prices or rates, we can identify the historical daily returns. Assuming P is the price of a certain asset and "t" is time (daily), the daily price returns (DP_t) are calculated from the following equation:

$$\Delta P_t = \ln P_t - \ln P_{t-1} \qquad (12)$$

Based on the normal distribution assumption of the historical daily returns, we can estimate the volatility of price by using its mean (m) and spread of the delta prices around its mean value or standard deviation (s). A detailed description of the techniques used to estimate the volatilities and correlations is beyond the discussion of this paper.

In normal distribution, the probability that the volatility lies at a certain value depending on the mean (m) and the standard deviation (s). According to Green (1993, p.58) and Griffiths, et al (1993, p.48) the probability density function of a normal distribution is calculated using the following formula:

$$f(x) = \frac{1}{\sqrt{2ps}} \exp\left[-\frac{1}{2s^2}(x-m)^2 \right] \qquad (13)$$

where, m = mean and s = standard deviation.

The probability that an event lies within one standard deviation from the mean is 0.68. This statement can be written in the following mathematical form:

$$(m-s < X < m+s) = \int_{m-s}^{m+s} \frac{1}{\sqrt{2ps^2}} e^{\frac{1}{2s^2}(X-m)^2} \approx 0.68 \qquad (14)$$

Additionally, we can also identify that the probability of an event lying within 1.65 s is 0.90; 1.96 s is 0.95 and in 2.57 s is 0.99.

To estimate the future volatility of prices or rates, we can adopt this rule by assuming an adverse movement will occur in certain confidence intervals (i.e. 0.90, 0.95 or 0.99). Assuming the mean of daily returns is 0.120% and the standard deviation is 1.40%, for an 0.90 confident interval, the daily return will be in the range of 2.43% [i.e. 0.120% + (1.65 x 1.40%)] and -2.19% [i.e. 0.120% - (1.65 x 1.40%)]. For the purpose of value at risk, we consider just the case of negative return, or loss.

Therefore, risk estimation can be derived from the standard deviation[8] of the delta prices by multiplying the estimate of delta price by the market value of assets. This treatment is true for a single portfolio which is sensitive only to price (single risk factor). For a single portfolio which is sensitive to price volatility and exchange rate volatility simultaneously, we need to consider the possible relationship between volatility of price and the exchange rates. For a portfolio of assets, risk estimation requires calculation of the risk relationship among portfolio investments (Markowitz, 1952, Sharp, 1970). The coefficient of risk relationship is between 0 and 1 and can be either positive or negative. Section 2.2.2.e shows the detailed mathematical explanation of this theory. If we recall equation 9 from Section 3.6.4;

$$s_{AB} = \sqrt{a^2 s_A{}^2 + b^2 s_B^2 + 2 r_{AB} s_A s_B} \qquad (15)$$

In a matrix notation, the daily diversified risk (DEaR) can be calculated as follows:

$$DEaR = \sqrt{\bar{V} * [C] * \bar{V}^T} \qquad (16)$$

8 Variance (s^2) is calculated from $\frac{1}{N}\sum_{i=1}^{N}(X_i - \overline{X})^2$. Covariance (s^2_{AB}) between A and B is calculated from $\frac{1}{N}\sum_{i=1}^{N}(X - \overline{X}_A)(X - \overline{X}_B)$. Risk correlation between investment in A and B is calculated from $r_{AB} = \frac{Cov_{AB}}{s_A * s_B}$.

where,

$$\bar{V} = [DEaR_1 \ldots\ldots DEaR_N] \rightarrow \text{It is the DEaR vector}$$

$$[C] = \begin{bmatrix} 1 & \cdot & \cdot & \cdot & r_{1N} \\ \cdot & \cdot & & & \cdot \\ \cdot & & \cdot & & \cdot \\ \cdot & & & \cdot & \cdot \\ r_{iN} & \cdot & \cdot & \cdot & 1 \end{bmatrix} \rightarrow \text{It is the correlation matrix}$$

$$\bar{V}^T = \begin{bmatrix} DEaR_1 \\ \cdot \\ \cdot \\ DEaR_N \end{bmatrix} \rightarrow \text{It is the transposed vector of V}$$

The matrix above can be solved using an EXCEL spreadsheet.

4.5. Problems with VaR

VaR models can provide a tool for management to control risk. With the VaR models, management can proxy the maximum of expected losses in a certain time horizon by employing a certain probability. The resulting VaR can be used to judge how to reallocate assets in a portfolio to achieve the desired risk level. However, the VaR may produce biased results and lead the management to make wrong decisions if several assumptions are not valid. According to Chew (1996, pp.216-19) and Hopper (1996), the VaR methodology contains some pitfalls which create bias in risk estimation. First, the normality assumption in the parametric approach may create a bias in the risk estimate as the true distribution is not normal. Additionally the choice of confidence level is arbitrary. Boudoukh (1997) argues that worst case scenario provide precise measure of every one and prudence. The distribution of returns may exhibit skewness (i.e. right or left) or kurtosis. The reason why the normality assumption is often used in quantitative analysis in finance is that the normal distribution has lots of useful statistical properties that make solving problems easy. Second, the VaR models exclude credit risk in their calculation, especially for OTC derivatives. The true value of VaR will be higher if we incorporate credit risk into the calculation models. Third, the VaR assumes that all instruments can be settled at current market price. This assumption is not valid for illiquid assets, which need to be sold at a discount. In this condition, the VaR provides biased information concerning the risk to portfolios. Fourth, the parametric approach employs volatilities and correlations, which are derived from historical records. In other words, the VaR assumes that future returns will follow what happened in the past. If there is an extreme negative return, the VaR will fail to capture the event. However, Zangari (1997) argues that we can capture event risk by employing a mixture of models, data and intuition, and using a stress test to test whether the model can capture event risk. Payant (1997) reported that VaR method is still unclear concerning how risk is estimated, what risk factors and their correlation will be included and how to validate the volatility and correlation estimate.

To account for the deficiencies, the Basle Committee on Banking Supervision introduced minimum qualitative and quantitative standards for banks, which intend to use internal models (BIS, 1996). Notwithstanding its weaknesses, VaR is the best risk management tool currently available to the banking industry and most multinational banks adopt VaR for internal risk management purposes.

5. Conclusions

The discussion in this chapter has shown that there are many approaches available for calculating market risk. The BIS proposal provides for simple and practical calculations, including the use of internal models which have been adopted by most multinational banks. From a theoretical point of view, the proposal produces inaccurate measures of risk as a result of simplification and false assumptions of exposure and risk factors. Simplification of the calculation of exposure, approximations for volatility and exclusion of volatility correlations are the main pitfalls of the BIS proposal.

However, VaR also contains some weaknesses, which may provide biased information concerning bank risk. The normality assumption and choice of confidence interval are among the issues, which may produce biased information about bank risk. By using the normality assumption, VaR fails to capture shock events (outliers) in the volatility measure. Furthermore, the results vary depending on the probability level, which is used in the model.

It is unclear whether the BIS standardised proposal is more accurate and suitable as the basis for minimum capital adequacy regulation around the world than VaR. However, the BIS' s standardised proposal is more practical and simple. Hence, the BIS proposal can be used widely by both modern and traditional banks around the world. But, the standardised proposal will produce less accurate measures than those deriving from the use of VaR if the sophisticated derivatives operations are undertaken.

To compare the results of the BIS standardised proposal and VaR in measuring risk, this study will conduct an empirical study using data of banks in Indonesia.

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