İSTANBUL TECHNICAL UNIVERSITY ★ INSTITUTE OF SCIENCE AND TECHNOLOGY

SCENARIO SUPPORTED VALUE AT RISK APPLICATIONS

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ABBREVIATIONS

VaR : Value-at-Risk
P&L : Profit and Loss
ARCH : Autoregressive Conditional Heteroskedasticity
GARCH : Generalized Autoregressive Conditional Heteroskedasticity
EGARCH : Exponential General Autoregressive Conditional Heteroskedasticity
EVT : Extreme Value Theory
EWMA : Exponentially Weighted Moving Average
NYSE : New York Stock Exchange
IMKB : İstanbul Menkul Kıymetler Borsası
IRB : Internal Rating Block
FRA : Forward Rate Agreement
LIBOR : London Interbank Offered Rate
BRSA : Banking Regulation and Supervision Agency
ERM : European Exchange-Rate Mechanism
CAPM : Capital Asset Pricing Model
APT : Arbitrage Pricing Theory
LTCM : Long-Term Capital Management
EM Algorithm : Expectation Maximization Algorithm

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SYMBOL LIST

N	**:** Holding period
VU	**:** Variation of the underlying of the option
C	**:** Confidence Level Parameter
Δ	**:** Delta
Γ	**:** Gamma
Θ	**:** Theta
σ	**:** Standard Deviation
ρ	**:** Correlation
w^t	**:** Weight Vector
P	**:** Value of Portfolio
D	**:** Modified duration
y	**:** Yield
γ	**:** Skewness
C_t	**:** Capital Requirement at time T
SR_t	**:** Capital specific risk
Cov_i	**:** Covarience
w_i	**:** Weight given to the x_i th observation

ÖZET

SENARYO DESTEKLİ RİSKE MARUZ DEĞER UYGULAMALARI

Riske maruz değer belirli bir hata payıyla finansal kuruluşların maruz kalabileceği riskleri ölçmede kullanılan yöntemlerin genel adıdır. Riske maruz değer hesaplamaları için literatürde parametrik ve simulasyon bazlı yöntemler bulunmaktadır. Bankacılık sektöründe özellikle 2001 yılında yaşanan finansal krizlerin etkisiyle riske maruz değer ölçümlerinin ağırlığı gün geçtikçe artmaktadır. 2001 yılındaki finansal krizler sonucu Bankacılık Düzenleme ve Denetleme Kurumu bankalarda riske maruz değer hesaplamalarının yapılmasını zorunlu kılmış ve bu tarihten itibaren riske maruz değer hesaplamaları konusunda çalışmalar yoğunlaşmıştır.

Bu çalışmada, Riske Maruz Değer ölçümlerinde sürekli olarak sorun teşkil eden kurtosis düzeltmesinin önemli bir yolu olan "Mixture of Normals" düzeltmesi ile ilgili bir örnek üzerinde çalışılmıştır. Kurtosis düzeltmesi özellikle Türkiye gibi yeni gelişmekte olan piyasalarda büyük önem taşımaktadır. Çünkü piyasalarda oluşan ani dalgalanmalar finansal kuruluşlar üzerinde oldukça büyük yıkımlara sebep olabilmektedir. Bu açıdan bakıldığında literatürde bilinen adıyla "Mixture of Normals" yaklaşımıyla yapılan kurtosis düzeltmesinin önemi gün geçtikçe artmaktadır. Literatürde "Mixture of Normals" yaklaşımından başka kurtosis düzeltme teknikleri de bulunmakla birlikte gerek veri ulaşılabilirliği gerek parametrik riske maruz değer ölçümlerinde sağladığı kolaylık açısından "Senaryo Destekli Riske Maruz Değer" yaklaşımı kullanılmıştır.

Çalışmada, kullanılan senaryonun seçiminden düzeltmenin parametrik riske maruz değer hesaplarına nasıl entegre edilmesi gerektiğine kadar uygulama sürecine ilişkin ayrıntılar, parametrik riske maruz değer hesaplamalarının detayları ve etkin bir risk yönetimi sürecinin ana parçaları anlatılmıştır.

Yapılan düzeltme sonrasında parametrik yaklaşımla karşılaştırıldığında senaryo destekli yaklaşımın önemli artılarının olduğu ortaya çıkmaktadır.

SUMMARY

SCENARIO SUPPORTED VALUE AT RISK APPLICATIONS

Value-at-Risk is a general name for measuring financial risks of an institution within a given confidence level. In literature several methods like parametric and non-parametric methods are present in order to calculate Value-at-Risk of an institution. Importance of VaR calculations are increasing day by day since financial crisis occurred in 2001. VaR calculations are mandatory part of risk management systems since 2001 crisis according to BRSA regulations. After that studies related with VaR calculations gained importance.

In this study, an example concerning with kurtosis adjusted Value at Risk application has been presented. Kurtosis adjustment is a vital part of risk measurement process especially in emerging markets such as Turkey. Because sudden changes in market conditions may result in financial disasters especially in emerging markets. From this point of view importance of normal mixture adjustment is increasing day by day. In the literature there are some other kurtosis adjustment tools present as well. However, since the approach's data reachablity and easiness to combine with parametric approaches is present, Scenario supported Value at Risk method is used.

In the study, scenario selection, integration details of normal mixture with parametric VaR, parametric VaR calculation details and main components of a financial institution's risk management framework are presented.

After the adjustment, the results are improved significantly with respect to parametric approach.

1. INTRODUCTION

1.1 Overview

Value at Risk or VaR is a special measure to quantify the risk for financial institutions. It tries to measure the *market risk* of a financial firm's "book", which means the list of positions in various instruments that expose the firm to financial risk. Generally speaking, VaR measures the worst expected loss over a given horizon under typical market conditions at a given confidence level.

VaR calculation models basically say following: "We are c percent certain that we will not lose more than V dollars in the next N days" [1]. Here the variable V is the VaR of the portfolio. It depends on two parameters: a time period (horizon) N and a confidence level c. Therefore when we calculate VaR for a portfolio of a financial institution, we calculate the expected loss in the portfolio's market value over a given horizon such as one day or two weeks (N) that is exceeded with a small probability, say, 1 percent (1-c). Additionally quality of model directly depends on model assumptions. Assumptions about distribution indicate what the VaR model assumes about the distribution of trading revenues profits and losses (P&L).

Other measures to quantify risk are quantile measures which includes standard deviation, interquartile range, and lower partial moments or shortfall measures of the financial firm's portfolio.

VaR model also says what the model assumes about the distribution of the underlying market risk sources which the portfolio's market value depends on. The valuation model states how VaR relates the portfolio's value to different shocks in the market risk sources, or the association between the return of the portfolio and returns on the instruments included in the portfolio.

One important type of VaR methodology is so-called normal approach to VaR. This approach assumes that all risk factors in the market are normally distributed and the portfolio is a linear function of those normally distributed risks, which means the P&L distribution for the portfolio is also normally distributed. Under these assumptions, VaR calculations become easy to solve. VaR turns into a multiple of the portfolio standard deviation, where the standard deviation is a linear function of individual volatilities and covariances of underlying market risk factors. Therefore what is needed to calculate VaR is the variance covariance matrix and information about sizes of individual positions to determine the portfolio standard deviation. After employing this into the model we have to multiply calculated standard deviation by a confidence level parameter and scale variable reflecting the size of the portfolio, finally we obtain a VaR number.

Generally normality assumption gives “normal VaR” great advantages such as tractability and easiness. However the worst news may be generally normal approach to VaR does not always fit actual financial institutions’ portfolios or actual finance data. Because generally financial institutions have nonlinear positions since their portfolios have fixed income and option positions. Additionally, normality is a very powerful assumption for finance data, since many empirical studies in time series data have shown that rate of return of percentage change of many financial variables are not normally distributed.

In order to solve non-linearity problem, risk managers generally use Taylor series expansion. The simplest approximation produces the so-called delta-normal approach. Delta-normal, by definition, is the first order Taylor series expansion of a portfolio’s value with respect to stock returns. Delta-normal sets up the linear normality and makes VaR assessment easy. However, such a simple approximation produces an inaccurate VaR estimate. Wilson (1996) claims that delta-normal approach would make steady estimates for VaR for a small holding period or / and when the portfolio has few option positions (close to normality).

Since Delta-Normal approach cannot give precise answers to problem, in order to get a more accurate VaR for non-linear positions (options and fixed income), some authors use the quadratic model or the second Taylor series expansion known as delta gamma approach. Some successful studies can be found in the literature which says that their delta-gamma approaches improve VaR estimates tremendously compared with delta-normal.

Gamma, the first derivative of delta with respect to stock returns, measures the concavity of the relationship between the portfolio value and the underlying market variable. A non-zero gamma implies skewness in the distribution of P&L of the portfolio. When gamma is positive (negative), changes in the portfolio are positively (negatively) skewed. The normality assumption of risk factors or P&L of the portfolio would certainly affect VaR predictions since it depends extensively on the distribution of the tail. Thus if we have a thicker (thinner) tail compared with the normal distribution, then VaR estimates based on normality would be under (over) estimated.

In literature many studies have shown that VaR calculated under normality assumption underestimates risk since the observed distribution of many financial return series have tails that are flatter than those implied by conditional normal distribution.

In general, with deviation from normality assumption, there are two major methods to build VaR models: parametric approach (analytical approach) and the non-parametric approach (the simulation approach). In the parametric approach, an alternative distribution is explicitly assumed instead of the normal distribution, and based on this assumed distribution; a formula to describe the confidence interval is logically derived. The variance-covariance approaches that include the distribution of portfolio return method, the delta normal valuation method and delta-gamma method fall under the parametric approach. In the non-parametric approach, no particular distribution assumption is needed.

Apart from parametric calculations, VaR can be calculated via Monte Carlo simulations. In this approach multiple runs have been performed in order to produce alternative price movements.

As in its definition VaR particularly deals with left tail of the distribution. Parametric VaR approaches that deviate from normality assumption aim basically at modifying for kurtosis. A probability distribution with fat tails has a greater probability mass out in the tails of the distribution, where large price movement occurs compared with the normal distribution. Accordingly, VaR estimates tend to under- or over- estimate risk if normal distribution is assumed.

Some other researches say that fat tails could come from jumps of underlying risk factors. New opinions say that these jumps are significant in explaining the basics of returns. VaR methods try to model kurtosis of underlying risk factors, which may have some jumps in the past.

In order to account for kurtosis in the distribution of underlying risk factors in VaR estimates, authors use different methods. One method that is used for modeling tail is assuming an alternative distribution for tail of data and deal with thickness of it. Some of authors use gamma distributions while others use fixed paretian models for modeling P&L of the portfolio.

Normal mixture or mixture of normals is another method to modeling tails of the distribution. Basically normal mixture approach mixes two normal mixtures, which are come from two scenarios and gives a generic new distribution. Other types of VaR models may employ extreme value theory which is out scope of this study.

The most important issue in modeling risk may be estimating correct volatility of underlying risk factors. Generally VaR models uses normal distributions and this assumption generally can not deal with catching volatility jumps, VaR models use the widespread estimation methods for estimating volatility including historical volatility, ARCH/GARCH volatilities, implied volatility from option pricing, moving average volatilities and extreme value theory (EVT).

In the study of Berkowitz, O'Brien, it can be seen that VaR models depend on GARCH estimation for volatility bound actual daily losses in banks' portfolio closer than internal VaR models used by banks [2]. On the other hand, May 2006 and March 2003 crisis showed that GARCH and EWMA techniques can not deal with this kind of jumps in volatilities. In later chapters these volatility estimation techniques are explained.

1.2 Motivation

This research is motivated by the last fluctuations that occurred in May 2006. In this period general VaR models which are widely used financial sector of Turkey had at least 3 hits (Exceptions), meaning every model has failed at least 3 days in this period. After stabilization of financial markets, many banks tried to find alternative methods to measure their market risks.

1.3 The Purpose of the Work

The main purpose of the thesis is establishing a more adequate and correct trading risk measurement approach. This approach must be enough stable with respect to daily changes. Additionally, it has to capture sudden changes in market conditions. In order to measure risk correctly, model assumes that market risk data has lognormal distribution. Additionally in order to capture volatility jumps EWMA method is used.

1.4 Data

The data used in the study comes from a small-mid sized commercial bank located in Turkey, which have fixed income positions, domestic currency positions and foreign exchange positions. In order to deal with VaR methods' results at least one year time period is examined according to BASLE II standards. In their daily uses bank uses "1-day" VaRs, at this time bank calculates only price fluctuation risk, and they ignore expected returns.

2. HISTORY

Another definition of VaR is a category of probabilistic measures of market risk. Assume a portfolio with fixed income elements. At this moment we can know the portfolios' value simply by making market to market to portfolio and that is it. However we do not know its future value exactly. Its future value is a random variable. Therefore since it is a random variable we can assign a probability distribution to variable. As a result VaR metric becomes a function of:

1. The distribution of portfolio

2. The portfolio's current market value.

With this definition, variance of return, standard deviation of P&L and .99-quantile of loss are all VaR metrics. We describe a VaR measure as any process that, given a VaR metric, allocates values for that metric to portfolios.

First VaR measures developed in two parallel lines. The first one was portfolio theory, and the other was capital adequacy computations. Here the history of VaR measures in the context of portfolio theory is briefly explained and development of VaR measures in the context of capital adequacy computations emphasized.

2.1 The Leavens VaR Measure

The origins of portfolio theory begin with non-mathematical studies of portfolio construction. Some authors have discussed intuitively the merits of diversification. Leavens (1945) presented a quantitative case, which may be the first VaR measure ever published.

Leavens supposed a portfolio of ten bonds over some horizon. Each bond would either mature at the end of the horizon for USD 1,000 or default or be worthless. Default events were assumed as independent. Leavens says that the portfolio's value at the end of the horizon had a binomial distribution.

Of course, Leavens did not clearly recognize a VaR metric, but he stated repeatedly the “spread between probable losses and gains.” He seems to have had the standard deviation of portfolio market value in his mind.

2.2 The Markowitz and Roy VaR Measures

Markowitz and Roy (1952) work independent and give similar results to VaR literature. Each one was working to develop some significant elements of selecting portfolios, meaning finding best components for a portfolio in order to achieve best reward. For this purpose, each VaR measures have covariances between risk factors in order to reflect hedging and diversification effects. Although the two measures look like each other, they support different VaR metrics. Markowitz used a variance of simple return metric. Roy used a metric of shortfall risk that represents an upper bound on the probability of the portfolio’s gross return being less than some specified “catastrophic return” [3].

2.3 Early Innovations

Main aim of early studies done by Markowitz and Roy is finding optimum portfolio composition. However Markowitz’s (1959) book is a “how-to” [3] guide to his optimization scheme was infeasible since there was not enough processing power to compute its complex findings. Markowitz was conscious about this problem and proposed a more tractable VaR measure that employed a diagonal covariance matrix.

Since the processing power of early years is very small VaR calculations was not practical. Mainly theoretical results are used and these results based on newly emerging portfolio theory. The first applications of VaR well suited especially for equity portfolios. In these times there were limited numbers of application areas of VaR measures since portfolio range was not as large as today.

Lietaer (1971) described a practical VaR measure for foreign exchange risk. His studies conducted just after establishment of fixed income VaR studies. He made his study after World War II when there was a devaluation trend among currencies and after firms discover this trend they tried to make hedging operations, and he tries to estimate devaluation trends via modeling historical distribution of them. These studies generally accepted as first Monte Carlo simulation applications.

The 1970s and 1980s come with wide changes for markets and technology. Therefore used VaR methodology also changed. At this time following changes in VaR methodology occurred.

- Expanding the types of assets to which VaR might be applied;
- Changing how organizations took risk;
- Providing the means to apply VaR in these new contexts.

When the Bretton Woods agreement collapsed in 1971, exchange rates were permitted to float, and an active foreign exchange forward market soon appeared. Today, this is the major forward market in the world.

After that every security market became more volatile. Portfolio returns become leveraged and therefore risk levels become higher, As a result of this high risk levels regulatory institutions came to play and capital requirement laws are cited.

2.4 Origins of Regulatory Capital Requirements

Before 1933 security markets were generally self regulated, however after the year 1929 some markets including New York Stock Exchange (NYSE) has set some limitations of its members therefore first regulatory capital requirement established. The requirement can be summarized as follows:

Capital Requirement in order to make transactions in NYSE is equal to:

- 5% of customer debits;
- A minimum 10% on proprietary holdings in government of municipal bonds;
- 30% on proprietary holdings in other liquid securities;
- 100% on proprietary holdings in all other securities.

After that market instruments became more complex day by day. Therefore these days’ working structure was not enough to meet firm’s requirements. These complications were solved via development of computers which have more processing power.

2.5 Garbade's VaR Measures

In the late 1980's Kenneth Garbade who was working for Bankers Trust Cross Markets Research Group developed complicated modeling methods for the US debt market. In this study, he prepared a range of study reports for distribution to institutional clients. One of these, Garbade (1986, 1987), explained complicated VaR measures for assessing internal capital requirements he says:

"In view of the importance of risk assessment and capital adequacy to regulatory agencies and market participants, it is not surprising that many analysts have tried to devise procedures for computing risk and/or capital adequacy which are (a) comprehensive and (b) simple to implement. Without exception, however, those who make the effort quickly discover that the twin goals of breadth and simplicity are seemingly impossible to attain simultaneously. As a result, risk and capital adequacy formulas are either complex or of limited applicability, and are sometimes both." [4]

2.6 The 1988 Basle Accord

In 1988 G-10 countries has decided to establish a standard for capital requirements.

These standards are set by Basle Committee on Banking Supervision; the committee includes representatives from central banks and regulatory authorities. Over time, the focus of the committee has developed, embracing initiatives designed to:

- Describe roles of regulators in cross-jurisdictional conditions;
- Guarantee that international banks or bank holding companies do not run off
- Comprehensive supervision by some "home" regulatory authority;
- Promote uniform capital requirements so banks from different countries may compete with one another on a "level playing field.

However, G-10 countries decided to regulate their capital requirements via their own regulations instead of Basle Accord. VaR calculations are the main part of the Basle accord but these calculation procedures generally not clearly defined until 2000's, today another capital requirement is set for financial institutions which generally known as BASLE II (BASEL II).

3. BASLE II

After BASLE I or known as Basle accord, many European countries have found that daily applications of BASLE I is not suitable for their purposes and they have made a second agreement known as BASLE II, in this part we try to explain main requirements of BASLE II accord especially from market risk point of view.

3.1 The risk measurement framework

As from the end of 1997 or earlier if their supervisory authority wants, banks will be required to determine and apply capital charges in respect of their market risks in addition to their credit risks. Market risk is defined as the risk of losses in on and off-balancesheet positions coming from market price movements. The risks subject to this requirement are:

• The risks related to interest rate related instruments and equities in the trading book;

• Foreign exchange risk and commodities risk throughout the bank.

3.1.1 Scope and coverage of the capital charges

The capital charges for interest rate related instruments and equities will apply to the current mark to market value of items in banks' trading books. The capital charges for foreign exchange risk and for commodities risk will worry to banks' total currency and commodity positions, subject to some caution to leave out structural foreign exchange positions. It is understood that some of these positions will be reported and hence evaluated at market value.

Currently, the Committee does not think that it is essential to allow any exceptions from the capital requirements for market risk; generally the Basle Capital Framework applies only to worldwide working banks, and essentially on a consolidated basis; since all of these positions likely to be involved in trading to some extent.

Market risk and credit risk are considered as similar risk groups in Basle II accord. Consequently as in the same way as for credit risk, the capital requirements for market risk should be applied on a worldwide consolidated basis. If possible , national authorities may allow banking and financial entities in a group which manages a global consolidated book. The capital of these entities is being evaluated on a global basis to report short and long positions in exactly the same instrument (e.g. currencies, commodities, equities or bonds), on a net basis, regardless of where they are booked.

There will be conditions in which supervisory authorities require that the individual positions used in measurement system without any offsetting or netting against positions in the remainder of the group. This may be required, for instance, where there are problems to the quick repatriation of profits from a foreign subordinate or where there are legal and procedural complexities in carrying out the timely management of risks on a consolidated basis.

All national authorities will hold the right to continue to watch the market risks of individual entities on a non-consolidated basis to guarantee that significant imbalances within a group do not escape supervision. Supervisory authorities will be especially cautious in ensuring that banks do not pass positions on reporting dates in such a way as to escape measurement.

3.1.2 Methods of measuring market risks

In assessing market risks, a choice between two extensive methodologies will be allowed, subject to the approval of the national authorities. First alternative will be to calculate the risks in a standardized manner, using the measurement frameworks described in committee decisions about interest rate, equity position, foreign exchange and commodities risk. The capital charge under the standardized measurement method will be the measures of risk obtained from this approach calculated as summation of each risk factor’s risk

The alternative method expose to the completion of certain conditions which requires the explicit approval of the bank’s supervisory authority. This method permits banks to use risk measures resulting from their own internal risk management models, subject to seven sets of conditions, they are:

• Certain common criteria regarding the sufficiency of the risk management system;

• Qualitative standards for internal supervision of the use of models, particularly by top management;

• Guidelines for identifying an suitable set of market risk factors (i.e. the market rates and prices that affect the worth of banks' positions);

• Quantitative standards concerning the use of common minimum statistical parameters for measuring risk;

• Procedures for stress testing;

• Validation procedures for external oversight of the use of models;

• Rules for banks which use a combination of models and the standardized approach.

The standardized methodology uses a "building-block" approach in which specific risk and the general market risk coming from debt and equity positions are calculated individually. The main aim of internal models is bank's general trading risk exposure, generally leaving specific risk (i.e. exposures to specific issuers of debt securities or equities) to be measured principally through separate credit risk measurement systems. Model user banks are charged to capital requirements for the risk that are not captured by their models. Consequently, a separate capital charge for specific risk will be given to each bank using a model to the level that the model does not reveal specific risk.

In calculating the price risk in options under the standardized approach, where a number of alternatives with different degrees of complexity are provided, nowadays many different types of options are emerged therefore their risk measurement tools are also come to play. According to Basle II accord; local supervisory authorities are responsible for accuracy of option pricing models. In the longer term, banks which are chief traders in options will be expected to move to complex value-at risk models.

Each bank subject to Basle II will be expected to watch and report the level of risk against which a capital requirement is to be applied. The bank's overall minimum capital obligation will be:

(a) The credit risk requirements laid down in the Basle Capital Framework, apart from debt and equity securities in the trading book and all positions in commodities, but including the credit counterparty risk on all over-the-counter derivatives whether in the trading or the banking books; plus

(b) Either the capital charges for market risks, summed arithmetically; or

(c) The measure of market risk derived from the models approach. or

(d) A mixture of (b) and (c) summed arithmetically.

All transactions, plus forward sales and purchases, will be included in the calculation of capital requirements as from the date on which they were entered into. Although usual reporting will in principle take place only at periods (in most countries quarterly), banks are expected to control the market risk in their trading book in such a way that the capital requirements are being met on a incessant basis, i.e. at the close of every business day.

Local Supervisory authorities have to recognize that banks can "window-dress" their positions during the reporting periods and therefore they have to take necessary actions in order to see actual positions. Banks will also, of course, be anticipated to keep strict risk management systems to assure that intra-day exposures are not extreme. If a bank fails to meet the capital requirements, the national authority shall ensure that the bank takes immediate measures to correct the situation.

3.1.3 Transitional arrangements

Until such time as the national authority wishes to apply the capital charges for market risk, the risks from positions enclosed by the market risk package will continue to be subject to the present capital charges laid down in the Basle Capital Framework.

Banks will be free to use a combination of the standardized measurement method and the internal models approach to calculate their market risks in transition period. As a common law, any such "partial" models should cover a whole risk category (e.g. interest rate risk or foreign exchange risk), meaning a combination of the two methods will not be permitted within the same risk category. However, as most banks are currently still implementing or further improving their risk management methods, the Committee says that banks should be given - even within risk categories - some elasticity in including all their operations on a global basis; this elasticity will be subject to endorsement by the national authority and reviewed by the Committee in the future (supervisory authorities will take precautions against "cherry-picking" between the standardized approach and the models approach inside a risk factor category).

Banks which implement the modeling alternative for any single risk class will be expected over time to incorporate all their operations subject to the exceptions mentioned below and to move towards a complete model (i.e. one which confines all market risk categories). Banks which implement a model will not be allowed, save in exceptional circumstances, to turn back to the standardized approach. In spite of these general principles, even banks using complete models to measure their market risk may still acquire risks in positions which are not captured by their internal trading risk management models, for example, in distant locations, in minor currencies or in negligible business areas. Any such risks that are not included in a model should be independently measured and reported

At the present stage, the Committee has not set a deadline for the change to comprehensive models even though individual member countries may choose to do so. For the moment, banks whose models do not deal with all their market risks will be subject to the standardized measurement method for the risks not captured and the Committee will watch the situation to avoid probable regulatory arbitrage that may arise from using a combination of the standardized and internal models methods. Moreover, the supervisory authorities of banks moving towards the models approach will wish to be reassured that those banks are gradually improving their risk management practices to the extent that they will be in a position to meet all the standards once they are applying a fully-fledged model for any risk category [5].

3.2 The capital requirement

3.2.1 Definition of capital

The principal form of suitable capital to cover market risks includes shareholders' equity and retained earnings (tier 1 capital) and supplementary capital (tier 2 capital). However, banks may also, at the judgment of their national authority, employ a third tier of capital ("tier 3"), consisting of short-term subordinated debt, for the individual purpose of meeting a share of the capital requirements for market risks, subject to the following conditions:

• Banks will be allowed to use tier 3 capital solely to support market risks. This means that any capital obligation arising in respect of credit and counterparty risk in the terms of the Basle Capital structure, including the credit counterparty risk in respect of derivatives in both trading and banking books, needs to be met by the current definition of capital in the 1988 Accord (i.e. tiers 1and 2);

• Tier 3 capital will be restricted to 250% of a bank's tier 1 capital that is required to support market risks. This means that a minimum of about 28½% of market risks needs to be supported by tier 1 capital that is not required to support risks in the remainder of the book;

• Tier 2 elements may be replaced for tier 3 up to the same limit of 250% in so far as the whole limits in the 1988 Accord are not violated, that is to say qualified tier 2 capital may not exceed total tier 1 capital, and long-term subordinated debt may not exceed 50% of tier 1 capital;

• Additionally, because the Committee believes that tier 3 capital is only proper to meet market risk, a large number of member countries are in favor of retaining the rule in the present Accord that tier 1 capital should represent at least half of total eligible capital, i.e. that the sum total of tier 2 plus tier 3 capital should not exceed total tier 1. On the other hand, the Committee has certain that any decision whether or not to apply such a rule should be a matter for national judgment. Some member countries may maintain the constraint, excluding in cases where banking activities are proportionately very small. Moreover, national authorities will have discretion to reject the use of short-term subordinated debt for individual banks or for their banking systems generally.

For short-term subordinated debt to be eligible as tier 3 capital, it needs, if conditions demand, to be capable of becoming part of a bank's permanent capital and thus be available to absorb losses in the event of insolvency. It must, therefore, at a minimum:

• be unsecured, subordinated and fully paid up;

• have an original maturity of at least two years;

• Not be repayable before the agreed repayment date unless the supervisory authority agrees;

• Be subject to a lock-in clause which stipulates that neither interest nor principal may be paid (even at maturity) if such payment means that the bank falls below or remains below its minimum capital requirement.

3.2.2 Calculation of the capital ratio

In order to guarantee uniformity in the computation of the capital requirements for credit and market risks, a clear numerical link will be formed by multiplying the measure of market risk by 12.5 (i.e. the reciprocal of the minimum capital ratio of 8%) and adding the resulting figure to the sum of risk-weighted assets collected for credit risk purposes. The ratio will then be calculated in relation to the sum of the two, using as the numerator only eligible capital.

In calculating eligible capital, it will be essential first to compute the bank's minimum capital requirement for credit risk, and only afterwards its market risk requirement, to compute how much tier 1 and tier 2 capital is available to maintain market risk. Eligible capital will be the sum of the whole of the bank's tier 1 capital, plus all of its tier 2 capital under the limits compulsory in the 1988 Accord (Basle I). Tier 3 capital will be regarded as appropriate only if it can be used to support market risks under the specific conditions set in accord. The quoted capital ratio will consequently symbolize capital that is available to guarantee both credit risk and market risk. Where a bank has tier 3 capital, within the limits set out in accord, which is not at hand supporting market risks, it may report that overload as unused but eligible tier 3 alongside its standard ratio.

4. THE STANDARDIZED MEASUREMENT METHOD

4.1 Interest Rate Risk

This part explains the standard framework for computing the risk of holding or taking positions in debt securities and other interest rate based instruments in the trading book. The instruments covered include all fixed-rate and floating-rate debt securities and instruments that act like them, as well as non-convertible preference shares. Convertible bonds, i.e. debt issues or preference shares that are convertible, at a stated price, into common shares of the issuer, will be treated as debt securities.

The minimum capital requirement is expressed via two individually calculated charges, one applying to the *"specific risk"* of every security, whether it is a short or a long position, and the other one is the interest rate risk in the portfolio (termed "general market risk") where long and short positions in different securities or instruments can be balanced.

4.1.1 Specific risk

The capital charge for specific risk is designed to defend against an adverse progress in the price of an individual security owing to factors related to the specific issuer. In computing the risk, offsetting will be limited to matched positions in the same issue (as well as positions in derivatives). Even if the issuer is the identical, no offsetting will be allowable between different issues since differentiations in coupon rates, liquidity, call features, etc. mean that prices may deviate in the short run.

4.1.1.1 Specific risk capital charges for issuer risk

The specific risk capital charges for "government" and "other" categories will be as follows.

Table 4.1 Specific Risk Capital Charge Rates

Categories	External credit assessment	Specific risk capital charge
Government	AAA to AA-	0%
	A+ to BBB-	0.25% (residual term to final maturity 6 months or less)
		1.00% (residual term to final maturity greater than 6 and up to and including 24 months)
		1.60% (residual term to final maturity exceeding 24 months)
	BB+ to B-	8.00%
	Below B-	12.00%
	Unrated	8.00%
Qualifying		0.25% (residual term to final maturity 6 months or less)
		1.00% (residual term to final maturity greater than 6 and up to and including 24 months)
		1.60% (residual term to final maturity exceeding 24 months)
Other		Similar to credit risk charges under the standardised approach of the Basle II Framework.
	BB+ to BB-	8.00%
	Below BB-	12.00%
	Unrated	8.00%

The group "government" will contain all types of government paper including bonds, treasury bills and other short-term instruments, but national authorities hold the right to apply a specific risk weight to securities issued by particular foreign governments, principally to securities denominated in a currency other than that of the issuing government. When the government paper is denominated in the domestic currency and funded by the bank in the identical currency, at national judgment a lower specific risk charge may be applied.

The "qualifying" category contains securities issued by public sector foundations and joint development banks, plus other securities that are:

- Rated investment-grade by at least two credit rating organizations set by the national authority
- Rated investment-grade by one rating organization and not less than investment-grade by any other rating organization specified by the national authority
- Subject to supervisory authorization, unrated, but believed to be of comparable investment quality by the reporting bank, and the issuer has securities listed on a recognized stock exchange.

Each supervisory authority will be responsible for watching the application of these qualifying criteria, mostly relative to the last criterion where the first categorization is fundamentally left to the reporting banks. National authorities will also have judgment to comprise within the qualifying category debt securities issued by banks in countries which have employed the Basle Capital Framework. Subject to the state understanding that supervisory authorities in such countries carry out prompt corrective action if a bank fails to meet the capital standards set forth in the Framework. Likewise, national authorities will have judgment to include within the qualifying category debt securities issued by securities firms that are subject to equivalent rules.

In addition, the “qualifying” group will contain securities issued by organizations that are deemed to be equivalent to investment grade excellence and expose to supervisory and regulatory arrangements similar to those under the Basle II Framework.

4.1.1.2 Specific risk rules for unrated debt securities

Unrated securities may be incorporated in the “qualifying” group when they are subject to supervisory approval, unrated, but deemed to be of comparable investment quality by the reporting bank, and the issuer has securities listed on a recognized stock exchange. This will stay unchanged for banks using the standardized approach. For banks using the IRB approach for a portfolio, unrated securities can be incorporated in the “qualifying” category if both of the following circumstances are present:

- The securities are rated comparable to investment grade under the reporting bank’s internal rating system, which the national supervisor has confirmed issuer fulfills with the requirements for an IRB approach; and
- The issuer has securities listed on a known stock exchange.

4.1.1.3 Specific risk rules for non-qualifying issuers

Instruments issued by a non-qualifying issuer will get the same specific risk charge as a non-investment grade company borrower under the standardized approach for credit risk under the Basle II Framework.

However, since this may in certain cases significantly underestimate the specific risk for debt instruments which have a high yield to redemption comparative to government debt securities, each national supervisor will have the judgment:

- To pertain a higher specific risk charge to such instruments; and/or
- To disallow offsetting for the purposes of defining the amount of general market risk between such instruments and any other debt instruments.

From this point of view, securitization exposures that would be subject to a judgment treatment under the securitization framework set forth in the Basle II Framework (e.g. equity trenches that take in first loss), as well as securitization exposures that are unrated liquidity lines or letters of credit should be subject to a capital charge that is not smaller than the charge set forth in the securitization framework.

4.1.1.4 Specific risk capital charges for positions hedged by credit derivatives

Full allowance will be recognized when the values of two legs (i.e. long and short) always move in the reverse direction and generally to the same extent. This would be the case in the following situations:

(a) The two legs consist of totally identical instruments, or

(b) A long cash position is hedged by a total rate of return swap (or vice versa) and there is an exact match between the reference responsibility and the underlying exposure

In these cases, no specific risk capital requirement affects to either sides of the position.

An 80% offset will be recognized when the worth of two legs (i.e. long and short) always shifts in the opposite direction but not mostly to the same extent. This would be the case when a long cash position is hedged by a credit default swap or a credit linked note (or vice versa) and there is an exact match in terms of the reference obligation, the maturity of both the reference obligation and the credit derivative, and the currency to the underlying exposure. In addition, key aspects of the credit derivative contract (e.g. credit event definitions, settlement mechanisms) should not cause the price movement of the credit derivative to significantly diverge from the price movements of the cash position. To the extent that the transaction transfers risk (i.e. taking account of limiting payout provisions such as fixed payouts and materiality thresholds), an 80% specific risk offset will be applied to the side of the transaction with the larger capital charge, while the specific risk requirement on the other side will be zero.

Partial allowance will be revealed when the value of the two legs (i.e. long and short) usually goes in the reverse way. This would be the case in the next situations:

(a) If there is an asset difference between the reference obligation and the underlying exposure.

(b) If there is a currency or maturity mismatch between the credit protection and the underlying asset.

(c) If there is an asset mismatch between the cash position and the credit derivative. However, the underlying asset is included in the (deliverable) obligations in the credit derivative documentation.

With regard to banks' first-to-default and second-to-default products in the trading book, the fundamental theories developed for the banking book will also apply. Banks holding long positions in these products (e.g. buyers of basket credit linked notes) would be treated as if they were protection sellers and would be compulsory to add the specific risk charges or use the external rating if available. Issuers of these notes would be thought as if they were protection buyers and are therefore allowed to off-set specific risk for one of the underlying, i.e. the asset with the lowest specific risk charge.

4.1.2 General market risk

The capital requirements for general market risk are intended to avoid the risk of loss arising from changes in market interest rates. A selection between two principal techniques of measuring the risk is permitted, a "maturity" method and a "duration" method. In each method, the capital charge is the sum of four figures:

- The net short or long position in the entire trading book;
- A small proportion of the matched positions in every time interval (the "vertical disallowance");
- A larger proportion of the matched positions across diverse time intervals (the "horizontal disallowance");
- A net charge for positions in options, where applicable

Separate maturity ladders should be used for every currency and capital charges should be computed for each currency individually and then summed with no offsetting between positions of opposite sign. In the case of those currencies in which business is unimportant, separate maturity ladders for each currency are not necessary. Rather, the bank may build a single maturity ladder and slot, within each appropriate time interval, the net long or short position for each currency. However, these individual net positions are to be summed within each time interval, irrespective of whether they are long or short positions, to create a gross position figure.

In the maturity method, long or short positions in debt securities and other sources of interest rate exposures including derivative instruments are put into a maturity ladder generally comprising thirteen time-bands (or fifteen time-bands in case of low coupon instruments). Fixed rate instruments should be placed according to the remaining days to maturity and floating-rate instruments according to the remaining days to the next repricing date. Reverse positions of the same amount in the same issues (but not different issues by the same issuer), whether actual or motional, can be skipped from the interest rate maturity framework, as well as closely matched swaps, forwards, futures and FRAs.

The first step in the computation is to weight the positions in all time-bands by a factor intended to reflect the price sensitivity of those positions to assumed differentiation of interest rates. The weights for each time-band can be seen in Table below. Zero-coupon bonds and deep-discount bonds (Bonds with a coupon of less than 3%) should be located according to the time-bands set out in the second column of the table.

Table 4.2 Maturity Method: Time-Bands and Weights

Coupon 3% or more	Coupon less than 3%	Risk Weight	Assumed Changes in Yield
1 Month or Less	1 Month or Less	0.00%	1.00
1 to 3 Months	1 to 3 Months	0.20%	1.00
3 to 6 Months	3 to 6 Months	0.40%	1.00
6 to 12 Months	6 to 12 Months	0.70%	1.00
1 to 2 Years	1 to 1.9 Years	1.25%	0.90
2 to 3 Years	1.9 to 2.8 Years	1.75%	0.80
3 to 4 Years	2.8 to 3.6 Years	2.25%	0.75
4 to 5 Years	3.6 to 4.3 Years	2.75%	0.75
5 to 7 Years	4.3 to 5.7 Years	3.25%	0.70
7 to 10 Years	5.7 to 7.3 Years	3.75%	0.65
10 to 15 Years	7.3 to 9.3 Years	4.50%	0.60
15 to 20 Years	9.3 to 10.6 Years	5.25%	0.60
Over 20 Years	10.6 to 12 Years	6.00%	0.60
	12 to 20 Years	8.00%	0.60
	Over 20 Years	12.50%	0.60

The next step in the computation is to offset the weighted longs and shorts in each time-band; consequently we can reach a single figure in each time band. However, each band would contain special instruments and different maturities, a 10% capital charge to reflect base risk and gap risk will be charged on the smaller of the offsetting positions, and here the direction of position is not important. Thus, if the sum of the weighted longs in a time-band is $100 million and the sum of the weighted shorts $90 million, the so-called "vertical disallowance" for that timeband would be 10% of $90 million (i.e. $9.0 million).

The result of the above computations is to give two different groups of weighted positions, the net long or short positions in each time-band ($10 million long in the example above) and the vertical disallowances, which have no sign. Additionally, banks will be permitted to perform two rounds of "horizontal offsetting", first among the net positions in each of three zones (zero to one year, one year to four years and four years and over), and then between the net positions in the three different zones. The offsetting will be subject to amount of disallowances expressed as a fraction of the matched positions, as set out in Table below. The weighted long and short positions in every one of three zones may be offset, subject to the matched portion drawing a disallowance factor that is part of the capital charge. The outstanding net position in each zone may be carried over and offset in opposition to opposite positions in other zones, subject to a second set of disallowance factors.

Table 4.3 Horizontal Disallowances

Zones	Time-Band	Within the zone	Between Adjacent Zones	Between Adjacent Zones 1 and 3
	1 Month or Less			
Zone 1	1 to 3 Months	40%		
	3 to 6 Months			
	6 to 12 Months		40%	
	1 to 2 Years			
Zone 2	2 to 3 Years	30%		100%
	3 to 4 Years			
	4 to 5 Years		40%	
	5 to 7 Years			
Zone 3	7 to 10 Years	30%		
	10 to 15 Years			
	15 to 20 Years			
	Over 20 Years			

Under the substitute duration method, banks with the required ability may, with their supervisors' permission, use a more accurate method of measuring all of their general market risk by calculating the price sensitivity of each position individually. Banks must choose and use the method on a constant basis (unless a change in method is accepted by the national authority) and will be subject to supervisory watch of the systems used. The mechanics of this method are as follows:

- First compute the price sensitivity of every product in terms of a change in interest rates of between 0.6 and 1.0 percentage points depending on the remaining days to maturity of the instrument
- Put the resulting sensitivity measures into a duration-based ladder with the fifteen time-bands
- Subject long and short positions in each time-band to a 5% vertical disallowance designed to capture basis risk
- Carry forward the net positions in each time-band for horizontal offsetting subject to the disallowances

Table 4.4 Duration Method: Time-Bands and assumed changes in yield

	Assumed Annual Change in yield		**Assumed Annual Change in yield**
Zone 1		Zone 3	
1 Month or Less	1.00	3.6 to 4.3 Years	0.75
1 to 3 Months	1.00	4.3 to 5.7 Years	0.70
3 to 6 Months	1.00	5.7 to 7.3 Years	0.65
6 to 12 Months	1.00	7.3 to 9.3 Years	0.60
		9.3 to 10.6 Years	0.60
Zone 2		10.6 to 12 Years	0.60
1 to 1.9 Years	0.90	12 to 20 Years	0.60
1.9 to 2.8 Years	0.80	Over 20 Years	0.60
2.8 to 3.6 Years	0.75		

In the case of remaining currencies the gross positions in each time-band will be subject to related risk weights which are shown in tables above either but if positions are reported using the duration method, with no further offsets.

4.1.3 Interest rate derivatives

The measurement system should contain all interest rate derivatives and off balance-sheet instruments in the trading book which respond to changes in interest rates, (e.g. forward rate agreements (FRAs), other forward contracts, bond futures, interest rate and cross-currency swaps and forward foreign exchange positions). Options can be dealt with many different ways.

4.1.3.1 Calculation of positions

The derivatives should be converted into positions in the appropriate underlying and become subject to specific and general market risk charges as described above. In order to compute the standard formula described above, the amounts reported should be the market value of the principal amount of the underlying or of the notional underlying.

Futures and forward contracts, including FRAs

These instruments are assumed as a combination of a long and a short position in a government security. The maturity of a future or a FRA will be the era until delivery or use of the contract, plus - where applicable - the maturity of the underlying instrument. For instance, a long position in a May three month interest rate future (taken in March) is to be reported as a long position in a government security with a maturity of five months and a short position in a government security with a maturity of two months. Where wide range of deliverable instruments may be delivered to fulfill the contract, the bank has ability to select which deliverable security goes into the maturity or duration ladder but should consider any conversion factor defined by the exchange. In the case of a future on a corporate bond index, positions will be incorporated at the market value of the notional underlying portfolio of securities.

Swaps

Swaps will be considered as two notional positions in government securities with relevant maturities. For instance, an interest rate swap which a bank is getting floating interest rate and giving fixed will be treated as a long position in a floating rate instrument of maturity equal to the period until the next interest fixing and a short position in a fixed-rate instrument of maturity equal to the remaining life of the swap. For swaps that give or get a fixed or floating interest rate against some other reference price, e.g. a stock index, the interest rate part should be put into the suitable repricing maturity class, with the equity component being incorporated in the equity structure. The separate legs of cross-currency swaps are to be reported in the related maturity ladders for the currencies concerned.

4.1.3.2 Calculation of capital charges for derivatives under the standardized methodology

Allowable offsetting of matched positions

Banks may not include the interest rate maturity framework altogether (for both specific and general market risk) long and short positions (both actual and notional) in the same instruments with precisely the same issuer, coupon, currency and maturity. A matched position in a future or forward and its corresponding underlying may also be completely offset, and thus not included in computation. When the future or the forward includes a range of deliverable instruments offsetting of positions in the future or forward contract and its underlying is only allowable in cases where there is a readily identifiable underlying security which is most profitable for the trader with a short position to send. The worth of this security, sometimes called the "cheapest-to-deliver", and the price of the future or forward contract should in such cases move in close alignment. No offsetting will be permitted between positions in different currencies; the separate legs of cross-currency swaps or forward foreign exchange deals are to be treated as notional positions in the relevant instruments and included in the appropriate computation for each currency.

Additionally, reverse positions in the identical category of instruments can indefinite conditions are regarded as matched and permitted to offset entirely. To meet the requirements for this treatment the positions must tell to the same underlying instruments, be of the same nominal value and be denominated in the same currency. In addition:

(i) For futures: If a netting operation is done on two different underlyings, maturities of these underlyings should be within seven days.

(ii) For swaps and FRAs: the reference price (for floating rate positions) must be identical and the coupon closely matched (i.e. in 15 basis points); and

(iii) For swaps, FRAs and forwards: the next interest fixing date or, for fixed coupon positions or forwards, the remaining maturity must stay within the following limits:

• Less than one month hence: same day;

• Between one month and one year hence: within seven days;

• Over one year hence: within thirty days.

Banks with big swap books may use another formula for these swaps to compute the positions to be incorporated in the maturity or duration ladder. One technique would be to first translate the payments required by the swap into their current values. For that purpose, each payment should be discounted using corresponding yields, and a single net number for the present value of the cash flows entered into the suitable time-band using procedures that apply to zero (or low) coupon bonds; these numbers should be slotted into the general market risk framework as defined earlier. A substitute method would be to compute the sensitivity of the net present value implied by the change in yield used in the maturity or duration method and distribute these sensitivities into the time-bands set out in table above. Additional methods which create similar results could also be used. Such substitute actions will, however, only be permitted if:

• The supervisory authority is completely satisfied with the accurateness of the systems being used;

• The positions calculated completely reflect the sensitivity of the cash flows to interest rate changes and are entered into the suitable time-bands;

• The positions are denominated in the same currency.

Specific risk

Interest rate and currency swaps, FRAs, forward foreign exchange contracts and interest rate futures will not be expose to a specific risk charge. This exception also applies to futures on an interest rate index (e.g. LIBOR). On the other hand, in the case of futures contracts where the underlying is a debt security, or an index representing a basket of debt securities, a specific risk charge will pertain according to the credit risk of the issuer.

General market risk

General market risk applies to positions in every derivative product in the similar way as for cash positions, subject only to an exception for fully or very closely matched positions in identical instruments. The different categories of instruments should be slotted into the maturity ladder and treated along with the rules identified earlier.

Table 4.5 Summary of treatment of interest rate derivatives

Instrument	**Specific risk Charge**	**General market risk charge**
Exchange-traded future		
- Government debt security	No	Yes, as two positions
- Corporate debt security	Yes	Yes, as two positions
- Index on interest rates	No	Yes, as two positions
OTC forward		
- Government debt security	No	Yes, as two positions
- Corporate debt security	Yes	Yes, as two positions
- Index on interest rates	No	Yes, as two positions
FRAs, Swaps	No	Yes, as two positions
Forward foreign exchange	No	Yes, as one position in each currency
Options		Either
- Government debt security	No	a) Carve out together with the associated hedging positions - simplified approach - scenario analysis - internal models (Part B)
- Corporate debt security - Index on interest rates - FRAs, Swaps	Yes No No	b) General market risk charge according to the delta-plus method (gamma and vega should receive separate capital charges)

4.2 Equity Position Risk

This section defines a minimum capital standard to cover the risk of holding or taking positions in equities in the trading book. It concerns to long and short positions in all instruments that display market behavior similar to equities, but not to non-convertible preference shares. Long and short positions in the same subject may be reported on a net basis. The instruments covered contain common stocks, whether voting or non-voting, adaptable securities that act like equities and commitments to buy or sell equity securities. The treatment of derivative products, stock indices and index arbitrage is described in following sections.

4.2.1 Specific and general market risk

As with debt securities, the minimum capital standard for equities is represented in terms of two independently calculated charges for the “specific risk” of having a long or short position in an individual equity and for the “general market risk” of having a long or short position in the market as a whole. Specific risk is defined as the bank’s total equity positions (i.e. the sum of all long equity positions and of all short equity positions) and general market risk as the difference between the sum of the longs and the sum of the shorts (meaning. the overall net position in an equity market).The long or short position in the market must be calculated on a market-by-market basis, i.e. for every different market calculations should be different.

The capital charge for specific risk is equal to 8%, except the portfolio is both liquid and well-diversified; in this case the charge will be 4%. Given the special characteristics of national markets in terms of marketability and concentration, public authorities will have right to set the criteria for liquid and diversified portfolios. The general market risk charge will be 8%.

4.2.2 Equity derivatives

Except for options, equity derivatives and off-balancesheet positions which are driven by changes in equity prices should be incorporated in the measurement system. This contains futures and swaps on both individual equities and on stock indices. The derivatives are to be transformed into positions in the relevant underlying.

4.2.2.1 Calculation of positions

In order to compute the standard formula for specific and general market risk, positions in derivatives should be transformed into notional equity positions:

• Futures and forward contracts involving to individual equities should be reported at current market prices;

• Futures relating to stock indices should be reported as the marked-to-market value of the notional underlying equity portfolio;

• Equity swaps have to be considered as two notional positions;

• Equity options and stock index options should be either "carved out" together with the associated underlyings or be incorporated in the measure of general market risk described in this section according to the delta-plus method.

4.2.2.2 Calculation of capital charges

Measurement of specific and general market risk

Matched positions in each matching equity or stock index in each market may be completely offset, resulting in a single net short or long position to which the specific and general market risk charges will concern. For example, a future in a given equity may be offset against a reverse cash position in the identical equity

Risk in relation to an index

In addition to general market risk, an additional capital charge of 2% will apply to the net long or short position in an index contract comprising a diversified portfolio of equities. This capital charge is proposed to wrap factors such as implementation risk. Public supervisory authorities will take care to ensure that this 2% risk weight concerns only to well-diversified indices.

Arbitrage

If bank has arbitrages related with the futures, via related arbitrage strategies described below, the extra 2% capital charge described above may be applied to only one index with the opposite position except from a capital charge. The strategies are:

• When the bank takes a reverse position in definitely the same index at different dates or in different market centers

• When the bank has a reverse position in contracts at the same date in different but similar indices, subject to supervisory oversight that the two indices contain adequate common components to validate offsetting.

Where a bank employs in a planned arbitrage strategy, in which a futures contract on a broadly-based index matches a basket of stocks, it will be permissible to carve out both positions from the standardized methodology on condition that:

• The trade has been consciously entered into and separately controlled;

• The composition of the basket of stocks represents at least 90% of the index when broken down into its notional components.

In such a case the smallest capital requirement will be 4% (i.e. 2% of the gross value of the positions on each side) to reflect difference and implementation risks. This applies even if all of the stocks including the index are held in the same proportions. Any excess value of the stocks including the basket over the value of the futures contract or excess value of the futures contract over the value of the basket is to be treated as an open long or short position. If a bank takes a position in stock receipts against an opposite position in the underlying equity or identical equities in different markets, it may match the position (i.e. bear no capital charge) but only on condition that any costs on change are fully taken into account.

Table 4.6 Summary of Treatment of Equity Derivatives

Instrument	**Spesific Risk**	**General Market Risk**
Exchange-traded or OTC Future		
Individual Equity	Yes	Yes, as underlying
Index	2%	Yes, as underlying
Options		
Individual Equity	Yes	Either (a) Carve out together with the associated hedging positions - simplified approach - scenario analysis - internal models
Index	2%	(b) General market risk charge according to the delta-plus method (gamma and vega should receive separate capital charges)

4.3 Foreign Exchange Risk

This section specifies a minimum capital standard to wrap the risk of holding or taking positions in foreign currencies, as well as gold.

Two procedures are needed to compute the capital requirement for foreign exchange risk. The first one is to determine the exposure in a single currency position. The second one is to measure the risks inherent in a bank's mix of long and short positions in different currencies.

4.3.1 Measuring the exposure in a single currency

The bank's net open position in every currency should be calculated by summing:

• The net spot position (i.e. all assets minus all liability items, including accrued interest, denominated in the currency in question);

• The net forward position (i.e. all amounts will be received less all amounts to be paid under forward foreign exchange transactions, counting currency futures and the principal on currency swaps not included in the spot position);

• Guarantees (and similar instruments) that are convinced to be called and are likely to be canceled;

• Net future income/expenses not yet accrued but already entirely hedged (at the judgment of the reporting bank);

• Depending on particular accounting conventions in different countries, any other item representing a profit or loss in foreign currencies;

• The net delta equivalent of whole foreign currency options.

Positions in merged currencies require to be independently reported but, for computing banks' open positions, may be either treated as a currency in their individual right or split into their component parts on a steady basis. Positions in gold should be measured in the same way.

Three aspects require more specific comment: the treatment of interest, other income and expenses; the measurement of forward currency positions and gold; and the treatment of "structural" positions.

4.3.1.1 The treatment of interest, other income and expenses

Interest accumulated (i.e. earned but not yet received) should be incorporated as a position. Accrued expenditures should be included as well. Unearned but expected future interest and predictable expenses may be excluded unless the amounts are certain and banks have taken the opportunity to hedge them. If banks incorporate future income/expenses they should do so on steady basis, and not be permitted to choose only those expected future flows which decrease their position.

4.3.1.2 The measurement of forward currency and gold positions

Forward currency and gold positions will generally be priced at present spot market exchange rates. Using forward exchange rates would be unsuitable since it would result in the measured positions reflecting present interest rate gaps to some extent. However, banks which base their normal management accounting on net present values are expected to use the net present values of each position, discounted using current interest rates and valued at current spot rates, for measuring their forward currency and gold positions.

4.3.1.3 The treatment of structural positions

A matched currency position will defend a bank against loss from fluctuations in exchange rates, but will not essentially defend its capital adequacy ratio. If a bank has its capital denominated in its domestic currency and has a collection of foreign currency assets and liabilities that is totally matched, its capital/asset ratio will drop if the domestic currency devalues. By running a short position in the domestic currency the bank can defend its capital adequacy ratio, although the position would result a loss if the domestic currency were to realize.

Supervisory authorities are free to let banks to defend their capital adequacy ratio in this way. Thus, any positions which a bank has intentionally taken in order to hedge partly or completely against the undesirable effect of the exchange rate on its capital ratio may be excluded from the calculation of net open currency positions, subject to all of the following conditions being met:

• Such positions require being of a "structural", i.e. of non-dealing, nature (the precise meaning to be set by national authorities according to national accounting standards and practices);

• The national authority needs to be satisfied that the "structural" position excluded does no more than keep the bank's capital adequacy ratio;

• Any prohibiting of the position needs to be applied constantly, with the treatment of the hedge remaining the same for the life of the assets or other items.

No capital charge need effect to positions related to items that are subtracted from a bank's capital when calculating its capital base, such as investments neither in non-consolidated subordinates, nor to other long-term participations denominated in foreign currencies which are reported in the published accounts at historic cost. These may also be treated as structural positions.

4.3.2 Measuring the foreign exchange risk in a portfolio of foreign currency positions and gold

Banks will have an alternative between two substitute measures at supervisory judgment; a "shorthand" method which assumes all currencies equally; and the employment of internal models which takes account of the real degree of risk dependent on the composition of the bank's portfolio.

Under the shorthand method, the nominal amount (or net present value) of the net position in each foreign currency and in gold is transformed at spot rates into the reporting currency. The general net open position is calculated by total:

• The sum of the net short positions or the sum of the net long positions, whichever is the greater; plus

• The net position (short or long) in gold, regardless of sign.

The capital charge will be 8% of the overall net open position

4.4 Treatment of Options

In recognition of the extensive variety of banks' activities in options and the difficulties of calculating price risk for options, several alternative methods will be allowed at the judgment of the national authority:

• Those banks which exclusively exercise purchased options will be free to use the simplified approach described below;

• Those banks which also write options will be anticipated to use one of the intermediate approaches as set out in below or a complete risk management model under the terms of internal models. Generally as the bank use more complicated instruments, the more the bank will be expected to use a sophisticated approach.

In the simplified approach, the option positions and the associated underlying, cash or forward, are not matter to the standardized methodology but rather are "carved-out" and subject to separately calculated capital charges that include both general market risk and specific risk. The risk numbers thus produced are then added to the capital charges for the related category, i.e. interest rate related instruments, equities, foreign exchange and commodities.

The delta-plus method employs the sensitivity parameters or "Greek letters" related with options to compute their market risk and capital requirements. In this technique, the delta-equivalent position of each option turns out to be part of the standardized methodology with the delta-equivalent amount subject to the appropriate general market risk charges. Separate capital charges are then applied to the gamma and vega risks of the option positions. The scenario approach employs simulation techniques to compute changes in the value of an options portfolio for alterations in the level and volatility of its associated underlyings. Under this approach, the general market risk charge is calculated by the scenario "grid" (i.e. the specified combination of underlying and volatility changes) that creates the biggest loss. For the delta-plus method and the scenario approach the specific risk capital charges are determined independently by multiplying the delta-equivalent of each option by the specific risk weights

4.4.1 Simplified approach

Banks which hold a narrow range of purchased options only will be free to employ the simplified approach set out below for particular trades. As an example of how the computation would work, if a owner of 100 shares currently valued at $10 each holds an equivalent put option with a strike price of $11, the capital charge would be: $1,000 x 16% (i.e. 8% specific plus 8% general market risk) = $160, less the amount the option is in the money ($11 - $10) x 100 = $100, i.e. the capital charge would be $60. A parallel methodology pertains for options whose underlying is a foreign currency, an interest rate related instrument or a commodity.

4.4.2 Intermediate approaches

4.4.2.1 Delta-plus method

Banks which write options will be permitted to contain delta-weighted options positions within the standardized methodology. Such options must be reported as a position equal to the market value of the underlying multiplied by the delta. However, as delta does not adequately cover up the risks connected with options positions, banks have to measure gamma (which measures the rate of change of delta) and vega (which measures the sensitivity of the value of an option with respect to a change in volatility) sensitivities in order to compute the total capital requirement. These sensitivities will be calculated according to an accepted exchange model or to the bank's proprietary options pricing model subject to approval of the national authority.

Delta-weighted positions with *debt securities or interest rates as the underlying* will be put into the interest rate time-bands, under the following procedure.

A two-legged method should be used as for other derivatives, at the first step the underlying contract takes effect and in second step the underlying contract matures. For example, if bank has bought a call option which is June three-month interest-rate future, this option has two legs naturally and its first leg matures in five months and should be put in maturity ladder according to delta equivalent value with a maturity of five months and a short position with a maturity of two months. Similarly the written option will be slotted as a long position with a maturity of two months and a short position with a maturity of five months. Floating rate instruments with caps or floors will be considered as a mixture of floating rate securities and a series of European-style options. For example, the holder of a three-year floating rate bond referenced to six month LIBOR with a cap of 15% will treat it as:

(i) A debt security that repricing every six months; and

(ii) 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

Generally speaking the capital charge for options with equities as the underlying is calculated using delta equivalent of the options. For this calculation each national market assumed as different market underlying. For delta risk, the net delta-based equivalent of the foreign currency and gold options will be included into the measurement of the exposure for the own currency (or gold) position. The capital charge for options on commodities will be based on the simplified or the maturity ladder approach.

Basle II comes another risk factor which concerns with gamma and vega risks of options. The delta-plus method user banks will be required to calculate the gamma and vega for each option position (including hedge positions) separately. The capital charges should be calculated in the following way:

(i) For **each individual option** a “gamma impact” should be computed according to a Taylor series expansion as:

Gamma impact = $\frac{1}{2}$ x Gamma x VU^2 **(4.1)**

where

VU = Variation of the underlying of the option.

(ii) VU will be calculated as follows:

• If the option is an interest rate option market value of the option should be multiplied by corresponding weight. An equivalent computation should be carried out where the underlying is an interest rate, again based on the assumed changes in the corresponding yield;

• For options on equities and equity indices: the market value of the underlying should be multiplied by 8%;

• For foreign exchange and gold options: the market value of the underlying should be multiplied by 8%;

• For options on commodities: the market value of the underlying should be multiplied by 15%.

(iii) For the reason of this calculation the following positions should be assumed as the same underlying:

• For interest rates, if they belong same time-band

• For equities and stock indices, each national market;

• For foreign currencies and gold, each currency pair and gold;

(iv) Every option has a positive or negative gamma effect. These individual gamma impacts are summed in order to evaluate total gamma impact. The capital charge imposed only those net gamma impacts that are negative will be included in the capital calculation.

(v) The total gamma capital charge will be the sum of the absolute value of the net negative gamma impacts as calculated above.

(vi) For volatility risk, banks will be required to compute the capital charges by multiplying the sum of the vegas for all options on the same underlying, as defined above, by a relative shift in volatility of ± 25%.

(vii) The total capital charge for vega risk is equal to the sum of the absolute value of the individual capital charges that have been calculated for vega risk.

4.4.2.2 Scenario approach

Banks which are using more sophisticated options are free to develop their own models to base the market risk capital charge for options portfolios and associated hedging positions on scenario matrix analysis. These values can be calculated via pre determined movements on option's risk factors and calculating changes in the value of the option portfolio at various points along this "grid". In order to determine these impacts banks reprice their own option portfolios according to assumptions on underlying rate or price and in the volatility of that rate or price. As a substitute, at the judgment of each national authority, banks which are important traders in options will be permitted to base the calculation on a minimum of six sets of time-bands for interest rate options. When using this method, not more than three of the time-bands should be combined into any one set.

The options and their hedge transactions have to be evaluated specific range above and below of the current value of the underlying. Alternative method user banks should use different price bands to calculate gamma impact for interest rate options for each set of time-bands. The other ranges are ± 8% for equities, ± 8% for foreign exchange and gold, and ± 15% for commodities. For all risk categories, at least seven observations (including the current observation) should be used to divide the variety into equally spaced intervals.

The second dimension of the matrix involves a change in the volatility of the underlying rate or price. A single alteration in the volatility of the underlying rate or price equivalent to a shift in volatility of + 25% and - 25% is expected to be sufficient in most cases. As conditions warrant, however, the supervisory authority may decide to require that a different change in volatility be used and/or that middle points on the grid be calculated.

After forming the matrix every cell holds the net profit or loss of the option and the underlying hedge tool. The capital charge for each underlying will then be calculated as the largest loss enclosed in the matrix.

The implementation of the scenario analysis by any specific bank will be subject to managerial permission, particularly as regards the exact way that the analysis is constructed. Banks' use of scenario analysis as part of the standardized methodology will also be subject to support by the national authority.

In drawing up these intermediate methods the Committee has wanted to cover the major risks connected with options. In doing so, it is aware that so far as specific risk is considered, only the delta-related elements are captured; to deal with other risks would require a much more complex system. On the other hand, in other areas the simplifying assumptions used have resulted in a comparatively conservative treatment of definite options positions. For these reasons, the Committee plans to keep this area under close review.

In addition the options risks cited above, the Committee is aware of the other risks also associated with options, e.g. rho (rate of change of the value of the option with respect to the interest rate) and theta (rate of change of the value of the option with respect to time). While not suggested a measurement system for those risks at present, it expects banks undertaking important options business at the very least to monitor such risks closely. In addition, banks will be allowed to incorporate rho into their capital calculations for interest rate risk, if they wish to do so.

5. USE OF INTERNAL MODELS TO MEASURE MARKET RISKS

Main aim of this thesis is establishing an alternative model to standardised approach. Therefore this part of the thesis is intended to state main guidelines in designing an internal model to monitor market risks.

5.1 General Criteria

The use of an internal model will be conditional upon the clear approval of the bank's supervisory authority. Banks which carry out material trading activities on different countries have to get approval from both country authorities.

The supervisory authority will only give its support if at a minimum:

- It is satisfied that the bank's risk management system is theoretically sound and is applying with honesty;
- The bank has enough numbers of staff skilled in the use of sophisticated models not only in the trading area but also in the risk control, audit, and if essential, back office areas, in the supervisory authority's sight;
- The bank's models have a confirmed track record of reasonable accuracy in measuring risk, in the managerial authority's judgment;
- The bank regularly performs stress tests.

In some cases supervisory authorities can monitor banks' internal model and make tests on it before it is used for supervisory capital purposes.

5.2 Qualitative Standards

It is very important that supervisory authorities have to feel that banks which use internal models have market risk management systems that are theoretically sound and implemented realistically. As a result supervisory authorities have to set some qualitative criteria that banks have to meet in order to implement and measure their market risks via a model-based approach. The model's success rate directly determines multiplication factor set by supervisory authority. Only the models which have ideal compliance with BASLE II requirements have minimum multiplication factor.

Generally speaking every bank has to have a self-governing risk control unit. This unit is responsible for monitoring and measuring market risk of the bank. The unit should create daily, weekly, monthly and or quarterly (if necessary) reports and should directly report them to senior management. The unit must be independent from trading department.

The Risk Management unit has to make back-tests concerning measurement of model's success rate. That is, the unit should calculate actual loss of the bank during the trading day and compare this actual daily loss with its initial loss estimation.

The unit should also perform the initial and on-going justification of the internal model.

Bank's senior management and board of directors should be actively involved in bank's risk management activities and should believe that risk management system is an important part of the bank management and its actions directly influence bank's profit. For this purpose the daily reports of risk management should be examined by management levels which have right to reduce bank's positions in order to decrease bank's risk exposure.

The daily risk management model of the bank should be directly integrated to bank's day-to-day risk management processes. Therefore the unit's output is main part of monitoring, planning, and controlling bank's market risk profile.

The risk management system should be designed to be in parallel with internal trading and exposure limits. Additionally its principles have to be explained to bank's traders and they have to follow their exposures according to limit structure.

Banks should make stress tests on their portfolios regularly and should present their findings according to a predefined program. The stress test results should be checked by board of directors and they have to follow bank's capital adequacy ratio with the effect of these stress tests as well. Stress tests may tell particular weakness to a given set of circumstances and prompt steps should be taken to handle those risks appropriately (e.g. by hedging against that outcome or reducing the size of the bank's exposures or increasing capital).

Banks should have well designed procedures that give information about basic principles of risk management structure. The procedures include theoretical explanations of risk measurement models used in bank. The internal control points and control procedures also have to be included in those procedures.

Internal auditing system of the bank should make detailed analysis on risk management department's outputs at least once a year and should specifically address, at a minimum:

- The sufficiency of the documentation of the risk management system and process;
- The structure of the risk control unit;
- The combination of market risk measures into daily risk management;
- The authorization process for risk pricing models and valuation systems used by front and back-office personnel;
- The justification of any important change in the risk measurement process;
- The extent of market risks included by the risk measurement model;
- The reliability of the management information system;
- The correctness and completeness of position data;
- The verification of the uniformity, timeliness and consistency of data sources used to run internal models, including the independence of such data sources;
- The correctness and appropriateness of volatility and correlation assumptions;
- The correctness of valuation and risk transformation calculations;
- The confirmation of the model's correctness through frequent back-testing as described above.

5.3 Specification of Market Risk Factors

One of the major parts of the bank's risk management framework is decision of risk factors because these risk factors are assumed as main determinant of bank's returns, meaning these factors represent actual position of bank's trading positions. Of course bank's risk factors should be good enough to capture risks that are embedded in bank's positions. Although banks have some judgment in stating risk factors for their internal models, the following guidelines should be satisfied.

For interest rates, banks should have a set of risk factors representing interest rates of each currency on which the bank has interest-rate-sensitive on- or off-balance sheet positions.

The assumed yield curve of the bank should be modeled via commonly accepted methodology, for instance, by estimation of zero coupon yields' forward rates. In order to see the variance of interest rate volatility, the yield curve should be separated into various maturity segments; generally Basle committee expects one risk factor to each maturity interval. For material positions bank's have to have at least six different risk factors to model bank's risks. However, the number of risk factors used in modeling process can be higher for the portfolios which have large number of securities with wide range of maturities in order to capture interest rate risk accurately.

Different risk factors should be included in risk measurement system to contain spread risk. Different types of approaches can be used to include the spread risk arising from less than completely correlated movements between government and other fixed-income interest rates, such as identifying a totally different yield curve for non-government fixed-income instruments (for instance, swaps or municipal securities) or predicting the spread over government rates at different points along the yield curve.

In modeling exchange rates (which may include gold), measurement system of the bank should contain risk factor of corresponding foreign currencies. Given that the value-at-risk figure extracted from bank's risk management system is expressed in terms of domestic currency, the positions other than domestic currency create a foreign exchange risk. Therefore bank's risk management system has to include a risk factor corresponding to major exposures of each currency.

For equity prices, there should be risk factors corresponding to each of the equity markets in which the bank holds significant positions:

At least, there should be a risk factor that is intended to capture market-wide movements in equity prices (e.g. a market index). When bank holds positions in individual securities or in sector indices which can be expressed in "beta-equivalents" relative to this market wide index;

- A rather more comprehensive approach would be to have risk factors subsequent to a variety of sectors of the whole equity market (for example, industry sectors or cyclical and non-cyclical sectors). As above, positions in individual stocks inside every sector could be expressed in beta-equivalents relative to the sector index;

- The broadest approach would be to have risk factors corresponding to the volatility of individual equity issues.

The complexity and environment of the modeling method for a given market should monitor the bank's overall market as well as its concentration in individual equity issues in that market.

If bank has commodity positions, risk factors reflecting exposure of bank on the commodity should be employed in risk management system of bank.

For banks with relatively small positions in commodity-based instruments, a simple specification of risk factors would be appropriate. Such a condition would probably involve one risk factor for each commodity price to which the bank is exposed. In conditions where the cumulative positions are relatively small, it might be adequate to employ a single risk factor for a comparatively broad sub-category of commodities (for example, a single risk factor for all types of gold);

For further dynamic trading, the model must also consider variation in the "convenience yield" between derivatives positions such as forwards and swaps and cash positions in the product.

5.4 Quantitative Standards

Banks will have flexibility in developing the precise nature of their models, but the following minimum standards will concern for the purpose of calculating their capital charge. Individual banks or their supervisory authorities will have right to employ stricter standards.

(a) "Value-at-risk" must be calculated on daily basis.

(b) In value-at-risk calculations, 99th percentile, one-tailed confidence interval should be used.

(c) In calculation of value-at-risk, an immediate price hit equivalent to a 10 day movement in prices is to be used, i.e. the smallest "holding period" will be ten trading days. Banks may employ value-at-risk numbers computed according to shorter holding periods leveled up to ten days by the square root of time.

(d) The choice of historical observation period (sample period) for measuring value-at-risk should not be less than one year. For banks that use a weighting system or other methods for the past observation period, the "efficient" observation period must be at least one year (that is, the weighted average time cover of the individual observations cannot be less than 6 months).

(e) Banks should revise their data sets frequently; meaning should not be more than every three months and should also reconsider them when market prices are subject to material changes. Banks may also have to recalculate its value-at-risk measures based on shorter time horizons at the request of supervisory authority.

(f) Banks can use any type of model they want as long as model captures all the risks carried by bank. For instance, banks can use variance-covariance matrices, historical simulations or Monte Carlo simulations.

(g) Banks will have judgment to recognize pragmatic correlations within broad risk categories (e.g. interest rates, exchange rates, equity prices and commodity prices, including related options volatilities in each risk factor category). The supervisory authority may also identify empirical correlations across wide risk factor categories, provided that the supervisory authority is satisfied that the bank's system for monitoring correlations is sound and implemented with integrity.

(h) Banks' models must exactly capture the unique risks related with options within each of the extensive risk categories. The following criteria apply to the measurement of options risk:

- Banks' models should include non-linear price characteristics of options positions;
- Banks are anticipated to eventually move towards the application of a full 10 day price shock to options positions or positions that exhibit option-like

characteristics. In the interim, national authorities may want banks to change their capital measure for options risk through other methods, e.g. periodic simulations or stress testing;

➢ Each bank's risk measurement system must contain a set of risk factors that represents the volatilities of the rates and prices underlying option positions, i.e. vega risk. Banks with quite large and/or complex options portfolios should have comprehensive specifications of the related volatilities. This means that banks should measure the volatilities of options positions broken down by diverse maturities.

(i) Minimum capital requirement of the bank is calculated via maximum of following two figures. (i) Its previous day's value-at-risk figure calculated according to the model parameters. (ii) An average of the daily value-at-risk figures on each of the past sixty business days, multiplied by a multiplication factor.

(j) The multiplication factor shows the degree of model correctness. The factor set by national authorities and its smallest amount is 3. In addition of this multiplication factor banks have another multiplication number in the range of (0, 1). This number directly depends on the past success rate of the model. The success rate of model can be measured by the procedure called as "backtesting.". If the backtesting results of the model is satisfactory and the model meets the standards stated above, the factor becomes zero. The Basle committee publishes a document which gives details of this factor usage. Supervisors will have national judgment to involve banks to perform backtesting on either hypothetical (i.e. using changes in portfolio value that would occur where end-of-day positions to remain unchanged), or actual trading (i.e. excluding fees, commissions, and net interest income) outcomes, or both.

(k) Banks using models will also be subject to a capital charge to wrap specific risk (as defined under the standardized approach for market risk) of interest rate related instruments and equity securities.

5.5 Stress Testing

Internal model user banks have to employ reliable and precise stress testing programs in order to see their actual exposures to severe events. Stress testing to recognize events or influences that could significantly impact banks is a key component of a bank's assessment of its capital position.

Banks' stress scenarios require wrapping a range of factors that can create unexpected losses or gains in trading portfolios or make the control of risk in those portfolios very complex. These factors contain low-probability events in all major types of risks, including the various components of market, credit, and operational risks. Stress scenarios require shedding light on the crash of such events on positions that display both linear and nonlinear price characteristics (i.e. options and instruments that have options-like characteristics).

Stress tests have quantitative and qualitative nature; these tests reflect both market risk and liquidity risk of sudden market movements. Quantitative criteria should identify reasonable stress scenarios to which banks could be exposed. Qualitative criteria should point out that two major goals of stress testing are to assess the capacity of the bank's capital to absorb potential great losses and to identify steps the bank can take to decrease its risk and save capital. This assessment is essential for setting and evaluating bank's management strategy and the consequences of stress testing should be regularly talked to senior management and periodically to the bank's board of directors.

Banks should merge the use of supervisory stress scenarios with stress tests created by banks themselves to reveal their specific risk characteristics. Specifically, supervisory authorities may require banks to give information on stress testing in three broad areas which are discussed in turn below.

5.5.1 Supervisory scenarios requiring no simulations by the bank

Banks should have data on the largest losses occurred during the reporting era available for supervisory examination. This loss data could be judged against to the level of capital that results from a bank's internal measurement system. For example, it could offer supervisory authorities with a picture of how many days of peak day losses would have been enclosed by a given value-at-risk prediction.

5.5.2 Scenarios requiring a simulation by the bank

The stress tests should be performed on bank's portfolios and these results should be presented to supervisory authorities as well. These scenarios could include testing the present portfolio against historical bad days which have significant disturbance, for example, the 1987 equity crash, the ERM crises of 1992 and 1993 or the fall in bond markets in the first quarter of 1994, March 2001 "Tezkere" crises in Turkey incorporating both the large price shifts and the quick decrease in liquidity associated with these events. Another type of scenario would assess the compassion of the bank's market risk disclosure to alterations in the assumptions about volatilities and correlations. Application of this test would require an assessment of the historical range of variation for volatilities and correlations and valuation of the bank's current positions against the extreme values of the historical range. Due consideration should be given to the quick difference happened in a matter of days in periods of important market disturbance.

5.5.3 Scenarios developed by the bank itself to capture the specific characteristics of its portfolio.

In addition to the scenarios set by supervisory authorities, a bank should also build up its own stress tests which it recognizes as most adverse based on the characteristics of its portfolio. Banks should offer supervisory authorities with an explanation of the method used to recognize and carry out the scenarios as well as with an explanation of the results resulting from these scenarios.

The consequences should be evaluated periodically by senior management and should be reflected in the policies and limits set by management and the board of directors. Furthermore, if the testing tells particular weakness to a given set of circumstances, the national authorities would anticipate the bank to take prompt steps to supervise those risks properly (e.g. by hedging against that outcome or reducing the size of its exposures).

5.6 External Validation

The validation of models' accuracy by external auditors and/or supervisory authorities includes at least followings:

(a) Verifying that the internal validation processes are working in an acceptable manner;

(b) Ensuring that the formula used in the computation process as well as for the pricing of options and other complex components are validated by a competent unit, which should be self-governing from the trading area, in all cases;

(c) Checking that the organization of internal models is sufficient with respect to the bank's activities and geographical coverage;

(d) Checking the consequences of the banks' back-testing of its internal measurement system (i.e. evaluating value-at-risk estimates with actual profits and losses) to guarantee that the model gives a reliable measure of potential losses over time. This means that banks should make the results as well as the underlying inputs to their value-at-risk calculations accessible to their supervisory authorities and/or external auditors on demand;

(e) Making sure that data flows and processes connected with the risk measurement system are transparent and available. In particular, it is essential that auditors or supervisory authorities are in a position to have straightforward access, whenever they judge it necessary and under suitable procedures, to the models' specifications and parameters.

5.7 Combination of Internal Models and the Standardized Methodology

As a general law, if a bank has a significant exposure in a risk factor, internal model approach says that the internal model should occupy this risk factor as well. Therefore, banks which begin to employ models for one or more risk factor categories will, over time, be projected to expand the models to all their market risks. A bank which has developed one or more models will no longer be able to turn back measuring the risk by those models according to the standardized methodology (except the supervisory authorities withdraw authorization for that model). However, awaiting further knowledge regarding the process of changing to a models-based approach, no specific time limit will be set for banks which use a combination of internal models and the standardized methodology to move to a complete model.

The following criteria will relate to banks using such combinations:

(a) Each big risk factor group must be evaluated by means of a single approach (either internal models or the standardized approach), i.e. no mixture of the two methods will in principle be allowed within a risk category or across banks' different entities for the same type of risk

(b) Banks may not change the mixture of two approaches they use without justifying to their supervisory authority that they have a good reason for doing so;

(c) No element of market risk may run off measurement, i.e. the exposure for all the diverse risk factors, whether calculated according to the standardized approach or internal models would have to be captured;

(d) The capital charges judged under the standardized approach and under the models approach are to be combined according to the simple sum method.

5.8 Treatment of Specific Risk

Wherever a bank has a VaR measure that includes specific risk and that satisfies all the qualitative and quantitative necessities for general risk models, it may base its charge on modeled estimations, given the measure is based on models that satisfy the extra criteria and requirements defined below. Banks which are not capable to meet these extra criteria and requirements will be required to base their specific risk capital charge on the full amount of the specific risk charge computed under the standardized method.

The criteria for supervisory respect of banks' modeling of specific risk involve that a bank's model must capture all material components of price risk and be reactive to changes in market conditions and components of portfolios. In particular, the model must:

- Explain the historical price deviation in the portfolio;
- Capture concentrations (magnitude and changes in composition);
- Be strong in an adverse environment;
- Capture event risk;
- Be certified through backtesting.

Where a bank is expose to event risk that is not included in its VaR measure because it is ahead of the 10-day holding period and 99 percent confidence interval (i.e. low probability and high severity events), banks must guarantee that the shock of such events is factored in to its in-house capital assessment, for example through stress testing.

The bank's model must normally evaluate the risk arising from less liquid positions and/or positions with restricted price precision under realistic market situations. In addition, the model must satisfy minimum data standards. Substitutes may be used only where available data is inadequate or is not reflective of the true volatility of a position or portfolio, and only where they are properly conservative. Further, as techniques and best practices develop, banks should benefit themselves of these advances.

In addition, the bank must have an approach in place to capture in its regulatory capital default risk of its trading book positions which expand the risk captured by the VaR-based computation as specified above. To get rid of double counting a bank may take into account the scope to which default risk has already been included into the VaR calculation, particularly for risk positions that could be closed within 10 days in the event of bad market conditions or other signals of decline in the credit atmosphere. No specific method for capturing the incremental default risk is set; it may be part of the bank's internal model or a supplement from a separate computation. Where a bank captures its incremental risk through a surcharge, the surcharge will not be subject to a multiplier or regulatory backtesting, even though the bank should be able to show that the surcharge satisfies its target.

Whichever method is used, the bank must demonstrate that it has a reliable standard comparable to that of the internal-ratings based approach for credit risk as set forth in the Basle II Framework, under the supposition of a steady level of risk, and accustomed where suitable to reflect the crash of liquidity, concentrations, hedging, and optionality. Banks which cannot measure its own incremental default risk should withdraw their internal model usage request.

Whichever method is used, cash or synthetic disclosures that would be subject to an assumption treatment under the securitization framework set forth in the Basle II Framework (e.g. equity trenches that absorb first losses), as well as securitization disclosures that are unrated liquidity lines or letters of credit, would be subject to a capital charge that is no less than that set forth in the securitization framework.

An exception to this conduct could be given to the banks that are dealers in the above exposures where they can reveal, in addition to trading meaning that a liquid two-way market exists for the securitization exposures or, in the case of synthetic securitizations that rely exclusively on credit derivatives, for the securitization exposures themselves or all their ingredient risk components. For purposes of this section, a two-way market is assumed to exist where there are self-governing tenders to buy and sell so that a price realistically related to the last sales price or current competitive bid and offer quotations can be determined within one day and settled at such price within a relatively short time in compliance to trade custom. In addition, for a bank to apply this exclusion, it must have adequate market data to ensure that it completely captures the concentrated default risk of these exposures in its internal approach for measuring the incremental default risk in accordance with the standards set above.

Banks that already have received specific risk model credit for particular portfolios or lines of business should agree a schedule with their supervisors to bring their model in line with the new standards in an appropriate manner as is practicable.

Banks which apply modeled guess of specific risk are required to perform backtesting aimed at judging whether specific risk is being accurately captured. The method a bank should utilize for validating its specific risk estimates is to make separate backtests on sub-portfolios using daily data on sub-portfolios subject to specific risk. The key sub-portfolios for this principle are traded-debt and equity positions. On the other hand, if a bank divides its trading portfolio into finer categories (e.g. emerging markets, traded corporate debt, etc.), it is suitable to maintain these distinctions for sub-portfolio backtesting purposes. Banks are necessary to commit to a sub-portfolio structure and stick to it unless it can be demonstrated to the supervisor that it would make sense to modify the structure

Banks are required to have in place a procedure to examine exceptions identified through the backtesting of specific risk. This process is intended to provide as the fundamental way in which banks correct their models of specific risk in the occurrence they become incorrect. There will be an assumption that models that include specific risk are “unacceptable” if the results at the sub-portfolio level create a number of exceptions equal with the Red Zone as defined in committee documents. Banks with “improper” specific risk models are anticipated to take instant action to correct the problem in the model and to guarantee that there is a sufficient capital buffer to absorb the risk that the backtest showed had not been sufficiently captured.

5.9 Model Validation Standards

It is vital that banks have procedures in place to guarantee that their internal models have been effectively licensed by properly qualified parties, free of the development process to guarantee that they are theoretically sound and sufficiently capture all material risks. This validation should be done when the model is originally developed and when any major changes are made to the model. The validation should also be performed on a periodic basis but particularly where there have been any significant structural changes in the market or changes to the composition of the portfolio which might cause to the model no longer being adequate. More general model validation is mostly important where specific risk is also modeled and is necessary to meet the further specific risk criteria. As techniques and best practices develop, banks should benefit themselves of these advances. Model validation should not be limited to backtesting, but should, at a minimum, also contain the following:

(a) Tests to prove that any assumptions done within the internal model are suitable and do not underestimate risk. This may contain the statement of the normal distribution, the use of the square root of time to scale from a one day holding period to a 10 day holding period or where extrapolation or interpolation methods are used, or pricing models;

(b) Further to the regulatory backtesting programs, testing for model validation should be carried out by means of extra tests, which may contain, for instance:

- Testing carried out using theoretical changes in portfolio worth that would happen where end-of-day positions to remain unaffected. It consequently excludes fees, commissions, bid-ask spreads, net interest income and intra-day trading;
- Testing carried out for longer periods than necessary for the regular backtesting program (e.g. 3 years). The longer time period usually improves the power of the backtesting. A longer time period may not be attractive if the VaR model or market conditions have changed to the degree that historical data is no longer appropriate;
- Testing carried out by means of confidence intervals other than the 99 percent interval required under the quantitative standards;
- Testing of portfolios below the general bank level;

(c) The use of theoretical portfolios to guarantee that the model is able to account for particular structural features that may occur, for example:

- Where data histories for a particular instrument do not meet the quantitative standards and where the bank has to map these positions to substitutes, then the bank must guarantee that the substitutes create conservative results under relevant market scenarios;
- Guaranteeing that material basis risks are sufficiently captured. This may contain mismatches between long and short positions by maturity or by issuer;
- Ensuring that the model captures concentration risk that may emerge in an undiversified portfolio.

5.10 Backtesting

Banks that implement an internal model-based approach to market risk measurement regularly compare daily profits and losses with model-generated risk measures to determine the superiority and correctness of their risk measurement systems. This procedure, known as "backtesting", has been found useful by many institutions as they have developed and introduced their risk measurement models.

As a technique for assessing the power of a firm's risk measurement model, backtesting continues to develop. New approaches to backtesting are still being developed and discussed within the broader risk management society. At present, different banks make different types of backtesting comparisons and the standards of interpretation also vary somewhat across banks. Active efforts to develop and refine the methods currently in use are under way, with the goal of distinguishing more sharply between precise and inaccurate risk models.

The spirit of all backtesting efforts is the judgment of actual trading results with model-generated risk measures. If this comparison is close enough, the backtest raises no questions about the superiority of the risk measurement model. In some cases, however, the comparison tells sufficient differentiations that problems almost definitely must exist, either with the model or with the assumptions of the backtest. In between these two cases is a grey area where the test results are, on their own, uncertain.

The Basle Committee thinks that backtesting proposes the best opportunity for incorporating suitable incentives into the internal models approach in a manner that is steady and that will cover a variety of circumstances. Certainly, many of the public comments on the April 1995 internal models plan stressed the need to keep strong incentives for the constant development of banks' internal risk measurement models. In considering how to include backtesting more closely into the internal models approach to market risk capital requirements, the Committee required to disclose both the fact that the industry has not yet settled on a single backtesting methodology and concerns over the defective nature of the signal generated by backtesting.

The Committee thinks that the framework outlined below strikes an appropriate balance between recognition of the potential limits of backtesting and the need to put in place suitable incentives. At the same time, the Committee recognizes that the methods for risk measurement and backtesting are still developing, and the Committee is dedicated to incorporate important new developments in these areas into its structure.

The backtesting framework that is to accompany the internal models capital requirement is described in the following paragraphs. The aim of this structure is the encouragement of more precise approaches to backtesting and the supervisory understanding of backtesting results. The next section deals with the nature of the backtests themselves, while the section that follows concerns the supervisory explanation of the results and sets out the settled standards of the Committee in this regard.

5.10.1 Description of the backtesting framework

The backtesting structure developed by the Committee is based on that it is adopted by many of the banks using internal market risk measurement models. These backtesting programs classically consist of a periodic evaluation of the bank's daily value-at-risk measures with the successive daily profit or loss ("trading outcome"). The value-at-risk measures are proposed to be larger than all but a certain part of the trading outcomes could be larger than projected VaR figures, where that portion is determined by the confidence level of the value-at-risk measure. Evaluating the risk measures with the trading outcomes just means that the bank counts up the number of times that the risk measures were bigger than the trading outcome. The portion really covered can then be compared with the planned level of coverage to measure the performance of the bank's risk model. In some cases, this last step is relatively informal, although there are statistical tests that may also be applied.

The managerial framework for backtesting employs all of the steps identified in the preceding paragraph, and tries to set out a steady explanation of each step as it is reasonable without imposing unnecessary weights. Under the value-at-risk framework, the risk measure is an approximation of the amount that could be lost on a set of positions due to general market activities over a given holding period, measured using a specified confidence level.

The backtests to be applied for assessing whether the observed percentage of outcomes covered by the risk measure is constant with a 99% level of confidence. That is, they try to prove if a bank's 99th percentile risk measures truly cover 99% of the firm's trading outcomes. While it can be argued that the extreme-value nature of the 99th percentile makes it harder to estimate consistently than other, lower percentiles.

An additional consideration in specifying the suitable risk measures and trading outcomes for backtesting occurs because the value-at-risk approach to risk measurement is usually based on the sensitivity of a stable portfolio to instant price shocks. That is, end-of-day trading positions are enter into the risk measurement model, which assesses the potential change in the value of this static portfolio due to price and rate movements over the assumed holding period.

While this is basic in theory, in practice it makes difficult the topic of backtesting. For example, it is frequently disagreed that value-at-risk measures cannot be compared against real trading outcomes, since the real outcomes will unavoidably be "affected" by alterations in portfolio composition throughout the holding period. According to this view, the enclosure of payment income together with trading gains and losses resulting from changes in the composition of the portfolio should not be included in the description of the trading outcome because they do not transmit to the risk inherent in the static portfolio that was assumed in building the value-at-risk measure.

This argument is realistic with regard to the employment of value-at-risk measures based on price shocks adjusted to longer holding periods. That is, comparing the ten-day, 99th percentile risk measures from the internal models capital requirement with actual ten-day trading outcomes would possibly not be a meaningful exercise. In particular, in any given ten day period, major changes in portfolio composition comparing with the initial positions are common at major trading institutions. For this reason, the backtesting framework described here involves the use of risk measures adjusted to a one-day holding period. The test would be based on how banks model risk internally.

Given the use of one-day risk measures, it is suitable to use one-day trading outcomes as the benchmark to use in the backtesting program. The similar concerns about “contamination” of the trading outcomes discussed above continue to be relevant, but, even for one-day trading outcomes. That is, there is a concern that the overall one-day trading outcome is not a suitable point of comparison, because it reveals the effects of intra-day trading, possibly including fee income that is booked in association with the sale of new products.

On the one hand, intra-day trading might cause to raise the volatility of trading outcomes, and may result in cases where the general trading outcomes go beyond the risk measure. This event obviously does not mean a problem with the methods used to compute the risk measure; rather, it is just outside the extent of what the value-at-risk method is planned to estimate. On the other hand, counting fee income may similarly deform the backtest, but in the other direction, since fee income often has annuity-like characteristics and this fee income is not normally included in the calculation of the risk measure, problems with the risk measurement model could be masked by including fee income in the description of the trading outcome used for backtesting purposes.

Some have disagreed that the real trading result experienced by the bank are the most important and related figures for risk management functions, and that the risk measures should be benchmarked against this truth, even if the hypothesis behind their calculations are limited in this regard. Others have also argued that the issue of fee income can be addressed sufficiently, although crudely, by simply removing the mean of the trading outcomes from their time series before performing the backtests. A more complicated approach would entail a detailed attribution of income by source, including fees, spreads, market movements, and intra-day trading results.

To the extent that the backtesting program is viewed simply as a statistical test of the integrity of the calculation of the value-at-risk measure, it is obviously most suitable to use a definition of daily trading outcome that allows for an "uncontaminated" test. To meet this standard, banks should develop the ability to perform backtests based on the hypothetical changes in portfolio value that would occur where end-of-day positions to stay unchanged.

Backtesting using real daily profits and losses is also a helpful exercise since it can uncover cases where the risk measures are not precisely capturing trading volatility in spite of being calculated with reliability.

For these reasons, the Committee recommends banks to build up the capability to perform backtests using both hypothetical and actual trading outcomes. Even though national supervisors may differ in the weight that they wish to put on these different approaches to backtesting, it is obvious that each approach has value. In combination, the two approaches are likely to provide a strong understanding of the relation between intended risk measures and trading outcomes.

The next step in developing the backtesting program concerns the characteristics of the backtest itself, and the frequency with which it is to be performed. The structure adopted by the Committee, which is also the simplest procedure for evaluation of the risk measures with the trading outcomes, is just to calculate the number of times that the trading outcomes are not enclosed by the risk measures ("exceptions"). For example, over 300 trading days, a 99% daily risk measure should cover, on average, 297 of the 300 trading outcomes, leaving three exceptions.

With regard to the occurrence of the backtest, the desire to base the backtest on as many observations as possible must be balanced against the wish to perform the test on a regular basis. The backtesting framework to be applied involves a formal testing and accounting of exceptions on a quarterly basis using the most recent twelve months of data.

Using the latest twelve months of data gives approximately 250 daily observations for the reasons of backtesting. The national supervisor will use the number of exceptions (out of 250) generated by the bank's model as the basis for a supervisory response. In many cases, there will be no answer. In other cases, the supervisor may start a dialogue with the bank to verify whether there is a problem with a bank's model. In the most serious cases, the supervisor may require an increase in a bank's capital requirement or forbid use of the model.

The application of using the number of exceptions as the main reference point in the backtesting process is the ease and straightforwardness of this approach. From a statistical point of view, using the number of exceptions as the basis for assessing a bank's model requires comparatively a small number of strong assumptions. In particular, the primary assumption is that each day's test (exception/no exception) is independent of the outcome of any of the others.

The Committee of course knows that tests of this type are restricted in their power to differentiate an accurate model from an inaccurate model. To a statistician, this says that it is not feasible to standardize the test so that it properly signals all the problematic models without giving false signals of trouble at many others. This limitation has been a vital consideration in the design of the framework presented in committee papers, and should also be important among the considerations of national supervisors in understanding the results of a bank's backtesting program. However, the Committee does not view this restriction as a critical objection to the use of backtesting. Rather, conditioning supervisory standards on a clear framework, though limited and defective, is seen as preferable to a simply judgmental standard or one with no incentive features whatsoever.

5.10.2 Supervisory framework for the interpretation of backtesting results

5.10.2.1 Description of three-zone approach

It is with the statistical boundaries of backtesting in mind that the Committee sets up a framework for the supervisory explanation of backtesting results that covers a range of potential responses, depending on the power of the signal produced from the backtest. These responses are divided into three zones, distinguished by colors into a hierarchy of responses. The green zone matches to backtesting results that do not themselves propose a problem with the excellence or correctness of a bank's model. The yellow zone includes results that do raise problems in this regard, but where such a conclusion is not ultimate. The red zone points out a backtesting result that almost definitely indicates a problem with a bank's risk model.

The Committee has decided to set standards concerning the definitions of these zones with respect of the number of exceptions produced in the backtesting program, and these are set forth below. To place these definitions in appropriate perspective, however, it is useful to check the probabilities of obtaining various numbers of exceptions under different assumptions about the accuracy of a bank's risk measurement model.

5.10.2.2 Statistical considerations in defining the zones

Three zones have been defined and their borders chosen in order to balance two types of statistical error: (1) the possibility that a precise risk model would be classified as incorrect on the basis of its backtesting result, and (2) the possibility that an incorrect model would not be classified that way based on its backtesting result.

Table 5.1 says the possibility of obtaining a particular number of exceptions from a sample of 250 independent observations under a number of assumptions about the real percentage of results that the model captures (that is, these are binomial probabilities). For instance, the left-hand section of Table 5.1 reports probabilities related with a precise model (that is, a true coverage level of 99%). Under these assumptions, the column labeled "exact" says that exactly five exceptions can be anticipated in 6.7% of the samples.

The right-hand portion of Table 5.1 reports probabilities associated with several possible imprecise models, specifically models whose true levels of coverage are 98%, 97%, 96%, and 95%, respectively. Thus, the column labeled "exact" under an implicit coverage level of 97% shows that five exceptions would then be anticipated in 10.9% of the samples.

Table 5.1 also reports several significant error probabilities. For the assumption that the model envelopes 99% of outcomes (the preferred level of coverage), the table reports the probability that choosing a given number of exceptions as a threshold for rejecting the correctness of the model will result in an incorrect rejection of an accurate model ("type 1" error). For example, if the threshold is set as low as one exception, then correct models will be rejected fully 91.9% of the time, because they will escape refusal only in the 8.1% of cases where they create zero exceptions. As the threshold number of exceptions is enlarged, the probability of making this type of error declines.

Under the assumptions that the model's actual level of coverage is not 99%, Table 5.1 says the possibility that selecting a given number of exceptions as a threshold for rejecting the correctness of the model will result in an mistaken acceptance of a model with the implicit (wrong) level of coverage ("type 2" error). For example, if the model's real level of coverage is 97%, and the threshold for rejection is set at seven or more exceptions, the table points out that this model would be incorrectly accepted 37.5% of the time.

In understanding the information in Table 5.1, it is also vital to recognize that while the alternative models appear close to the preferred standard in probability terms (97% is close to 99%), the deviation between these models in terms of the size of the risk measures produced can be significant. That is, a bank's risk measure could be considerably less than that of a precise model and still cover 97% of the trading outcomes. For example, in the case of normally distributed trading outcomes, the 97th percentile matches to 1.88 standard deviations, while the 99th percentile matches to 2.33 standard deviations, an enlargement of nearly 25%. Thus, the supervisory aim to distinguish between models providing 99% coverage, and those providing say, 97% coverage, is a very realistic one.

5.10.2.3 Definition of the green, yellow, and red zones

The results in Table 5.1 also reveal some of the statistical limitations of backtesting. In particular, there is no threshold number of exceptions that gives both a low probability of incorrectly rejecting a precise model and a low probability of incorrectly accepting all of the relevant imprecise models. It is for this reason that the Committee has rejected an approach that contains only one threshold.

Given these restrictions, the Committee has categorized outcomes into three categories. In the first category, the test results are constant with an accurate model, and the possibility of inaccurately accepting an inaccurate model is low (green zone). At the other extreme, the test results are really unlikely to have resulted from an accurate model, and the probability of inaccurately rejecting an accurate model on this basis is remote (red zone). In between these two cases, however, is a zone where the backtesting results could be either accurate or inaccurate models, and the supervisory authority should push a bank to show additional information about its model before taking action (yellow zone).

Table 5.2 sets out the Committee's decided boundaries for these zones and the presumptive managerial reaction for each backtesting result, based on a sample of 250 observations. For further sample sizes, the boundaries should be deduced by computing the binomial probabilities associated with true coverage of 99%, as in Table 5.1. The yellow zone starts at the point such that the probability of getting that number or fewer exceptions equals or exceeds 95%. Table 5.2 reports these cumulative probabilities for each number of exceptions. For 250 observations, it can be understood that five or fewer exceptions will be extracted 95.88% of the time when the true level of coverage is 99%. Thus, the yellow zone starts at five exceptions.

In the same way, the beginning of the red zone is defined as the point such that the probability of obtaining that number or fewer exceptions equals or exceeds 99.99%. Table 5.2 shows that for a sample of 250 observations and a true coverage level of 99%, this occurs with ten exceptions.

The green zone

The green zone needs little clarification. Since a model that really provides 99% coverage would be fairly likely to produce as many as four exceptions in a sample of 250 results, there is little reason for concern raised by backtesting results that fall in this range. This is reinforced by the results in Table 5.1, which show that accepting outcomes in this range leads to only a little chance of wrongly accepting an inaccurate model.

The yellow zone

The range from five to nine exceptions composes the yellow zone. Outcomes in this range are reasonable for both accurate and inaccurate models, although Table 5.1 proposes that they are usually more probable for inaccurate models than for accurate models. Furthermore, the results in Table 5.1 points out that the assumption that the model is imprecise should grow as the number of exceptions increases in the range from five to nine.

The Committee has decided that, within the yellow zone, the number of exceptions should usually guide the size of potential supervisory increases in a firm's capital requirement. Table 5.2 sets out the Committee's agreed guidelines for increases in the multiplication factor appropriate to the internal models capital requirement, resulting from backtesting results in the yellow zone.

These guidelines help in maintaining the proper structure of incentives appropriate to the internal models approach. In particular, the possible supervisory penalty increases with the number of exceptions. The results in Table 5.1 normally support the notion that nine exceptions is a more troubling result than five exceptions, and these steps are meant to reflect that.

These particular values reveal the common idea that the increase in the multiplication factor should be sufficient to return the model to a 99th percentile standard. For example, five exceptions in a sample of 250 imply only 98% coverage. Thus, the raise in the multiplication factor should be sufficient to transform a model with 98% coverage into one with 99% coverage. Needless to say, accurate calculations of this kind require additional statistical assumptions that are not likely to hold in all cases. For example, if the distribution of trading outcomes is assumed to be normal, then the ratio of the 99th percentile to the 98th percentile is approximately 1.14, and the increase needed in the multiplication factor is therefore approximately 0.40 for a scaling factor of 3. If the actual distribution is not normal, but instead has "fat tails", then bigger increases may be required to reach the 99th percentile standard. The concern about fat tails was also a significant factor in the selection of the particular increments set out in Table 5.2.

It is important to stress, however, that these increases are not meant to be simply automatic. The results in Table 5.1 specify that results in the yellow zone do not always mean an imprecise model, and the Committee has no interest in penalizing banks exclusively for bad luck. However, to keep the incentives aligned correctly, backtesting results in the yellow zone should usually be supposed to involve an increase in the multiplication factor unless the bank can reveal that such an increase is not warranted.

In other words, the burden of proof in these situations should not be on the supervisor to demonstrate that a problem exists, but rather should be on the bank to demonstrate that their model is basically sound. In such a situation, there are many different types of additional information that might be related to an assessment of the bank's model.

For example, it would then be principally valuable to see the results of backtests covering disaggregated subsets of the bank's general trading activities. Many banks that employ in routine backtesting programs break up their overall trading portfolio into trading units organized around risk factors or product categories. Disaggregating in this manner could allow the tracking of a problem that surfaced at the aggregate level back to its source at the level of a precise trading unit or risk model.

Banks should also document all of the exceptions produced from their ongoing backtesting program, including an explanation for the exception. This documentation is vital to determine a suitable supervisory response to a backtesting result in the yellow zone. Banks may also employ backtesting for confidence intervals other than the 99th percentile, or may carry out other statistical tests not considered here. Clearly, this information could also prove very helpful in assessing their model.

In practice, there are several probable explanations for a backtesting exception, some of which go to the fundamental integrity of the model, some of which propose an underspecified or low-quality model, and some of which propose either bad luck or poor intra-day trading results. Classifying the exceptions generated by a bank's model into these categories can be a very useful exercise.

Basic integrity of the model

The bank's systems just are not deal with the risk of the positions themselves (e.g. the positions of an overseas office are being reported inaccurately).

Model volatilities and/or correlations were calculated inaccurately (e.g. the computer is dividing by 250 when it should be dividing by 225).

Model's accuracy could be enhanced

The risk measurement model is not evaluating the risk of some instruments with adequate accuracy (e.g. too few maturity buckets or an omitted spread).

Bad luck or markets moved in fashion unanticipated by the model

Random chance (a very low likelihood event).

Markets moved by more than the model predicted was likely (i.e. volatility was considerably higher than expected)

Markets did not move together as estimated (i.e. correlations were significantly different than what was assumed by the model).

Intra-day trading

There was a big (and money-losing) alteration in the bank's positions or some other income event between the end of the first day (when the risk guess was calculated) and the end of the second day (when trading results were tabulated).

Generally, problems relating to the fundamental integrity of the risk measurement model are potentially the most serious. If there are exceptions belonged to this category for a particular trading unit, the plus should apply. In addition, the model may require of extensive review and/or adjustment, and the manager would be expected to take suitable action to guarantee that this occurs.

The next category of problem (lack of model precision) is one that can likely to occur at least part of the time with common risk measurement models. No model can expect to achieve unlimited precision, and thus all models entail some amount of approximation. If, however, a particular bank's model seems more prone to this type of problem than others, the supervisor should employ the plus factor and also consider what other incentives are needed to encourage improvements.

The third category of problems (markets moved in a way unexpected by the model) should also be anticipated to occur at least some of the time with value-at-risk models. Especially, even a precise model is not expected to cover 100% of trading outcomes. Some exceptions are definitely the random 1% that the model can be expected not to cover. In other cases, the performance of the markets may change so that previous estimates of volatility and correlation are less appropriate. No value-at-risk model will be protected from this type of problem; it is natural in the reliance on past market behavior as a means of gauging the risk of future market movements.

Finally, depending on the description of trading outcomes engaged for the purpose of backtesting, exceptions could also be emerged by intra-day trading results or an unusual event in trading income other than from positioning. Even though exceptions for these reasons would not naturally suggest a problem with the bank's value-at-risk model, they could still be cause for supervisory concern and the obligation of the plus should be considered.

The scope to which a trading outcome hits the risk measure is another relevant piece of information. All else equal, exceptions produced by trading outcomes far in excess of the risk measure are a matter of bigger concern than are outcomes only slightly bigger than the risk measure.

In deciding whether or not to impose increases in a bank's capital requirement, it is predicted that the supervisor could weigh these factors as well as others, including an assessment of the bank's fulfillment with applicable qualitative standards of risk management. Based on the supplementary information provided by the bank, the supervisor will choose appropriate course of action.

Generally, the imposition of a higher capital requirement for outcomes in the yellow zone is a suitable reaction when the supervisor thinks the reason for being in the yellow zone is a correctable problem in a bank's model. This can be contrasted with the case of an unexpected session of high market volatility, which almost all models may fail to forecast. While these events may be stressful, they do not essentially specify that a bank's risk model is in need of redesign. Finally, in the case of rigorous problems with the basic integrity of the model, the supervisor should consider whether to prohibit the use of the model for capital purposes altogether.

The red zone

Lastly, in contrast to the yellow zone where the director may exercise decision in interpreting the backtesting results, outcomes in the red zone (ten or more exceptions) should normally lead to an automatic assumption that a problem is present within bank's model. This is because it is really unlikely that a precise model would separately generate ten or more exceptions from a sample of 250 trading outcomes.

If a bank's model falls into the red zone, the supervisor should automatically enlarge the multiplication factor appropriate to a firm's model by one (from three to four). It is unnecessary to say, the supervisor should also begin examining the reasons why the bank's model created such a large number of misses, and should require the bank to begin work on improving its model right away.

Even if ten exceptions is an extremely high number for 250 observations, there will on very rare instances be a valid reason why a precise model will produce a lot of exceptions. Especially, when financial markets are subjected to a major regime move, many volatilities and correlations can be anticipated to move as well, perhaps significantly. Unless a bank is prepared to update its volatility and correlation estimations instantaneously, such a regime shift could produce a number of exceptions in a short period of time. Basically, however, these exceptions would all be occurring for the same reason, and therefore the suitable supervisory reaction might not be the same as if there were ten exceptions, but each from a separate incident. For example, one probable supervisory response in this case would be simply to require the bank's model to take account of the regime move as quickly as it can, while maintaining the integrity of its procedures for updating the model.

It should be stressed, however, that the Committee thinks that this exception should be permitted only under the strangest circumstances, and that it is committed to an automatic and non-discretionary enlargement in a bank's capital requirement for backtesting results that fall into the red zone.

5.11 Summary

The above structure is proposed to set out a steady approach for implementing backtesting procedure into the internal models methods to market risk capital requirements. The goals of this effort have been to build suitable and necessary encouragements into a framework that relies deeply on the efforts of banks themselves to compute the risks they face, to do so in a way that respects the natural limitations of the available tools, and to keep the burdens and costs of the imposed procedures to a minimum.

The Basle Committee thinks that the framework described above provides the right balance in this regard. Perhaps more prominently, however, the Committee thinks that this approach represents the first, and therefore vital, step towards a tighter integration of supervisory guidelines with provable measures of bank performance.

Table 5.1: Definition of zones

Model is accurate			Model is inaccurate: Posible alternative levels of coverage								
Exceptions	Coverage=99%		Exceptions	Coverage=98%		Coverage=97%		Coverage=96%		Coverage=95%	
(Out of 250)	exact	type 1	(Out of 250)	exact	type 1	exact	type 1	exact	type 1	exact	type 1
0	8.1%	100.0%	0	0.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1	20.5%	91.9%	1	3.3%	0.6%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%
2	25.7%	71.4%	2	8.3%	3.9%	1.5%	0.4%	0.2%	0.0%	0.0%	0.0%
3	21.5%	45.7%	3	14.0%	12.2%	3.8%	1.9%	0.7%	0.2%	0.1%	0.0%
4	13.4%	24.2%	4	17.7%	26.2%	7.2%	5.7%	1.8%	0.9%	0.3%	0.1%
5	6.7%	10.8%	5	17.7%	43.9%	10.9%	12.8%	3.6%	2.7%	0.9%	0.5%
6	2.7%	4.1%	6	14.8%	61.6%	13.8%	23.7%	6.2%	6.3%	1.8%	1.3%
7	1.0%	1.4%	7	10.5%	76.4%	14.9%	37.5%	9.0%	12.5%	3.4%	3.1%
8	0.3%	0.4%	8	6.5%	86.9%	14.0%	52.4%	11.3%	21.5%	5.4%	6.5%
9	0.1%	0.1%	9	3.6%	93.4%	11.6%	66.3%	12.7%	32.8%	7.6%	11.9%
10	0.0%	0.0%	10	1.8%	97.0%	8.6%	77.9%	12.8%	45.5%	9.6%	19.5%
11	0.0%	0.0%	11	0.8%	98.7%	5.8%	86.6%	11.6%	58.3%	11.1%	29.1%
12	0.0%	0.0%	12	0.3%	99.5%	3.6%	92.4%	9.6%	69.9%	11.6%	40.2%
13	0.0%	0.0%	13	0.1%	99.8%	2.0%	96.0%	7.3%	79.5%	11.2%	51.8%
14	0.0%	0.0%	14	0.0%	99.9%	1.1%	98.0%	5.2%	86.9%	10.0%	62.9%
15	0.0%	0.0%	15	0.0%	100.0%	0.5%	99.1%	3.4%	92.1%	8.2%	72.9%

Table 5.2: Scaling Factors

Zone	Number of Exceptions	Increase in Scaling Factor	Cumulative Probability
Green Zone	0	0.00	8.11%
	1	0.00	28.58%
	2	0.00	54.32%
	3	0.00	75.81%
	4	0.00	89.22%
Yellow Zone	5	0.40	95.88%
	6	0.50	98.63%
	7	0.65	99.60%
	8	0.75	99.89%
	9	0.85	99.97%
Red Zone	10 or more	1.00	99.99%

6. LITERATURE REVIEW

Two methodologies of VaR measures have developed through the last decade. One obtained by deriving an analytical valuation of VaR, which depends on given parameter estimates, called the parametric approach. The other methodology derives VaR by continually performing several simulation steps, including historical and Monte Carlo simulations. In this chapter these VaR concepts and their strengths and weaknesses are explained.

6.1 The Need for Unified and Quantified Risk Measure

Modern finance theory highlights risk as a main determinant of return. Merton (1980) states that expected return has a linear relationship with risk. According to him, measuring risk as a volatility of return easier than expected return itself. Merton's idea seems clear when applied to an equity portfolio replicating an index. On the other hand, it is uncertain when applied to a globally varying portfolio with positions traded in entirely segmented markets, as in trading portfolios of financial institutions. As a benchmark of the study first risk management techniques of large US banks are examined. If we look at trading portfolios of large financial institutions like BONY or CitiCorp as it is published in their reports suggests the following two observations: The big variety of trading positions, and the difficulty of and the need for combining all risk classes underlying those positions in one single measure. The trading portfolio of JP these institutions has positions on U.S and foreign governments' securities, corporate securities, and derivative securities of interest rates, foreign exchange rates, bonds, equities, and commodity contracts. Each of those positions is associated with a special source of risk and different risk computation methods which can be seen below.

The main risk underlying U.S Government securities is the interest rate risk. Duration is an easy measure for guessing volatility in the prices of those securities and their relationship with interest rates. By estimating convexity and sensitivity parameters in the case of non-parallel shift in the term structure of interest rates, duration can be customized to explanation of nonlinearity in the relationship between interest rates and government security prices.

A more complex analysis may entail a parametric quantifying of the matching risk factors affecting the term structure of interest rates. For foreign government securities, the foreign exchange rate is considered a distinguishing risk factor in determining returns. Foreign exchange rates have their individual risk indices, spreads, and volatilities. In recent times, target zones have been added to some currencies, Risk factors underlying corporate securities are dependent on the type of securities held in the portfolio. Additionally if institution has corporate bond, in addition to the risk connected with the interest rate, default is a main source of risk that correlates with other indices in the economy. One way to measure this risk is to use credit rating. For equities, volatility of returns is an easy measure of risk. Many models used in finance like the CAPM and the APT uses the correlation between the asset and the risk factor as a risk measure. For example, in the CAPM, where the only risk factor is the market, the measure of risk (Beta) is the covariance between the market and stock returns.

Risk factors, underlying derivative securities are fundamentally the similar to those related with the underlying assets of those derivatives. However, quantifying the risk related with each derivative position depends on the form of the relationship between the derivative value and the underlying asset price. Forwards and futures prices have a linear relationship with the prices of the underlying assets. Consequently, the risk connected with those contracts can be expressed as a linear transformation of the risk related with the underlying asset. For options, the relationship between the price of the option and the price of the underlying asset is non-linear; risk can be measured by the Greeks, delta, gamma, theta, vega and rho. Each of these measures reflects the rate of change in the price of the option when only one of the parameters change, similar to the price of the underlying asset, remaining days to maturity, volatility and interest rate, In order to measure risk of the interest rate and currency swaps default and recovery model has to be used . This model is used for measuring risk of credit derivatives as well. The risk sources which are discussed above main risk source of market risk. However financial institutions have credit risk, liquidity risk, legal risk and operational risk as well. However, sudden changes in market conditions are the most important market risk factor.

Every sub-element of the trading portfolio has unique characteristics; therefore every element of the portfolio should deal with separately. Generally a risk measurement technique suitable for only one element of the portfolio and can not be used in different portfolio elements. Obviously, those measures are not additive, or even comparable. Therefore risk measures cannot give simple answers to portfolio risk level. According to Linsmeier and Pearson these complex portfolio structures become widespread after collapse of Bretton Woods system of fixed exchange rates and the publication of the Black-Scholes option pricing formula [6].

After establishment of Black-Scholes model exchange rates and interest rates have greater volatilities than they have ever had. After establishment of options and other derivatives market risk became less obvious. With those changes, financial institutions enlarged their positions in financial derivatives for both hedging and speculative purposes.

Eventually, this situation end with discovery of a different rationale is provided by Jorion (2001) and Crouhy, Galai and Mark (2001). All of them state that the recent financial universal distresses were the main reason behind the search for an easy risk measurement tool. One way to avoid these above complexities is to look at the probability of a given loss to occur during a specified time horizon N, a simple statistical measure. List all possible outcomes in each of the *N* periods and for each outcome; assign a probability for the set of lower values to occur. If probability distribution of the P&L of a portfolio is known than we can easily calculate maximum loss with a requested level of confidence.

If we have a question like, "what is the worst loss we may undergo over some time horizon, say *N* days?" we can say, "we are c% confident that we are not losing more than $V of our wealth over this time horizon." Notice here that $V is the worst loss that would be exceeded by (1-c)%. Equally, we can say that there is a (1-c)% probability of losing more than $V of our assets over the next *N* trading horizon. This answer implies that we could lose all of the assets but this event has low probability. However, the probability of losing everything depends on our portfolio risk as defined by the standard deviation of the profits and losses assuming normal distribution.

For example, given a time horizon of 100 trading days, and a confidence level of 95%, our losses will exceed $V1 only in 5 trading days. Here N = 1 day and c = 95%. For 99% confidence level, we will suffer losses exceeding $V2 only in one day out of 100 trading days or 2-3 days during a trading year, where |V1| < |V2|. This means additionally that, for the next trading day, we are 95% sure that our losses will not exceed $V1, that is we are 99% sure that our losses for the next trading day will not exceed $V2.

6.2 The Concept of VaR

Before giving formal definition of Value at Risk, taking a look at to profit and loss distribution of Bank of America may be helpful. The figure below represents distribution of P&L account of bank's portfolio [7].

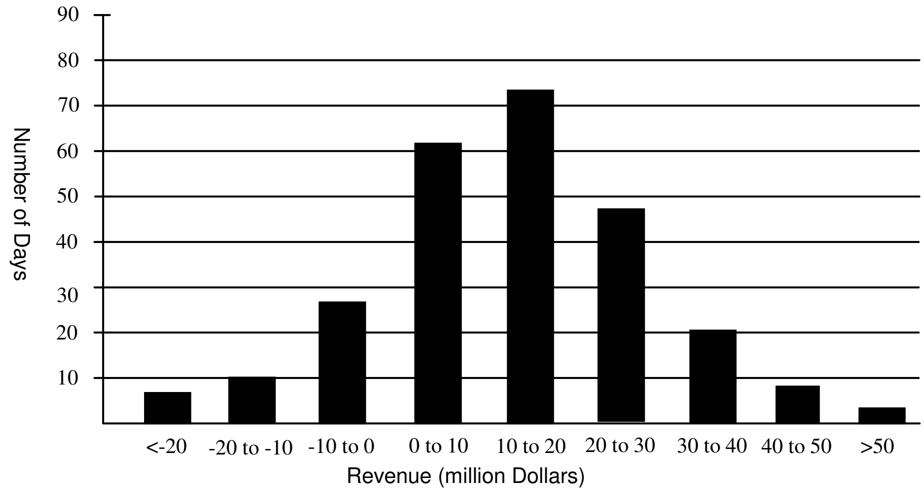

Figure 6.1 Profit and Loss Distribution of Bank of America

According to figure we can say that we are 97.2% confident that losses of Bank of America will not exceed $20 millions over the next trading day. This means with only 2.8 % confidence level bank have losses greater than $20 million USD dollars. In addition, we can say that at a 95% confidence level, the losses of Bank of America will not exceed $14.5 millions over the next trading day. Notice that 5% of the trading days is 12.5 days. We see from the histogram that there are 17 days (6.8% of total trading days) the bank suffered from losses exceeding $10 millions and 7 days (2.8% of the total trading days) the bank suffered from losses exceeding $20 millions. Interpolating, we find that the amount of losses that will be exceeded by 5% of the trading days is $14.5 millions. The number $14.5 millions is VaR at 95% confidence level over one trading-day time horizon.

After examination of the histogram the formal definition of Value at Risk as follows: *Value at Risk* or VaR as a quantile measure to quantify the risk for financial institutions. It tries to measure actual market risk of the bank's portfolio. VaR measures the worst likely loss over a given horizon under normal market scenarios at a given confidence level, As can be seen from formal definition of Value at Risk with saying value at risk of our portfolio is equal to V, we mean "We are c percent certain that we will not lose more than V dollars in the next N days". Here the variable V is the VaR of the portfolio. VaR function has two parameters: a time period (horizon), N, and a confidence level c. Thus, when we calculate VaR for a portfolio of a financial institution we calculate the expected loss in the portfolio's market value over a given horizon such as one day or two weeks, N, that is exceeded with a small probability say 1 percent, 1-c. Accordingly, VaR is defined as the upper limit of the one-sided confidence

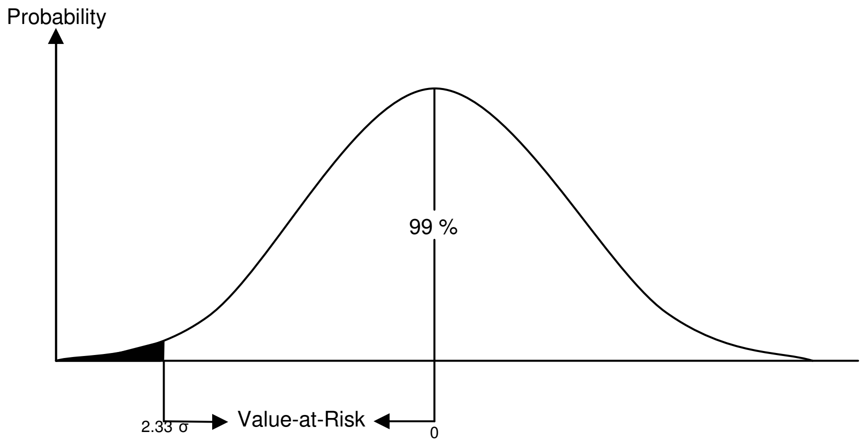

Figure 6.2: Representation of Value at Risk

interval:Pr [ΔP(N) < -VaR] = 1-c Where c is the confidence level, and ΔP(N) = ΔP_t (N) is the relative change in the portfolio value (P&L) over the time horizon N.

ΔPt (N) = P(t + N) - P_t . P(t + N) is the natural logarithm of the portfolio value at time $t + N$ and P_t is the natural logarithm of the portfolio value at time t. Statistically, equation (6.1) means that VaR values are obtained directly from the probability distribution of P&L as follows,

$$\Pr[\Delta P(N) < -VaR] = F[\Delta P(-VaR)] = \int_{-\infty}^{-VaR} f(\Delta P(x))dx = 1 - c \qquad \textbf{(6.1)}$$

Where F[ΔP(.)] is the cumulative distribution function of the trading revenues, ΔP, and f(ΔP(.)) is the probability density function of ΔP.

6.3 VaR Conversion across Time Horizons and Confidence Levels

At a confidence level of 99%, a one day VaR is a one day loss that is predicted to be exceeded in only one trading day out of 100 trading days. A 99% two weeks VaR is a two weeks loss that will be exceeded approximately once every 4 years. By the same way, a 99% three months VaR is a three months loss that will be exceeded once every 25 years.

$$VaR_{2weeks} = VaR_{1day}\sqrt{10} \approx 3.16 VaR_{1day} \quad \textbf{(6.2)}$$

$$VaR_{3Months} = VaR_{1day}\sqrt{63} \approx 7.93 VaR_{1day} \quad \textbf{(6.3)}$$

$$VaR_{3Months} = VaR_{2weeks}\frac{\sqrt{63}}{\sqrt{10}} \approx 2.51 VaR_{2weeks} \quad \textbf{(6.4)}$$

Here we have to be sure that absolute values of VaR has following characteristics, $VaR_{1\ day} < VaR_{2weeks} < VaR_{3\ Months}$, and so on.

For confidence level calculations confidence VaR can be easily calculated via normality assumption. If we try to express a 99% confidence level VaR via a 95% confidence level VaR then following equation has to be used.

$$VaR_{99\%} = VaR_{95\%}\frac{2.326}{1.645} \approx 1.41 \quad VaR_{95\%} \quad \textbf{(6.5)}$$

Where 2.326 and 1.645 (known as α's) are the standard normal deviate corresponding to a 99% and 95% confidence level. In the same way, the three months 99% confidence level VaR can be expressed via one day, two weeks or any horizon length. VaR at any confidence level can be calculated as follows:

$$VaR_{99\%,3Months} = VaR_{95\%,1day} \frac{2.326\sqrt{63}}{1.645} \approx 11.19 VaR_{95\%,1day} \quad \textbf{(6.6)}$$

$$VaR_{99\%,3Months} = VaR_{95\%,2weeks} \frac{2.326\sqrt{63}}{1.645\sqrt{10}} \approx 3.54 VaR_{95\%,2weeks} \quad \textbf{(6.7)}$$

Here may be most important thing to say is this method is mostly applicable where we suppose that the standard deviation of trading revenues is constant.

6.4 VaR Users and VaR in Regulations

VaR may be seen as very recent development of market risk measurement actually it is, but became very widespread after discovery of method. First users of Value at Risk method emerged in late 1980's. According to literature VaR method was introduced to financial system by JP Morgan to via its RiskMetricsTM system in 1994. VaR is now used by most of derivatives' dealers, even small financial firms, non-financial corporations, institutional investors and central banks. After the development of VaR tools, regulators become more interested in VaR applications, especially after the consecutive financial disasters during the late 1980's and 1990's. Basle Committee also tries to force usage of VaR models in order to measure risks of the financial institutions and also forces to use VaR as a decision making tool [8]. The Securities and Exchange Commissions requires U.S. companies to disclose quantitative measures of market risk, with VaR listed as one of three possible market risk disclosure measures.

6.5 Components of VaR Measures

In order to use VaR models we must have an idea about distribution of the financial firm's profit and loss figures. In order to see distribution of P&L we need to collect data concerning the present portfolio positions or the trading revenues, for a specified time interval, which stands for the holding period or the trading horizon. We must construct a model to forecast the distribution of the P&L of the portfolio as a function of the market parameters. The last step means that we need to infer the cumulative distribution function or the probability density function. As we will see later, VaR methodologies are fully different in the ways of constructing probability density functions.

Generally, VaR for any trading portfolio depends on its excellence on the following components:

1. The distribution assumption
2. Volatility and covariance estimates
3. The window length of the data used for parameter estimates
4. Time horizon or the holding period
5. Confidence level

In addition to the above components which suppose the mean of return zero, some VaR measures as Jackson, Maude and Perraudin (1997) include the mean of return in VaR analysis. However, their results show no evidence for any convinced differences when the mean of returns assumed to be zero [9].

6.5.1 The Distribution Assumption

As said before, VaR methods are differ mainly from their ways in which they construct the pdf. Usually, VaR techniques estimate the cdf's in three extensive methods: the parametric method or analytical models, historical simulation or the empirical based methods and the Monte Carlo simulation or stochastic simulation method. The last two methods are called as non-parametric approaches.

6.5.2 Volatility and Covariance Estimates

Estimating actual volatility of current risk factors is a mandatory component of VaR model. However as the portfolio becomes more complex, VaR calculations involves estimation for the variance-covariance matrix and the correlation matrix, this is known as variance covariance VaR method. As can be seen statements above increasing number of positions makes calculations more difficult.

General VaR models used widely in finance sector assumes constant volatility in calculating VaR figures but it is also known that, volatility of financial data is not constant, therefore combining volatility updating models with standard VaR models become a must for financial institutions.

In order to employ volatility updating in VaR models researchers have discovered many different methods. To account for volatility updating, researchers in VaR use different models. Some of them employ a uniform exponential weighting volatility model. While others use asset-specific exponential weighting volatility models. These models generally give higher tail probabilities. This researchers show that there is a trade off between the degree of approximating time-varying volatility and VaR predictions. A study shows that there is a negative relationship between size of the parameters of the exponential weighting volatility model and the variability of VaR measurements. This means as we increase the risk factors which are subject to volatility updating model's performance decreases [10].

Other models which tries to model volatility in volatility of risk factors known as ARCH models, GARCH models, EGARCH models, extreme value theorem EVT and implied volatilities from option prices. These models show that VaR models that depend on GARCH estimation for volatility bound the actual daily losses in banks' portfolios closer than internal VaR models used by banks. Many studies perform on comparison of volatility updating models but the results shows that every model has own advantages and disadvantages. Therefore decision of model choice is a vital part of VaR modeling.

VaR predictions for portfolios that hold many positions require estimating the correlation matrix alongside the covariance matrix. Beder (1995) finds that VaR are sensitive to correlation assumptions. She calculated VaR for a portfolio under different assumptions of the correlation matrix. Her consequences show major differences of VaR estimates under those different assumptions of correlation matrix.

6.5.3 The Window Length

The window length defined as length of the data that is used in VaR calculations. Data length depends on many parameters but main parameter of the length is data availability. The Basle committee suggests 250 day (on year) window length.

Beder (1995) tries to estimate VaR applying historical simulation method with using 100 day and 250 day window lengths. Study showed that success rate of VaR estimates increases with longer estimation data sets. Additional VaR studies made by different researchers such as Hendricks used VaR measures using the parametric approach with equally weighted volatility models and the historical simulation approach. Hendricks used diverse window lengths ranging from 50 days to 1250 days. He says that VaR measures become steadier for longer observation periods. Jackson, Mauder and Perraudin arrive at to the same conclusion of Hendricks by computing parametric and simulation VaRs for 1-day and 10 day time horizons using window lengths from three to 24 months. All of the studies reach same conclusion meaning: VaR predictions based on longer data windows are more stable and reliable [11].

6.5.4 The Holding Period and Confidence Level

The holding period or the time horizon in VaR analysis can be any trading interval. The time horizon generally set by regulations and may differ from one day to two weeks. (10 trading days). The choice mainly depends on liquidity of assets and trading frequencies of portfolio elements. A basic assumption of VaR models says that the portfolio remains unchanged over the time horizon therefore P&L of the portfolio does not affected by portfolio's volume changes. The Basle Committee recommends 10-day holding period. Many banks use one day holding periods in their VaR calculations. Long holding periods are usually recommended for portfolios with illiquid instruments.

Some studies tries to investigate relationship between time horizon and VaR accuracy a study has showed that longer trading horizons gives higher VaR values. The confidence level, on the other hand, reflects some internal measures of the financial institution. Some institutions uses 95% confidence levels while Basle committee recommends 99 % confidence level. Committee choice of 99% confidence level can be seen as a reflection of the tradeoff between the desire of regulators to ensure a safe and sound financial system and the adverse effect of capital requirements.

6.5.5 Basle Committee Parameters

As mentioned above, Basle Committee wants financial institutions to calculate its VaR models at a 99% confidence level and 10-business-days horizon. The resulting VaR then multiplied by a safety factor, K, equal 3 to give the minimum capital requirement for regulatory purposes. Many financial foundations says that 10 day holding period is a too long holding period for calculations and tries to force the committee to shorten its holding period assumptions. However, Jorion (2001) suggests that the choice of the 10-trading-day period reflects the trade off between the cost of frequent monitoring and the benefits of early detection of potential problems. According to Basle criteria, a 2 weeks loss value more than VaR would occur once every 4 years. Jorion also says that safety factor can be seen as a fuse for model defects. Model defects include underestimation of VaR numbers because of inaccuracy of VaR components' choice. Stahl (1997) justifies the choice of the safety factor to be 3 based on Chebyshev's inequality. Other authors link the choice of the number 3 to the kurtosis of the normal distribution, but this sounds a little indefensible.

6.6 VaR Methods

VaR generally represents a family which consists of different methods. Basically these methods can be divided into two main classes, parametric ones and non-parametric ones.

6.6.1 Parametric Methods

In the parametric approach the modeler have to make an assumption on distribution of P&L of the portfolio. According to assumption P&L may have normal distribution, Gamma distribution, Student t-distribution or any other distribution or a mixture of any set of distributions. Other parametric methods comprise a linearization and quadratic guess of portfolios' value. VaR estimates derived by this method appear as a function of the parameters of the assumed distribution, and that is why it is called parametric [12].

Parametric methods are exposed to some kind of inaccuracy. This defaults mainly come from distribution assumption. For example, if the VaR method assumes the P&L to have a multivariate normal distribution (as frequently assumed) whereas the actual data shows excess kurtosis, resulted VaR estimate underestimates the maximum potential losses at high confidence levels [13]. Under the parametric method with normality assumption, two VaR approaches are usually used: the variance covariance approach, and the Greeks approach. Both of those approaches keep the normality assumption of risk factors underlying portfolio returns. While the variance covariance approach assumes a linear relationship between portfolio returns and the underlying risk factors, the Greeks approach deals with nonlinear events as in the case of option portfolios and fixed income portfolios.

6.6.1.1 Variance Covariance

May be the most popular approach employing in VaR is the variance covariance method [14]. This method assumes all risk factors have normal distribution and the total portfolio is linear combination of all these normally distributed portfolio members. Therefore the P&L distribution of total portfolio is also normally distributed. Under these assumptions VaR calculation becomes easy to handle. VaR principally is a multiple of the portfolio standard deviation, and the standard deviation is a linear function of individual volatilities and covariances of the underlying market risk factors. Therefore, all we need to calculate VaR is the variance covariance matrix and information about the sizes of individual positions to determine the portfolio standard deviation. After that we multiply this standard deviation by a confidence level parameter and scale variable reflecting the size of the portfolio, this approach can be defined via matrix notations as follows,

$$VaR_p = -\alpha\sigma_p P = -\alpha\left[w\sum w^T\right]^{1/2} P = \left[VaR * \rho * VaR^T\right] \qquad \textbf{(6.8)}$$

Here α is the standard normal deviate matching to a specific confidence level. σ_P is the standard deviation of the portfolio, P the scale variable reflecting the size of the portfolio. ***w*** represents n x 1 vector of sizes of individual positions in the portfolio. ρ is the correlation matrix of positions present in the portfolio and **VaR** represents n x 1 vector of individual positions' VaRs (undiversified VaRs), where VaR for individual positions is $-\alpha\sigma W$ and W is a scaling variable reflects the initial value of individual positions [15].

However, the variance covariance approach to VaR does not always robust to actual financial institutions' portfolios. Portfolio returns may be nonlinear in risk factors, as in the case when the portfolio contains positions in options or fixed-income instruments. In response to non-linearity, modelers use the Taylor series expansion or linear approximation

6.6.1.2 The Greeks Methods

The Greeks methods come mainly from the sensitivity parameters of option prices to different risk factors underlying an option portfolio. Assume the value of the portfolio depends on the value of the underlying asset, and remaining time to maturity, such that P=P(S,t). Taking Taylor series expansion or alternatively applying Ito's Lemma to get the progression for dynamics in the portfolio worth, we obtain:

$$dP = \frac{\partial P}{\partial S} dS + \frac{1}{2}\frac{\partial^2 P}{\partial S^2} + \frac{\partial P}{\partial t} dt + \frac{\partial^2 P}{\partial S \partial t} dSdt \qquad \textbf{(6.9)}$$

As can be seen that all higher order of change in t goes to zero, thus the last term in the right-side of equation goes to zero. The first part in the right side of is defined as delta of the portfolio, Δ , which means the change of the portfolio value with respect to the change in the price of the underlying asset. The second term is gamma of the portfolio, Γ , which is the second derivative of the value of the portfolio with respect to the underlying asset price (first derivative of delta to underlying asset price). The third term, known as theta, Θ , is the change of the value of the portfolio with respect to time to maturity.

$$dP = \Delta dS + \frac{1}{2}\Gamma dS^2 + \Theta dt \qquad \textbf{(6.10)}$$

The easiest approach is generally known delta-normal approach. Delta –normal approach implies first order Taylor series expansion of a portfolio's value with respect to stock returns according to its definition. In this case we ignore the second and the third argument in the equation stated above meaning we ignore Γ and Θ. After that we calculate potential loss of the portfolio as $dP = \Delta\ dS$ which occupies likely change in prices. This relationship is linear and the worst loss in P is related with an extreme value of S. When the distribution of *dS* is normal the portfolio VaR, VaR_P, will be a product of the sensitivity parameter Δ and the VaR_S of the underlying asset as:

$$VaR_P \left|\Delta\right| \ VaR_S = \left|\Delta\right| x \alpha \sigma S_0 \qquad \textbf{(6.11)}$$

For fixed income securities the underlying asset's risk factor is the yield, and the first order Taylor series expansion will be a function of the yield, and the constant in this case is the modified duration, as follows:

dP=-DPdy **(6.12)**

Here, D is the modified duration of regarding risk factor and y is the yield.

Delta-normal approach supplies the linear normality and VaR estimation becomes easier. However, this simple approximation causes incorrect VaR estimate. Therefore many authors argues that this approach would produce reliable estimate for VaR for small holding periods or/and when the portfolio has few option positions.

To get more precise VaR for non-linear positions (options and fixed income), some authors apply the quadratic model or the second Taylor series expansion known as delta- gamma approaches. In terms of equation (6-1), we include the second term that includes Γ . Then the change in the portfolio value that includes positions in option would be $dP = \Delta dS + \frac{1}{2}\Gamma dS^2$. Gamma is the first derivative of delta with respect to underlying asset price [16]. It measures the curvature of the connection between the portfolio value and the underlying market variable. A non-zero gamma means skewness in the distribution of P&L of the portfolio. When gamma is positive (negative), changes in the portfolio value is positively (negatively) skewed.

For a portfolio with fixed income positions, we can see the relationship between portfolio value and its yield as follows:

$$dP = -DPdy + \frac{1}{2}CVdy^2 \qquad \textbf{(6.13)}$$

Here the coefficient C is the convexity parameter and it is equivalent to Γ

The task now is to deal with dS and dS^2 for option portfolios or dy and dy^2 for fixed income portfolios. Authors deal with those terms by taking the variance for the both sides of the quadratic approximation. This is what is called delta-gamma method [17]. If dS is normally distributed then all odd moments will be zero. And with the assumption that dS and dS^2 are jointly normally distributed then dP is normally distributed and then VaR can be calculated directly.

Some authors employ a different method to understand VaR estimates based on delta gamma approximation. In his method known as delta-gamma-Monte Carlo, They firstly generate a random simulation of the risk factor S. Then he uses the Taylor approximation to produce simulated movement in the option value. VaR in this case can be predicted from the experimental distribution of the portfolio value. Other modifications of delta-gamma methods include delta-gamma-minimization which suggested by Wilson and Fallon.

Some authors made some developments to improve delta-gamma method by employing Cornish-Fisher expansion which deals with skewness. In the method standart normal deviate of the distribution α is replaced by $\alpha' = \alpha - \frac{1}{6}(\alpha^2 - 1)\gamma$ here γ is the skewness parameter.

Many authors agree that this delta-gamma approach tremendously increases correctness of VaR predictions. However this Greeks method also assumes normality of finance data which is still a strong assumption. Some studies on financial data showed that the data does not have normal distribution it tends to be skewed.

The normality assumption of risk factors or P&L of the portfolio would definitely influence VaR predictions since it depends remarkably on the distribution of the tail. Thus, if we have thicker (thinner) tail with respect to normal distribution, then VaR estimates based on normality would be under- (over-) estimated. Some models show that VaR calculated under normality assumption underestimates risk since the observed distribution of many financial return series have tails that are flatter than those implied by conditional normal distribution.

Apart from normality assumption we can still employ parametric approach to construct Value at Risk. Nevertheless, many researchers use non-parametric approach (the simulation approach) to deal with non-normality. In the parametric approach, another distribution is explicitly assumed instead of the normal distribution, and based on this assumed distribution; a formula to describe the confidence interval is analytically derived.

In the non-parametric approach (Simulation), no exact distribution assumption is wanted. VaR is deriving from the standard theory of order statistics, as in Kupic (1995), or from Monte Carlo simulations, where VaR is calculated from multiple runs that might be representative of the possible market price outcomes. In some cases, actual historical return allocation is used by bootstrapping rather than simulations.

6.6.1.3 Analytical VaR Approaches with Deviation from Normality

Generally, the parametric approach for VaR estimates with non-normal distribution classes aims at modifying for kurtosis since VaR estimates depend on the distribution of the left tail. A probability distribution with fat tails has greater probability mass out in the tails of the distribution, where large price movement occurs compared with the normal distribution. Accordingly, VaR estimates tend to under or over estimate risk if the normal distribution is assumed [18].

Fat tails in actual finance data results from stochastic unpredictability of the underlying market factor (like stock returns). The dimension of the “tail fatness” depends on the correlation between volatility of returns and returns’ themselves. However, some authors says that actual market data are typically found to have flatter tails compared with that would come from stochastic volatility alone.

An additional basis of fat tails in the distribution of financial data comes from price jumps, New evidences discover that stochastic volatility and jumps are both important in explaining the dynamics of stock returns for different frequencies. Chenov, Gallant, Ghysels and Tauchen find that non-affine jumps and stochastic volatility are important in finance time series data.

6.6.2 Non-Parametric Approaches

As we mentioned earlier, an essential part on VaR estimation is the probability density function. Non-parametric approaches suppose the P&L distribution directly from the standard theory of order statistics, with no need for pre-assumption about the distribution. The next two sections look at the two non-parametric approaches and the recent developments on those approaches

6.6.2.1 Historical Simulation

This method is the most naïve approach to calculate VaR. Typically it has no main assumptions about the distribution of trading revenues. As a substitute, the distribution is built from the historical behavior of the portfolio P&L. Here the current portfolio ran according to actual changes in the market factors during the past. The only assumption that is made in this method is that the past trends of profits and losses will continue in the future [9]. An advantage of this method is that it is free from any estimating inaccuracy.

On the other hand there is a trade off between length of the data used in historical simulation and the accuracy or relevancy of simulation results. Because we try to have more historical data to catch heavy daily loses but this causes our data to be more different than current one.

In order to reduce this effect researchers have tried to discover new methods. After that bootstrapped historical simulation method was developed. Here returns of risk factors are generated by bootstrapping from historical observations. By this approach, volatilities and correlations are updated rather than estimated from old data [19].

Butler and Schachter (1996, 1998) propose combining the historical simulation with the kernel estimation. They carry out this mixture in three steps: at the start they estimate the pdf and the cdf of portfolio returns. After that, they approximate the distribution of the order statistics corresponding to the confidence level. In the final step, they guess VaR using the first and the second moments of the pdf for the order statistics determined by (1-c)th quantile. This alteration lets us to estimate the precision of VaR estimate and to construct confidence intervals around them.

Boudoukh, Richardson, and Whitelaw (1998) make special modification to the historical simulation method. They mix the historical simulation method with exponential smoothing. Principally, this method connects exponentially declining weights to historical portfolio returns starting from current time and going back. The future returns are calculated from past returns and sorted in increasing order (regular historical approach). After that, VaR guess is computed from the experiential density function. This alteration is know as hybrid approach, and it also ties to overcome the problem of using past information by highlighting the most recent observations. One advantage of this method is that it takes into account time varying volatility and it is suitable for fat-tailed series.

Boudoukh, Richardson, and Whitelaw (1998) make the hybrid approach to a diverse financial series and evaluated the results with exponential smoothing and plain vanilla historical simulations. Results for 99% confidence level VaR, applied to the S&P 500, show a reduction in the absolute error estimation ranging from 30%-40% compared with the exponential smoothing method. The improvement over the historical simulation was less clear. The absolute error reduced by 14%-28% compared with the historical simulation. Boudoukh, Richardson, and Whitelaw (1998) say that hybrid approach works better for exchange rate portfolios and heavy-tailed series.

6.6.2.2 Monte Carlo Simulation

The Monte Carlo simulation approach may be the most widely used one of VaR calculation methods. This method generally used by sophisticated and experienced risk managers. At first look, it has some similarities with historical simulation approach. Both of them tries to estimate portfolios values from historical data, however Monte Carlo simulation generates new portfolio paths instead of applying historical ones. Monte Carlo simulations provide N possible portfolio values on a given future date (t + N). The VaR value can be determined from the distribution of simulated portfolio values.

In order to perform Monte Carlo simulation we must first define stochastic processes and process parameters which calculates risk factors. Here, important thing is selected procedure should grasp risk factors movements well. Theoretical price changes are attained by simulations drawn from the specified distribution. At the end, we obtain asset prices at time t + N from the simulated price trajectories and compute the portfolio value and VaR. One main difficulty of this method is that it takes long time to converge.

Main modifications of Monte Carlo models are done in order to improve time efficiency of models. Because when we want to increase accuracy of the model we have to run more simulations. Wiener (1997) reports that in order to increase the precision by a factor of 10, you must perform 100 times more simulations.

Some authors used n quasi-Monte Carlo idea to get quicker valuation financial derivatives and perform it to VaR estimates. After these studies, application of the quasi-Monte Carlo method noticeably improve the convergence of the simulation compared with the traditional Monte Carlo method with the same level of accuracy.

In 1996 Pritsker made two suggestions on Monte Carlo techniques. The first one known as grid Monte Carlo approach and the other one is the modified grid Monte Carlo. In the first suggestion, he makes network of changes in the risk factors. Then he computes the portfolio values at each node of the gird. The probable realizations of the grid are obtained from random drawings from pre-decided models. Portfolio values for new draws are approximated by interpolating portfolio values at adjacent grid points. However, this method is subject to a problem Pritsker (1996) call it dimensionality problem.

In order to eliminate the dimensionality problem, in the Monte Carlo approach, He tried to lower dimension of the grid by grouping risk factors. After grouping them he consolidated them via Taylor expansion. This modifications main assumption is the portfolio is formed by two types of factors, linear and non-linear. Moreover each type of element has to be estimated via particular method. Changes in the value according to linear factors are evaluated by linear approximation. Here changes in the portfolio values that are resulted from non-linear factors are estimated through grid points. Pritsker (1996) find that the modified gird Monte Carlo method involves the level of accuracy close to delta-gamma Monte-Carlo approach. However, delta-gamma Monte-Carlo requires less computational time. Gibson and Pritsker (2000) expand the modified gird technique to portfolios hold positions in fixed income securities.

6.6.3 Comparison among Different Methods

Different application of VaR methods produces different VaR estimates. The results of the applications sometimes give similar results but sometimes there may be huge differences occur between them. Usually the choice of the technique depends on the components of the portfolio.

VaR methods always compared among each other concerning numerous considerations. The first is the capability to capture risk factors underlying portfolio returns, with the hypothesis that the portfolio includes positions in options and fixed income securities. The second concern is the easiness of implementation. The third is how fast according to computation time. Other concerns that are generally taken into consideration are the easiness to explain to senior management. Table 6.1 contains a brief summary of comparisons among different traditional methods. However, the most important comparison among different methods includes the tradeoff between the accuracy of the estimate and the cost of implementing computations in terms of time and the easiness of implementation.

Each of the methods has advantages and disadvantages. Variance –covariance method become too complex to handle when portfolio have different risk factors since we have to calculate standard deviations and correlations of each risk factor. Additionally correlation and covariance matrixes become more complex as the number of risk factors increases. When we turn the Monte Carlo simulation approach, we must make a choice between run length and accuracy of model. One advantage for the Monte Carlo simulation is that it can be done under different assumptions, which is not offered in other methods. However, the Monte Carlo simulation method subjects to the model risk and measurement error. Monte Carlo simulation method models risk factors according to a pre-assumed stochastic process and this pre-assumed stochastic process might be incorrect. Measurement errors engage in all VaR predictions, because the true parameters should be estimated.

Pearson and Simthson give Figure 6.3 for comparison. The figure illustrates that the full Monte Carlo method is the most precise and the most time consuming method. Delta normal on the other side is the least precise [20]. We see also that delta-gamma Monte Carlo outperforms the modified gird Monte Carlo. In the same time, delta-gamma-delta outperforms delta-gamma minimization. Generally speaking, delta-gamma Monte Carlo is the best among the quadratic approximation methods in terms of comparing accuracy and speed of computation

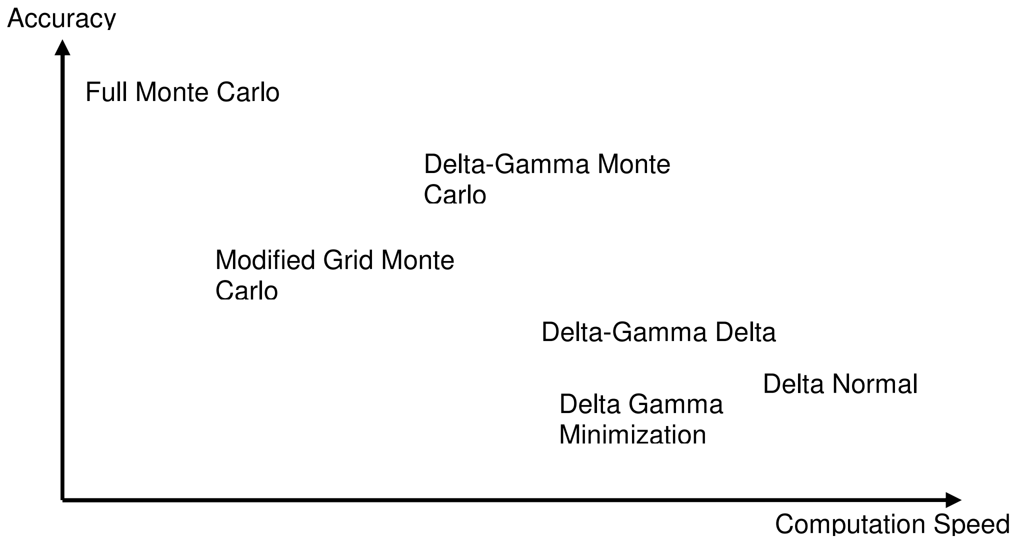

Figure 6.3: Correctness of VaR Methods against Computation Speed

The table below shows the advantages and disadvantages of different VaR methods.

Table 6.1: The advantages and disadvantages of different VaR methods

Method **Factor**	**Variance-Covariance**	**Quadratic Approximations**	**Historical Simulation**	**Monte Carlo Simulation**
Ability to capture risk Factors for position with nonlinear dependence on risk factors	Ineffective at all	Can handle it, but the accuracy diminishes with their existence. VaR value understated.	Effective	Effective
Assumptions	Impose normal Distribution assumption	Impose normal distribution assumption	Past trends continue in the future	Impose stochastic model for risk factors
Accounting for thick tails	No	No	Yes, if the past data imply it	Yes, if the modeled risk imply it
Accuracy	Inaccurate with thick tails data and when recent past is anomalous	Inaccurate with thick tails data and when recent past is anomalous	Future might have extreme events, or the opposite	Misleading when the past is anomalous
Easiness of implementation	Yes, when the number of positions in the portfolio is limited, difficult with large number of positions	Yes, with the availability of data and few number of position	Yes, with the availability of data	Yes, with complex software
Quickness of computation	Relatively quick, depending on the number of positions	Relatively quick, depending on the number of positions	Relatively quick	Time consuming, tradeoff between computation time and accuracy
Easy to explain to senior management	No	No	Yes	No
Performed under different assumption	No	No	No	Yes

6.7 Back Testing

The Basle Standard requires financial institutions to carry out back testing for its internal VaR models. Back testing is a subsequent procedure in which the financial institution checks how often actual losses have exceeded the level predicted by VaR. A financial institution that perform daily VaR over a 99% confidence level should not observe more than 1% cases of losses exceeds VaR. For 250 days trading period, the financial institution should notice that actual losses during that period exceeded VaR estimate only by 3 times.

Basle Standard calculates the market risk capital requirement at time t by:

$$C_t = A_t x Max\left\{\frac{1}{60}\sum VaR_{t-i}, VaR\right\} + SR_t \qquad \textbf{(6.14)}$$

Where C_t is the market risk capital requirement at time t. A_t is a multiplication factor ranging between three and four. SR_t is the capital specific risk.

The capital specific risk is element of the market risk. The new capital requirements consider market risk in two main dimensions, general market risk and specific risk. The general market risk comes from changes in overall market factors such as security prices, commodity prices, exchange rates and interest rates. Specific risk is the risk from changes in prices of assets for non-market reasons.

In equation, the value of A_t depends on the accuracy of the internal VaR model during the past periods, say past trading year. Basle committee has divided number of violations into three main zones. They are green, yellow and red zones. According to Basle Criteria if model has 4 or less exceptional days within last 250 workday the model is in green zone and capital requirement of the model is 3. The yellow zone represent a mode with more then 4 and less then 10 defaults within last year and capital requirement factor takes a value between 3 and 4. Finally if the model has more than 9 defaults within last year the model is in red zone and should be revised.

Wiener (1997) disagree that this process prevents banks from setting low levels of VaR, and with enough capital reserve safety, banks may only set upper bound level for VaR rather than precise value.

6.8 Stress Testing (Scenario Analysis)

As can be seen from previous information given above, VaR can be defined as worst normal loss for next trading day within given time interval. According to this, VaR is just a normal loss that occurs with respect to normal market conditions. However, this measure cannot give answers to following question on a bad day what is the worst level of loss.

Stress testing may be the unique method for answering this question and definitely this is not a VaR method. In general it tries to evaluate portfolio value under different bad day scenarios. There is no standard way to make stress testing, and no standard set of scenarios to consider. The process depends significantly on the decision and knowledge of the risk manager.

Generally Stress testing starts with setting hypothetical price movements so called scenarios. These scenarios can be created in terms of standard deviation movements. This movement can come from actual extreme events. For example, the scenarios might be based upon the extreme movements of the U.S. equity prices that happened on October 19, 1987 when the S&P 500 moved by 22.3 standard deviations or for a less extreme case when the S&P 500 moved by 6.8 standard deviations on January 8, 1988.

For fixed income securities portfolio, we can use the changes in US dollar interest rates and bond prices experienced during the winter and spring of 1994. For foreign exchange rate we can use the changes in some of the European exchange rates that occurred in September 1992, Generally speaking for Turkey March 2003 “Tezkere” crisis mainly used as worst case scenario for fixed income instruments.

6.9 Conclusion

Basically VaR models give estimation for the worst loss for a portfolio for predefined time horizon. During calculation of VaR, loses are calculated by the left tail quantile from distribution of portfolio returns. Therefore, basically VaR estimations depend on the left tail distribution of profit and loss account. As described before sections generally profit and loss of as given portfolio does not follow normal distribution especially in volatile market circumstances, additionally they suffers fat tails and excess kurtosis. Khindanova and Rachev (2000) say that neither the traditional methods of VaR nor its improvements do give adequate and mutual estimation for VaR that captures the above properties of real financial data.

According to historical results, the variance covariance method and the Greeks approximations can not deal with the observed thick tail aspect with financial data. The historical techniques are not trustworthy especially in estimating low quantiles. If we decided to use Monte Carlo simulation instead of parametric approaches, we still have the same assumption which implies risk factors are normally or log-normally distributed, this situation requires stochastic modeling as well.

Berkowitz and O'Brien compare the accuracy of the daily VaR models used by the largest six U.S banks which are used in predicting actual daily losses during the period January 1998 to March 2000 [2]. The study shows that none of the models produces reliable estimates for P&L of the bank. Jorion (2002), on the other hand, examines the worth of VaR disclosures in quarterly and annually reports for the largest eight U.S. Banks. He says that published VaR estimates reveal the actual quarterly P&L for those banks. On the other hand he also concludes that these VaR models are not successful in determining actual losses of Bank.

Of course the researchers does not give bank's names on their studies, but if we examine the quarterly reports of US major bank we can find the names of the banks and which bank use which method. For example Bank of New York reports that they use Monte Carlo simulations. Bankers Trust use proprietary simulations, JP Morgan Chase & Co. use historical simulations, CitiCorp covariance matrix, and Bank of America describe its method as "sophisticated techniques". These methods are revealed in the quarterly reports. Therefore we can conclude that none of those methods could predict the Banks' losses especially in the second half of 1998.

After that, additional studies which use regression analysis between the unpredictable P&L and daily volatility concluded that quarterly reports of banks' are applicable. However for some authors, these results are questionable since they use quarterly VaR over a 99% confidence level. According to this VaR specification, we anticipate to see that a three months loss exceeding VaR occurs once every 25 years, and any violations should be tested along 25 years or 100 quarters period. However, in order to perform this kind of study we have not enough data.

The conclusion from those works is that none of the VaR methods could predict the actual banks' losses even with inclusion of time varying volatility. Berkowitz and O'Brien find that VaR estimates that GARCH models for volatility bound actual daily losses in banks' portfolios closer than internal VaR models. However, even those models could not describe actual portfolio dynamics during the periods of the Russian crises and the near collapse of the LTCM in August and September 1998 [2].

Generally, elimination effort for thick tails may increase the performance of VaR predictions. However, VaR estimates that diverge from normality assumption in an attempt to account for thick tails do not consider for the following aspects:

1: The full kurtosis cannot be monitored completely by time varying volatility alone or jumps (event risk) alone. In study done by Gibson (2001) he says "what is needed is a model that can combine time varying volatility with event risk" and he found that job is challenging. Likewise, Lewis (2002) says that mixing the stochastic volatility with jumps gives much better fit to both real stock price distributions with their wide tails and smile paths. On the other hand, he believes this as a hard job but it deserves trying for the benefit of getting more accurate modeling of financial data. Other researchers also made several studies on this subject and they find that, both stochastic volatility and jumps are important in their estimations for mixed stock returns processes. Those studies even use a non-affine stochastic process and jump-diffusion process.

2: As Airoldi (2001) proposes, with fat tails, volatility grows and updates quicker. The thicker the tail, the quicker the dynamics of volatility. Thus jumps and extreme events are sources of hyper growth in volatility. Other authors including report similar evidences in their non affine estimations. Accordingly, the assumed linear relationship between volatility dynamics and volatility levels would no longer holds during jumps and extreme events (fat tails) for this reason a non-linear representation of volatility dynamics becomes essential.

3: When non-linear dynamics engage (even in the case of linear dynamics), point 2 above, restricted densities provide improved description of short term asset price movements contrast with the unconditional densities, which has very vital implication in risk management. Therefore, the dependence of VaR models on the unconditional densities would not give the greatest approximation for VaR when we suppose nonlinear dynamics (or even linear). And we distinguish that there are powerful evidences of nonlinear dynamics in short term movements of asset returns composition.

4: Kurtosis has non-flat term structure that differs over time and this extends the dependence of VaR estimates on the time horizon. Actually if we assume that volatility is time varying this implies that the fatness of tail would be time varying, this situations results in some covariance between the confidence level and the VaR horizon.

7. NORMAL MIXTURE

In recent years many empirical studies revealed that traditional VaR models are not enough to estimate losses of volatile market conditions. On the other hand many institutions make stress tests on their portfolios, they generally use hectic adverse market fluctuations occurred in the past. However here is another problem, which event is a hectic one. In literature many models have been introduced in order to solve problem including ARCH-type models, Extreme Value Theory and Stochastic Volatility models.

Here we try to employ a different approach to VaR methods; typically here we try to mix two different distributions with same means while they have different covariance matrices. Here we mix the observations of two distributions but as expected we give higher weights to normal ones. As can be seen in following paragraphs this approach can be seen as a solver for following questions:

- Correct identification of observations
- Predicting fat tails of VaR
- Performing stress testing analysis using severe condition scenario.

7.1 A Model for Asset Returns

Here we describe a model which shows returns of assets and with employing this model we can derive some properties of returns. If we have p assets $Y' = (Y_1....Y_p)$ then we can divide them into two subsets [21]. First subset called as core assets $Y_1' = (Y_1...Y_q)$ and second subset is so called peripheral set and contains $Y_2' = (Y_{q+1}...Y_p)$ assets. Then density of the total vector $Y' = (Y_1' \; Y_2')$ can be composition of two vectors. As a result density function becomes,

$f_Y(y) = \pi_1 f_{Y^{(1)}}(y) + \pi_2 f_{Y^{(2)}}(y)$ here $\pi_1 + \pi_2 = 1$ and $f_{Y^{(i)}}(y)$ is the probability density function of i th distribution. In matrix form the expected value and covariance matrix of two distributions can be expressed as:

$$E_i(Y) = \mu^{(i)} = \begin{pmatrix} \mu_1^i \\ \mu_2^i \end{pmatrix}, \quad i = 1,2 \qquad \textbf{(7.1)}$$

$$\text{cov}_i(Y) = \sum{}^{(i)} = \begin{pmatrix} \sum_{11}^{(i)} & \sum_{12}^{i} \\ \sum_{21}^{(i)} & \sum_{22}^{(i)} \end{pmatrix}, \quad i = 1,2 \qquad \textbf{(7.2)}$$

Here E_i and $Cov_i(Y)$ are stands for expectation and covariance matrices for corresponding distribution. The expected values of distribution parameters $\pi_1, \mu^{(1)}, \mu^{(2)}, \Sigma^{(1)}, \Sigma^{(2)}$ can be calculated via EM algorithm. As a product the algorithm gives posterior probabilities. $\tau_i(y_j)$

$$\tau_i(y_j;\hat{\Theta}) = \frac{\pi_i f_{Y^{(i)}}(y_j;\hat{\Theta})}{\pi_1 f_{Y^{(i)}}(y_j;\hat{\Theta}) + \pi_2 f_{Y^{(2)}}(y_j;\hat{\Theta})} \qquad \textbf{(7.3)}$$

Where $\Theta' = (\pi_1 \ \mu^{(1)'} \ \mu^{(2)'} \ vec(\Sigma^{(1)'}) \ vec(\Sigma^{(2)'}))$ stands for probability which is computed from estimates of parameters, in this situation that observation comes from i^{th} population. In this notation it is generally called posterior probability of the j^{th} observation.

As a result we can calculate conditional expectation of Y_2,.given Y_1 in each population via following formula:

$$E_i(Y_2 | Y_1 = y_1) = \mu_{2.1}^{(i)} = \mu_2^{(i)} + \sum\nolimits_{21}^{(i)} \left(\Sigma_{11}^{(i)}\right)^{-1} (y_1 - \mu_1^{(i)}), \quad i = 1,2. \qquad \textbf{(7.4)}$$

We guess this conditional expectation, when calculated using the (estimated) parameters of the high-volatility distribution to reveal the reaction of the minor assets according to the volatilities and correlations of the hectic periods.

7.2 Mixture Models in Risk Management

Setting adverse periods for Normal Mixture approach is first important question to answer. This problem is very important since volatility of risk factors in those periods grows tremendously. In particular correlations between alternative investment instruments differ in fluctuation periods as compared with normal periods, this phenomenon known as correlation breakdown. According to this phenomenon banks generally make their stress tests based on observations from adverse periods. Here identifying the worst observations is emerged as a big problem. Generally this approach suggests that observations should be generated from mixture of good day and bad day scenarios. As a result of this suggestion we can conclude that y_i is an hectic observation if and only if $\tau_2\left(y_j;\hat{\Theta}\right) > 0.5$

After finding parameter estimates for the distribution of profit and loss account, we can simply get the fat tails of VaR. Since resulting distribution is mixture of two distributions, we can simply find resulting distribution's parameters arbitrarily. If the distribution of data leptokurtic VaR extracted from Monte Carlo simulation process from this situation reflects reality. That means tails are larger than normal one. Here it is important to say that the resulting distribution still belongs to "Normal" observations, but uses adverse condition scenarios in order to address fat tails. Another advantage of method is usage of adverse case scenario as stress test. In order to make stress test VaR using covariance matrix $\Sigma^{(2)}$ should be calculated. Resulting VaR value represents conclusion of stress test.

Another way for stress testing is described in the study done by Kim and Finger (2000) main idea behind the approach is shocking core assets $Y^{(1)}$ and computing movement of the peripheral ones $Y^{(2)}$ as the conditional expectation $E_2(Y^{(2)} \mid Y^{(1)})$.

7.3 Validation

(i) Identifying adverse observations: In order to see that the probabilities give accurate results giving right indications about population membership of an observation, we made Monte Carlo simulations in order to achieve 500 different outcomes and observations come from the mixture:

$$f(y) = 0.9 f_1(y) + 0.1 f_2(y) \qquad \textbf{(7.5)}$$

Where $f_1(y) \approx N_5\left(0, \Sigma^{(1)}\right)$ and $f_2(y) \approx N_5\left(0, \Sigma^{(2)}\right)$. $\Sigma^{(1)}$ $\Sigma^{(2)}$ are given by:

$$\Sigma^{(1)} = \begin{pmatrix} 0.536 & 0.170 & -0.30 & -0.845 & 0.211 \\ 0.169 & 1.558 & 0.508 & -0.285 & -0.796 \\ -0.296 & 0.508 & 1.208 & -0.136 & -0.008 \\ -0.845 & -0.285 & -0.136 & 2.954 & -0.0774 \\ 0.211 & -0.796 & -0.008 & -0.774 & 1.899 \end{pmatrix} \quad \textbf{(7.6)}$$

$$\Sigma^{(2)} = \begin{pmatrix} 9 & 0.170 & -0.30 & -0.845 & 0.211 \\ 0.169 & 8 & 0.508 & -0.285 & -0.796 \\ -0.296 & 0.508 & 6 & -0.136 & -0.008 \\ -0.845 & -0.285 & -0.136 & 7 & -0.0774 \\ 0.211 & -0.796 & -0.008 & -0.774 & 10 \end{pmatrix} \quad \textbf{(7.7)}$$

Here we get an important result because when we compare this variance covariance matices we see that only variances are different, this is the main idea behind the normal mixture approach.

Unlike the multivariate normal case, in the multivariate normal mixture give the estimates of the parameter obtained via marginal and full dimensional data are not the same. For this reason we show below the estimates obtained five-two and one dimensional data. With five dimensional data

$$\hat{\pi}_1 = 0.916$$

$$\hat{\mu}^{(1)\prime} = (-0.044 \quad -0.108 \quad -0.048 \quad 0.110 \quad 0.071) \quad \textbf{(7.8)}$$

$$\hat{\mu}^{(2)\prime} = (-0.377 \quad -0.307 \quad -0.389 \quad 0.566 \quad -0.751) \quad \textbf{(7.9)}$$

$$diag\left(\hat{\Sigma}^{(1)}\right)' = (0.539 \quad 1.647 \quad 1.182 \quad 2.654 \quad 2.170) \quad \textbf{(7.10)}$$

$$diag\left(\hat{\Sigma}^{(2)}\right)' = (12.216 \quad 8.482 \quad 7.126 \quad 6.453 \quad 11.071) \quad \textbf{(7.11)}$$

With two dimensional data the results are:

$$\hat{\pi}_1 = 0.920$$

$$\hat{\mu}^{(1)'} = (-0.026 \quad -0.111) \qquad \textbf{(7.12)}$$

$$\hat{\mu}^{(2)'} = (-0.595 \quad 0.360) \qquad \textbf{(7.13)}$$

$$diag\left(\hat{\Sigma}^{(1)}\right)' = (0.552 \quad 1.631) \qquad \textbf{(7.14)}$$

$$diag\left(\hat{\Sigma}^{(2)}\right)' = (12.435 \quad 8.943) \qquad \textbf{(7.15)}$$

With one component we get:

$$\hat{\pi}_1 = 0.866$$

$$\hat{\mu}^{(1)'} = (-0.001)$$

$$\hat{\mu}^{(2)'} = (0.392) \qquad \textbf{(7.17)}$$

$$diag\left(\hat{\Sigma}^{(1)}\right)' = (0.550) \qquad \textbf{(7.18)}$$

$$diag\left(\hat{\Sigma}^{(2)}\right)' = (5.014) \qquad \textbf{(7.19)}$$

Figure 7.1 to 7.3 shown below represents observations of simulated adverse case scenarios. At first look first graph seems convincing but second and third ones give more information since they includes a few small returns that are generated by high volatility distribution. For further investigation a Monte Carlo experiment with mean vector $\mu^{(2)'} = (6\ 6\ 6\ 6\ 6)$ is shown.

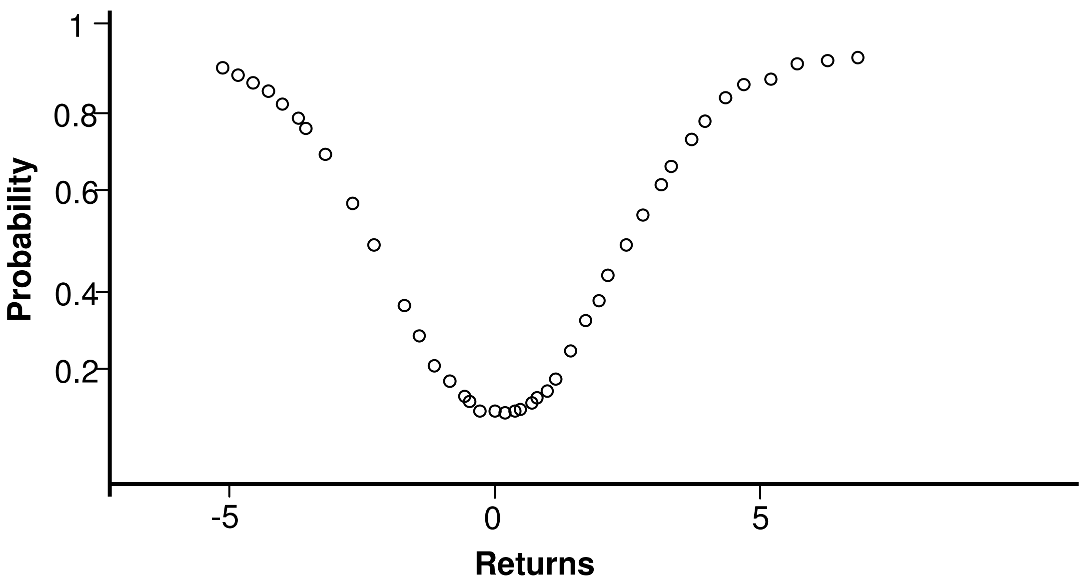

Figure 7.1 : Posterior probability as function of returns – univariate data

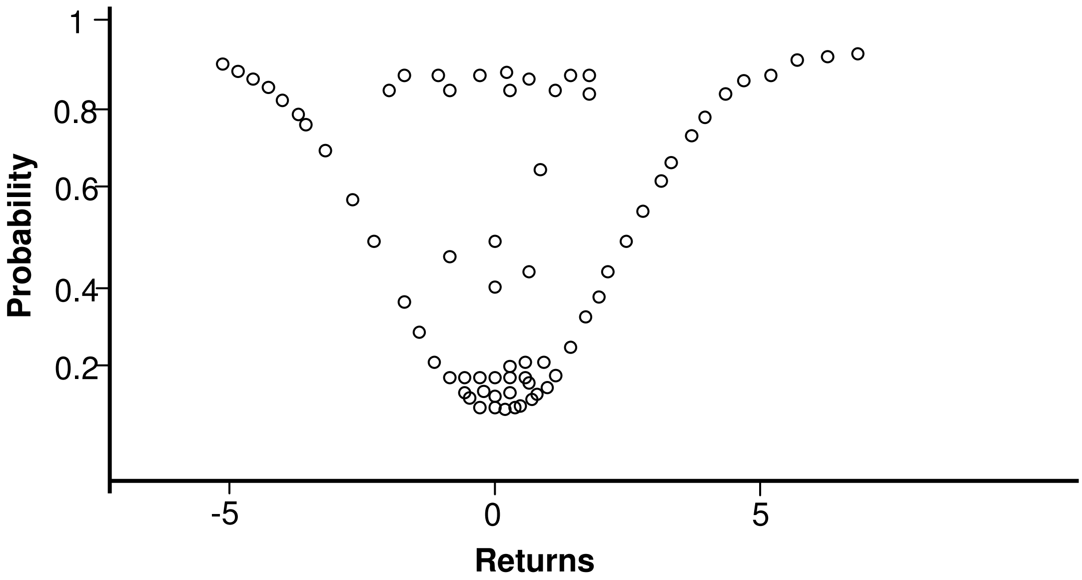

Figure 7.2 : Posterior probability as function of returns – bivariate data

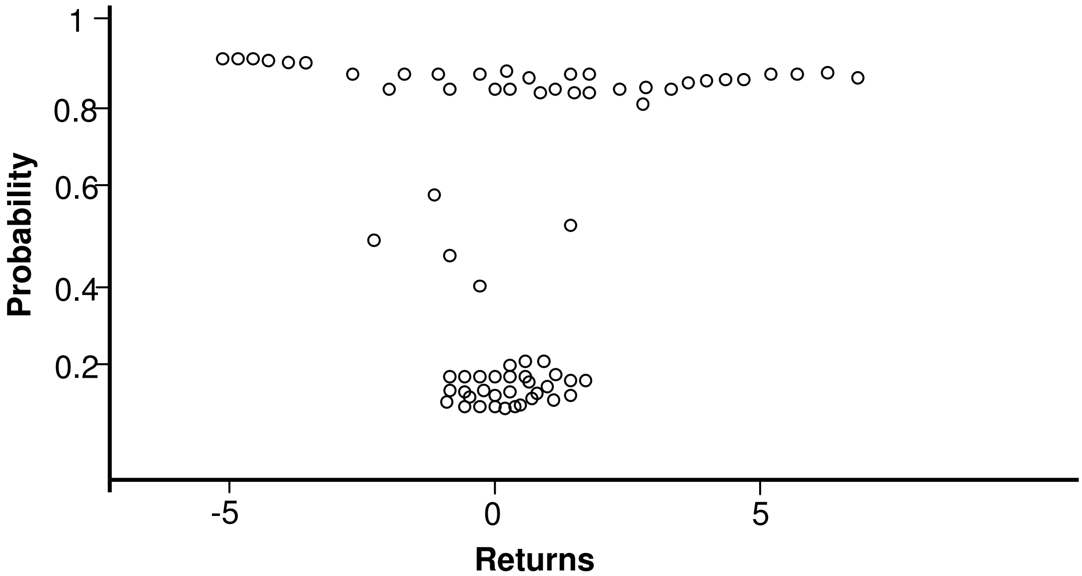

Figure 7.3 : Posterior probability as function of returns –multivariate data

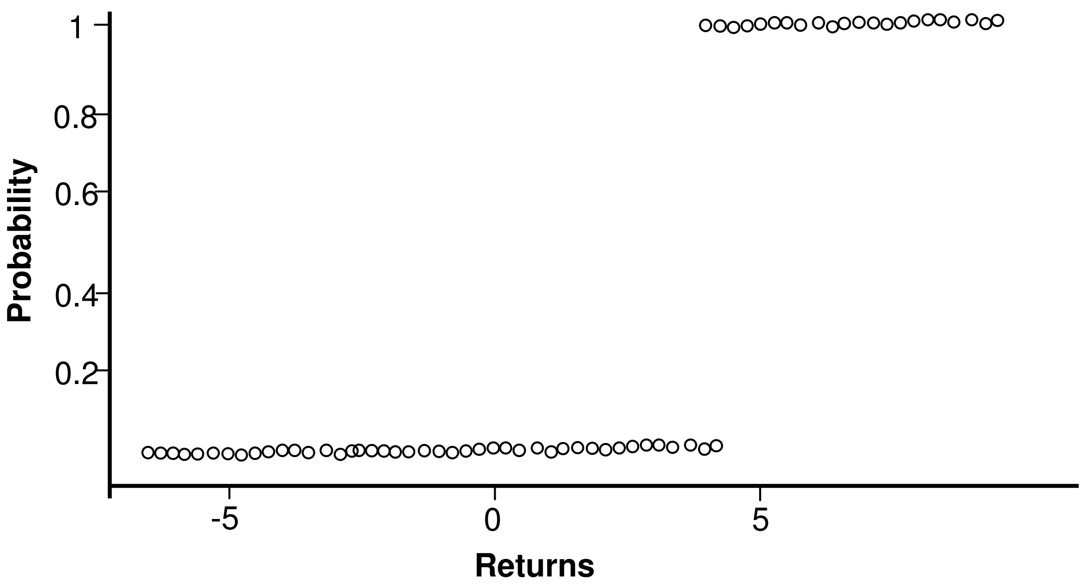

Figure 7.4 : Posterior probability as function of returns – different mean vectors

As can be seen from the results there is no straight way to determine which data set will be used. Studies show that if we use additional marginal distributions, we get additional benefits if and only if they provide additional information about separation of two populations. As in the case presented above means of the two populations are identical their contributions are almost zero.

In order to use full dimensional approach we have to deal with some computational difficulties. When we use the full- dimensional approach we have to run algorithm only one time, otherwise in case of bivariate mixtures we have to run the model p(p-1)/2 times.

In bivariate approach expected value and standard deviation of a variable is different because it depends on which bivariate distribution is used. If we have only three variables and we want to calculate expected values and expected standard deviations of the variables, we have to get estimates of $\text{cov}(Y_1, Y_2)$ and $\text{cov}(Y_1, Y_3)$. For these two covariance matrices we get two different estimates for, μ_1 and σ_1^2, but in this case these estimates are not the same and we have no instrument to recognize which one is better. For conservatism it is reasonable to take estimation of σ_1^2 as:

$$\hat{\sigma}_i^2 = \max 1 \le i \le p, \hat{\sigma}_i^2 \quad i = 1,...., p \qquad \textbf{(7.20)}$$

On the other hand if number of dimensions becomes too large the full dimensional method has some difficulties because in this case multicollinearity might come to play and algorithm may not converge at this point bivariate approach suggested by Kim and Finger can be used but this algorithm has huge computational requirements.

(ii) VaR: As computation example of Fat tails of VaR, a data set is formed with actual data and some simulation results. A 13-dimensional data set is used in NM VaR calculations the data set contains both equity and bond positions. In order to make comparison easy weights of equities and bonds are set in equal levels.

In the table shown below we calculated VaR of our portfolio with three approaches in four different confidence levels. In the first step we calculate VaR value based on adverse case scenario, in which we expect to have largest VaR values from every confidence level. In addition to adverse case scenario we calculate our VaR value based on our normal market conditions and lastly calculate mixture VaR in order to see normal mixture effect. For this last case we simulate 10000 observations and results of the study shown below.

Table 7.1: Comparison of VaR Results of Scenarios

	VaR_{hec}	VaR_{norm}	VaR_{mix}
95%	-1.64	-1.04	-1.05
98%	-2.02	-1.30	-1.45
99%	-2.27	-1.49	-1.75
99.5%	-2.50	-1.65	-2.03

To give successfulness of VaR models we should look at the actual losses. Indicating with r_c the proportion of times the return is smaller than c, we get the results shown in table 7.2:

Table 7.2: Comparison of Backtests

r-1.64	r-1.04	r-1.05
1.34%	5.44%	5.29%
r-2.02	r-1.30	r-1.45
0.75%	2.7%	2%
r-2.27	r-1.49	r-1.75
0.5%	2%	1%
r-2.50	r-1.65	r-2.03
0.25%	1.25%	0.75%

The results of the study show that standard normal VaR approach generally underestimates actual P&L account of the firm, but if we look at Normal Mixture VaR results, they are more conservative than traditional VaR approach and gives better estimates. Finally, the adverse scenario produces highest loss results but this time overestimates risk. The following figure represents VaR estimates of these 3 different distributions.

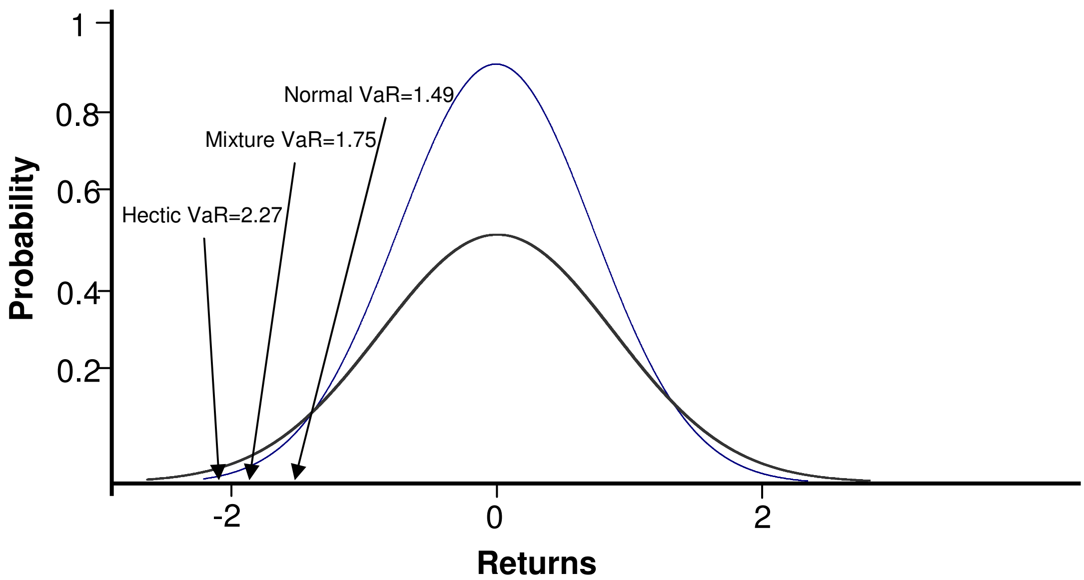

Figure 7.5 : VaR Estimates of Scenarios

The same simulation model has been run again 10000 times but in this case we use 5 equally weighted portfolio elements we obtain following results, in table 7.3 VaR results are presented and table 4 represents actual P&L of the portfolio. These results also show normal mixture VaR represents actual conditions.

Table 7.3: VaR Results of Scenerios

	VaR_{hec}	VaR_{norm}	VaR_{mix}
95%	-1.96	-0.85	-0.76
98%	-2.47	-1.05	-1.08
99%	-2.79	-1.21	-1.55
99.50%	-3	-1.35	-2.02

Table 7.4: Actual P&L

r-1.96	r-0.85	r-0.76
0.52%	3.68%	4.76%
r-2.47	r-1.05	r-1.08
0.19%	2.19%	2.04%
r-2.79	r-1.21	r-1.55
0.12%	1.62%	1.08%
r-3	r-1.35	r-2.02
0.08%	1.31%	0.49%

8. NORMAL MIXTURE APPLICATION

Basle II requirements have forced the banks to develop their own risk management tools and gradually all of the banks become interested in developing and/or outsourcing risk management systems. As a trading risk management and measurement system generally VaR family is widely used in banking sector since the VaR family is relatively cheap, easy, and fast to implement with respect to Extreme Value Theory.

A typical trading risk measurement system has to contain following basic elements:

1. Data feeding
2. Yield curve formation
3. Correlation and standard deviation calculation
4. Portfolio formation
5. Mapping and stripping
6. VaR calculation
7. Kurtosis adjustment (If present)
8. Limit Setting
9. Other Aspects

All of the basic elements stated above their own difficulties and have to be handled according to their nature and availability.

8.1 Data Feeding

Data feeding maybe the most important part of the risk management system since if the system is fed by wrong or inadequate data the VaR calculation gives inaccurate results. Currently data providers give many different types of outputs to banks and selection of suitable data provider becomes more difficult day by day.

Today many data providers for example Reuters, Bloomberg and Superderivatives give online data to banks and other financial institutions. These data providers afford many different types of data packages and their prices are different as well. At this point selection of right data providing package is very important because of limited budgets that are allocated to risk management departments.

Another dimension of data feeding is integrity, meaning getting the data from data provider to risk management system. Since not all the banks has integrated risk management systems today, many risk management activities are done on spreadsheets. Therefore data provider should send its data directly to excel or some other type of spreadsheet.

In order to deal with budget constraints and integrity problems data provider Reuters has been selected for getting real time data since the software is widely used in finance sector as a benchmark and it can directly feed data to Microsoft Excel.

The bank has several trading positions, including new Turkish lira bonds, Eurobonds issued by Turkish government, foreign exchange positions and finally option positions. If natures of these instruments are analyzed we see following unique characteristics:

New Turkish lira bonds can be both coupon bonds and discount bonds and they can be sold in both over the counter markets, IMKB stock exchange or interbank markets. First and third market data cannot be found since these markets are confidential and the counterparties do not want to show their own buy and sell rates to the market but as a cost they take the counterparty risk. However the second market is open the public and the transaction rates and volumes can be tracked by outside investors, but here counterparties cannot hide their positions but they do not take counterparty risk. The exchange market takes counterparty risk and act as a cleaning house.

In order to achieve accurate data, the bank decided to take daily transaction report of IMKB bond desk and tries to figure out actual interest rates. The report is downloaded at the end of every workday and put into common area that can be seen both financial control and risk management department in excel file format and the daily data is taken into databases.

Eurobond positions of the bank come from the Euro or USD bonds issued by Turkish Government. The Eurobonds are typically sold to investors that are located the outside of the Turkey and the bonds can be sold to Turkish or foreign investors by their original investors. Therefore this kind of trading can only be performed via trading platforms such as Reuters or Bloomberg. For this reason the Eurobond data are taken directly from Reuters to shared workbook and then databases take Eurobond data from this workbook.

The daily foreign exchange transactions reveal a representative foreign exchange rate for every currency pair. The Central Bank of Turkey takes five samples from the market each day and makes weighted average calculations on the data and sets end of the day foreign exchange rate for every different currency. The data present in Reuters servers, and that data is directly taken from the Reuters servers to excel workbook and then sent to databases.

8.2 Yield Curve Formation

Yield curve formation is another important part of the risk management system and there are several ways present in order to obtain accurate yield curve.

- Nelson Siegel
- Smoothed Nelson Siegel
- Extended Nelson Siegel
- Svennson
- OLS Loglineer Discount
- OLS Loglineer Coupon
- OLS Echols & Eliot
- Bootstrapping
- Smoothed Bootstrapping
- Interpolation
    - Linear
    - Logarithmic

- Cubic
- Quadratic
- Cubic Spline

Most practical way of yield curve formation is linear approximation. In order to make linear approximation, data fed to database system is directly modified by SQL queries.

The queries basically makes following modifications on the market data provided by Reuters software. At the first step the old data is updated by the fresh daily data (The data of last workday) and then another query modifies the data in which process all of the remaining queries can understand data. At the last step the data which contains yields of every New .Turkish Lira Bond is separated according to remaining days to maturity. Here the main idea is finding a suitable yield for every time bucket. The yield of corresponding maturity bucket simply calculated by taking weighted average of bonds that are present in this bucket.

After formation of yield curve the other risk factors which are not sensitive to interest rate changes are added to main data. The result is ready for standard deviation and correlation calculations.

8.3 Correlation and standard deviation calculation

Every VaR model has to estimate volatility of the risk factors that are included in the model. Since every portfolio has typically more than one risk factor, determination of variance-covariance matrix and correlation matrix are essential and as the number of risk factors involved in the VaR calculation becomes higher the process becomes harder.

In the literature there are many different methods present in order to calculate current volatility of the risk factors. Initially VaR models used constant volatility calculation models in order to estimate current volatility. However many historical evidence have revealed that this type of calculation is not suitable since volatility is not constant over time, therefore additional methods should be incorporated in order to achieve correct volatility estimation.

In order to catch up sudden changes in risk factor volatilities many different approaches have been developed in the literature. Some examples of fast volatility updating models are stated below:

1. Uniform exponential weighting Models (First developed by JP Morgan)

2. Asset-specific exponential weighting volatility model (First developed by Lawrance and Robinson)

3. ARCH models (First developed by Engle)

4. GARCH models (First developed by Bollershev)

All of the methods have their own advantages and disadvantages. If we consider advantages and disadvantages of the models we can say that exponentially weighted moving average or shortly EWMA model is relatively easy and cheap to implement and it supplies good estimates if correct EWMA coefficient is used.

According to EWMA model standard deviation of a given sample can be calculated as follows:

$$\sigma = \sqrt{\frac{1}{\sum_{i=1}^{n} w_i} * \left(x_i^2 w_i - 2 * x_i w_i \bar{x} + \bar{x}^2 \sum_{i=1}^{n} w_i \right)} \qquad \textbf{(8.1)}$$

Here w_i is the corresponding weight given to the x_i th observation.

Calculation of correlation and standard deviations is vital part of VaR calculation because VaR can be defined as a multiple of standard deviation. In order to calculate standard deviations and correlations an excel file with customized standard deviation formula is created. The file contains a macro which is responsible for importing data from access databases and makes calculations on the data via embedded formulas.

8.4 Portfolio Formation

In order to see bank's actual positions the trading portfolio has been divided into desks. The desk approach is a well-known approach in the financial literature since it supplies many advantages to bank. Firstly it gives easiness to follow positions of bank. Secondly it allows setting separate limits to bank's positions.

Generally a bank portfolio may contain following desks:

- Domestic Currency Bonds Desk
- Foreign Currency Bonds Desk
- Money Market Placements Desk
- Foreign Exchange Desk
- Option Book

Typically banks make VaR calculations on daily basis. VaR figures are calculated on end of day portfolios and sent to treasury beginning of the day. Therefore, portfolio should be formed immediately start of the day, so risk management framework has to be formed fast enough to catch up speed of daily life.

Principally Risk Management stuff have no financial knowledge, they are generally graduates of engineering or econometrics schools. Therefore they cannot assess correctness of data that they are using. For this reason Treasury Control Unit supplies daily data to Risk Management Unit. After formation of data Risk Management staff tries to map and strip cash flows of instruments.

8.5 Mapping and Stripping

Mapping and stripping is another important part of VaR calculation since it directly influences current value of the trading book. Every bond has unique characteristics and has different cash flows than others. Unfortunately, every bond can't have exact vertix hit. Vertix can be defined as a point on time which has known interest rate. In order to calculate actual value of the portfolio every bond's cash flow has to be divided into at least two components (Vertices) which have known interest rates.

This process is very hard to implement. To solve the problem generally visual basic based macros are used. The process can be done in 3 steps using a visual basic coded macro (See Appendix A).

In first step, a subroutine is written in order to determine cash flows of bonds. This subroutine decomposes bond transactions into their individual cash flows. The process is done in several steps:

In fist step transaction data is loaded from the input sheet. In the second step the type of underlying security is determined and decomposed the security into its cash flows. This is straightforward for discount or zero coupon bonds where the only cash flow is the principal. For fixed coupon bonds, the procedure simply loops over all remaining cash flows starting from the maturity date. For floating bonds, the macro decomposes them into the next coupon, known present value at the next reset date and a stream of excess coupons (annuity).

In second step, two vertices at which bond's cash flow can be divided is found. At the same time, standard deviations for the two vertices and their correlations are retrieved. The code uses two nested loops to figure out the bracketing bins. The outer loop runs over all cells in the Cash Flow Range. The inner loop runs over all vertices. Using this structure each cash flow is compared to every maturity bin. The inner loop does the followings:

Make sure that the cash flow currency and vertix currency match. Test for exact vertix maturity in this case bin1 and bin2 are the same. Find the two bracketing vertices.

In the last step cash flow of the each bond is split into its sub cash flows using another macro. The procedure splits the bond's cash flow between the two previously identified vertices and a cash flow at time 0. The split is setup to preserve duration, variance and present value. The code considers the following three cases.

1. Exact Vertix hit

- The cash flow is split equally between the two vertices

2. Degenerate case (sigma1 = sigma2 and correlation = 100%)

- In this case, standard deviation is preserved

- Regardless of the split. The function then does the split in such a way so as to have no CF at time 0.

3. Normal Case

- The split is done to preserve duration and variance

- Cash flow at time 0 is then added to adjust the present value

This procedure is repeated for every type of instrument that is used by bank and their cash flows are aggregated according to their vertices.

As said before mapping process is an important step of VaR calculation, since it directly influences present value of the portfolio. The approach which is stated above guarantees the correct calculation of portfolio present value. Therefore VaR calculation becomes easy to handle. After mapping, the data is ready for VaR calculation.

8.6 Parametric Value at Risk Calculation

Parametric VaR has become the sectoral standard way to calculate Value-at-Risk. It's fast, simple to understand, and often fairly accurate. It also has a number of side benefits such as providing the correlations between different groupings of instruments and allowing for great flexibility.

In calculation step mapped cash flows are entered to input sheet and their present values are calculated in the next sheets. The calculated risk factors are entered in another sheet and covariance matrix of risk factors is developed according to EWMA methodology. After employment of necessary calculations parametric VaR can been calculated via following formula.

$$VaR_{total} = VaR \quad Multiplier \times Weight \quad Vector^{T} \times Co\,\mathrm{var}\,iance \quad Matrix \times Weight \quad Vector \qquad \mathbf{(8.2)}$$

Here VaR Multiplier is confidence level parameter. If we use 99% confidence level the multiplier becomes 2.33.

The Risk Management Team has decided to implement parametric VaR methodology since it is comparatively cheap and fast to implement and very easy to understand for someone who does not familiar with VaR methodology.

8.7 Kurtosis Adjustment (Normal Mixture)

General VaR models assume that, risk factors have normal distributions. However in real life it can be realized that the factors do not follow normal distributions patterns during the crisis. Turkey is generally accepted as a developing country and generally it is very sensitive to global fluctuations and domestic political situations. Therefore, banks have to find alternative ways to model kurtosis of the market data, since the market data has fat tails.

One of the most common ways of modeling tail of a given market data is normal mixture. Normal mixture can be defined as a mixture of two scenarios one of the scenarios is called "Disaster Scenario" while the other one represent current situation.

First step in calculating normal mixture is selection of "Disaster Scenario". Turkey has many financial crises during last years; some of them are 2001, 2003 and 2006 crisis. First two are coming from internal problems while the other came from global fluctuations. In order to represent Turkey's situation 2003 scenario is considered as "Disaster Scenario".

Second step is determining weight of the "Disaster Scenario". Weight is determined by subjective judgment. Determination of weight is directly depends on Risk managers experience, top management's risk appetite and current situation's volatility level.

In the third step Normal Mixture factor is calculated. The calculation procedure can be seen below:

- Covariance matrices of each scenario should be calculated. Here the calculation is straight forward historical data of each risk factor is available and covariance matrices can be calculated via 1-year historical data.

- Weight vector of portfolio should be formed. In the mapping step portfolio's cash flows has been divided into sub cash flows with known yield to maturity.

- VaR of the portfolio should be calculated with using each matrix. Here the calculation formula is:

$$VaR_{total} = VaR \quad Multiplier \times Weight \quad Vector^T \times Co\,\mathrm{var}\,iance \quad Matrix \times Weight \quad Vector$$

Here we have two different VaR values the first one come from current data and the other one come from "Disaster Scenario".

- After calculation of VaR via two scenarios yearly volatility of portfolio should be calculated. Volatility of portfolio can be find via following formula:

$$\sigma_P = \frac{VaR}{(VaR \quad Multiplier \times Weight \quad Vector)} \times Scaling \quad Factor \times sqrt(Holding \quad Period) \quad \textbf{(8.3)}$$

➢ After calculation of individual volatilities mixture of them should be calculated. Mixture volatility is simple weighted sum of individual volatilities.

➢ After that the following equation should be set to zero. This process is done with an optimization algorithm

$$p \times Normsdist(-\frac{NM \quad Unit \quad VaR}{Current \quad Annual \quad Volatility}) + (1-p)Normsdist(-\frac{NM \quad Unit \quad VaR}{Stress \quad Annual \quad Volatility}) - 0.01 \quad \textbf{(8.4)}$$

.Here p is weight of the current scenario and Normsdist is a spreadsheet function which returns the normal cumulative distribution for the specified mean and standard deviation. NM Unit VaR is VaR of mixture with PV=1

➢ After calculation of unit VaR. Annual VaR of the mixture portfolio can be found by simply multiplication of weight vector with NM unit VaR.

➢ In the next step daily mixture VaR is calculated via following formula:

$$\frac{NM \quad Annual \quad VaR}{Scaling \quad Factor \times \sqrt{Holding \quad Period}} \quad \textbf{(8.5)}$$

➢ Lastly Normal Mixture Factor is calculated by formula stated below:

$$\frac{NM \quad Daily \quad VaR}{Current \quad VaR} \quad \textbf{(8.6)}$$

Calculation of NM factor allows us to assess risk level of the portfolio and it can be seen as scaling factor of parametric VaR. As a result NM adjusted parametric VaR equals to parametric VaR times NM factor.

8.8 Limit Setting

Limit setting is another important aspect of risk management framework. Generally management board sets yearly loss limit to treasury department. After that risk management department tries to give daily loss limits to treasury department on desk and consolidated basis. According to banking regulations of Turkey foreign exchange exposures are subject to legal limits while interest rate based instruments are not. Therefore treasury department needs to know their fixed income and foreign exchange limits separately.

These limits are set according to economic capital allocated to treasury activities. First, economic capital allocated to trading activity is converted to daily potential loss limit via following formula:

$$Daily\ \ VaR\ \ Limit = \frac{Economic\ \ Capital}{Scaling\ \ Factor \times \sqrt{Holding\ \ Period}} \qquad \textbf{(8.7)}$$

After that this daily limit is divided into desk limits meaning foreign exchange desk and fixed income desk. In order to guarantee not violating legal foreign exchange limits all of the foreign exchange positions are fixed their own caps and remaining limit is allocated to fixed income desk. The limit breakdown can be seen below.

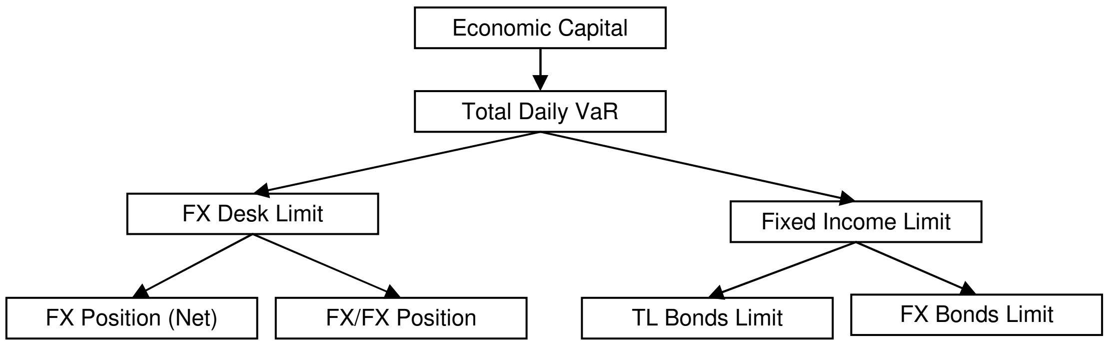

Figure 8.1 Limit Breakdown

Therefore we can say that when trading limit is fully used, bank has stable foreign exchange position and carry floating interest rate risk.

Additionally, risk management departments have to supply necessary information, data and know-how to bank's other departments. In this perspective risk management department supplies risk coefficients for bonds that are used by treasury. The risk coefficients basically say following if you purchase 1 million nominal from this bond your potential loss increases approximately this amount. Limit and their usages and risk coefficients to treasury management to monitor its usage.

8.9 Other Aspects

Risk management framework contains some other aspects according to bank's needs and the board's management perspectives. Some of the aspects concerns with legal issues of risk management department while the others done according to MIS principles.

Risk management departments prepare and report legal weekly currency position reports to BRSA and prepares monthly market risk reports on sole and quarterly on consolidated base.

Risk management frameworks have to deal with option portfolio of the bank and structured products sold or bought by treasury management as well. Principally an option may be done on many different underlying. In Turkey most of the options are made on foreign currencies. Typically an option gives a right to its owner to buy or sell a predetermined amount of foreign currency at predetermined price on agreed day. Options have many different types such as European or American types according to their exercise styles and barrier or vanilla according to its structure.

A vanilla European option gives a right to its owner to buy or sell a predetermined amount of foreign currency at predetermined price on agreed day. These types of options are easiest option type to model and they typically priced with Black and Scholes option pricing model. In this type option, option owner have to wait until exercise date of the option and at this date he/she decides to use its right or not.

Other types of options are priced with Monte Carlo simulation models and the models should be designed according to options unique characteristics. Another type of option is vanilla American option which gives a right to its owner to buy or sell a predetermined amount of foreign currency at predetermined price until agreed day. Other structured options contain some barriers which stand for activation or deactivation levels of options.

Risk management system has to supply option portfolio's greeks to financial control, treasury control and treasury management departments on daily basis. Moreover option Delta's directly added to bank's foreign exchange desk position in order to reflect actual position of the bank.

Risk management framework has to back-up its daily calculations and prepare monthly reports on them. Therefore a spread sheet has to be developed in order to monitor and collect limits and limit usages of treasury management.

Model's performance has to be monitored according to bactesting regulations. Therefore a rigid policy has to be employed to monitor model's daily accurateness. A spread sheet has been developed in order to compare daily predicted loss with actual profit and loss. The figure below represents model's bactesting results from beginning of the year 2006. The figure below shows that the model has 4 exceptional days in the last 23 months (The exceptional days fall below the VaR line).

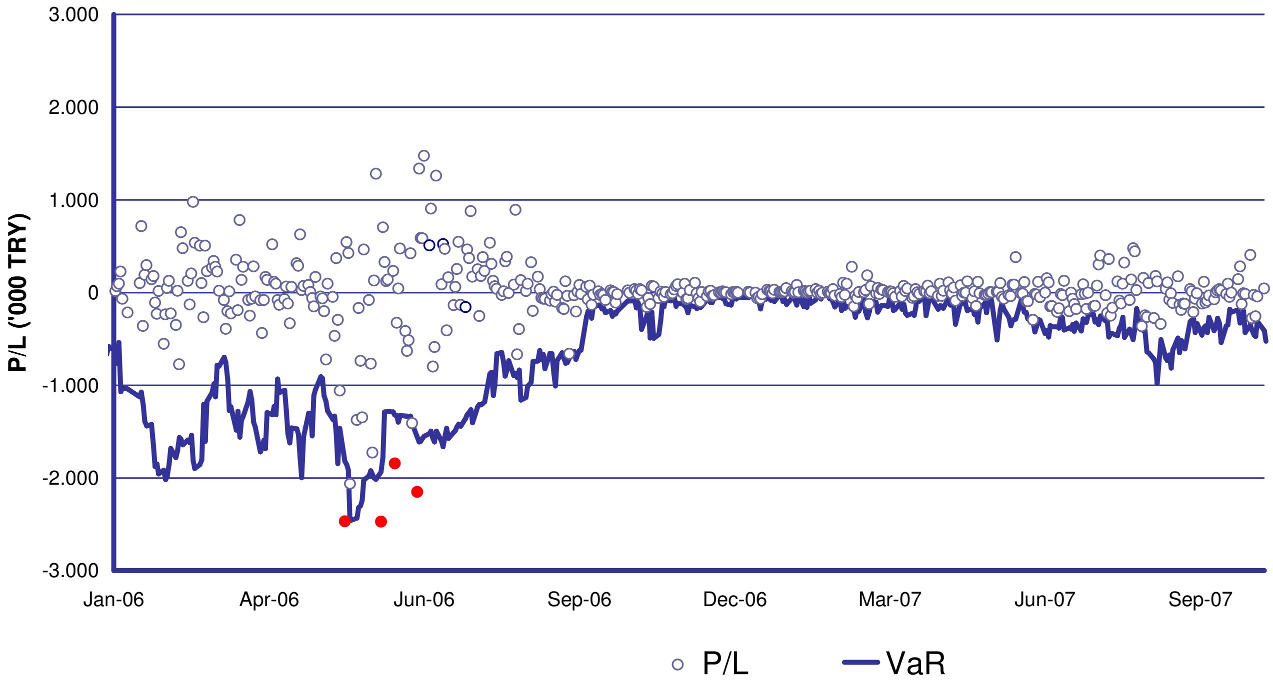

Figure 8.2 Backtesting Results

9. CONCLUSION

Risk management systems gained importance since 2001 financial crisis. Risk management systems have to be implemented according to BRSA requirements. Currently every bank in Turkey has to use standardized approach in measuring market risk. However with BASLE II, bank's can use their own models in calculating their market risks if BRSA accepts.

As a regulation capital adequacy ratio of a bank should be greater than or equal to 12% and capital adequacy ratio can be expressed via following formula:

$$Capital\ \ Adequacy\ \ Ratio = \frac{Capital}{Market\ \ Risk\ \ Capital + Credit\ \ Risk\ \ Capital + Operational\ \ Risk\ \ Capital} \quad \textbf{(9.1)}$$

As can be seen in formula, market risk capital should be lowest level. Market Risk capital can be calculated via following:

$$Market\ \ Risk\ \ Capital = VaR_{Portfolio} \times Scaling\ \ Factor \times \sqrt{Holding\ \ Period} \quad \textbf{(9.2)}$$

When we examine the formula we see that we have to minimize scaling factor and VaR of the portfolio if we want to minimize legal market risk capital. The backtesting results of the model say the model has no exceptional days during the last year; therefore model scaling factor is 3. According to model results VaR of the portfolio is equal to 525 776 YTL as at the end of September 2007 if we calculate market risk capital it is equal to: 4 990 000 YTL. This number is calculated economical capital according to internal model's approach. The standardized approach requires approximately 60 000 000 YTL market risk capital at the end of September 2007 which is 15 times larger than internal models approach.

This model's success directly influences profitability of the bank because it is requires less amount of capital in order to sustain banking activities of the bank. When we examine backtesting results of the model we can conclude that standardized approach over estimate market risk of bank.

For future work the bank have to prepare a paper regarding its models performance to BRSA and try to get permission to use its internal model in Market Risk calculations.

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APPENDIX A

The macros given below find vertices and corresponding cash flows to the vertices of a given cash flow.

```
Sub VertixIdentifier(CashFlowRange As Range)
Rem This function identifies which two vertices bracket a given cashflow
Rem At the same time, standard deviations for the two vertices
Rem and their correlation is retrieved.
Rem  The code uses two nested loops to figure out the bracketing bins.
Rem  The outer loop runs over all cells in the CashFlowRange.
Rem  The inner loop runs over all vertices. Using this structure
Rem  each cashflow is compared to every maturity bin.
Rem  The inner loop does the following
Rem  1. Make sure that the cashflow currency and vertix currency match
Rem  2. Test for exact vertix maturity
Rem         - in this case bin1 and bin2 are the same
Rem  3. Find the two bracketing vertices
Rem  Please note that this code relies on the fact that
Rem  risk factor vertices are ordered in the order of increasing
Rem  maturity in the Vertix Range.

Dim ac As Range
Dim Vertix As Range
Dim Key As String
Dim NumberOfRows As Integer

'Test for non-existing instruments
If IsEmpty(CashFlowRange.Cells(1, 1)) = False Then 'a

NumberOfRows = CashFlowRange.Rows.Count

Rem Update StatusBar and Turn-off
Application.ScreenUpdating = False
Application.Calculation = xlCalculationManual

'Begin Main Loop Over All CashFlows
For Each ac In CashFlowRange
  Application.StatusBar = "Identifying Vertices, Row Number: " _
     & ac.Row & "/" & NumberOfRows
   With ac
     'For Each CashFlow, loop over all vertices
      For Each Vertix In Range("VerticesRange")
        'Match Currency
```

```
        If .Offset(0, -1).Value > 10950 Then
        .Offset(0, -1).Value = 10950
         Else
        If .Offset(0, -2).Text = Vertix.Offset(0, -2).Text Then
        'Test for Exact Vertix Maturity
         If .Offset(0, -1).Value = Vertix.Offset(0, -1).Value Then
          .Offset(0, 1) = Vertix
          .Offset(0, 2) = Vertix
          .Offset(0, 3) = Vertix.Offset(0, 1)
          .Offset(0, 4) = Vertix.Offset(0, 1)
          .Offset(0, 5) = Vertix.Offset(0, 2)
          .Offset(0, 6) = Vertix.Offset(0, 2)
         Else
            'Find the two bracketing cashflows
            If .Offset(0, -1).Value > Vertix.Offset(0, -1).Value And _
               .Offset(0, -1).Value < Vertix.Offset(1, -1).Value Then
               .Offset(0, 1) = Vertix
               .Offset(0, 2) = Vertix.Offset(1, 0)
               .Offset(0, 3) = Vertix.Offset(0, 1)
               .Offset(0, 4) = Vertix.Offset(1, 1)
               .Offset(0, 5) = Vertix.Offset(0, 2)
               .Offset(0, 6) = Vertix.Offset(1, 2)
            End If
         End If
        End If
        End If
      Next Vertix
    End With

   'Lookup Correlation
   If (ac.Offset(0, 1).Text <> "") And (ac.Offset(0, 1).Text <> "") Then
      Key = ac.Offset(0, 1).Text & ac.Offset(0, 2).Text
      ac.Offset(0, 7).Value = _
        Application.WorksheetFunction.VLookup(Key, Range("CorrelationRange"),
2, False)
   End If
Next ac

End If 'a

Rem ReturnControl to MS Excel
Application.ScreenUpdating = True
Application.StatusBar = False
Application.Calculation = xlCalculationAutomatic

End Sub
Sub CashFlowSplitter(CashFlowRange As Range)
Rem This procedure splits the cashflow between the two previously
Rem identified vertices and a cashflow at time 0. The split is setup
Rem to preserve duration, variance and present value.
```

```
Rem The code considers the following three cases.
Rem 1. Exact Vertix hit
Rem         - the cashflow is split equally between the two vertices
Rem 2. Degenerate case(sigma1 = sigma2 and correlation = 100%)
Rem         - in this case, standard deviation is preserved
Rem         - regardless of the split. The function then does
Rem         - the split in such a way so as to have no CF at time 0.
Rem 3. Normal Case
Rem         - the split is done to preserve duration and variance
Rem         - cash flow at time 0 is then added to adjust the present value

Dim ac As Range
Dim WeightOfVertix1 As Double
Dim WeightOfVertix2 As Double
Dim Vertix1DTM As Double
Dim Vertix2DTM As Double
Dim Rate As Double
Dim Duration As Double
Dim Duration1 As Double
Dim Duration2 As Double
Dim PresentValue As Double
Dim QuadraticCoefficient As Double
Dim LinearCoefficient As Double
Dim Intercept As Double
Dim Sigma1 As Double
Dim Sigma2 As Double
Dim Sigma As Double
Dim Rho12 As Double
Dim SplitFactor As Double
Dim Root1 As Double
Dim Root2 As Double
Dim Root As Double
Dim PresentValue1 As Double
Dim PresentValue2 As Double
Dim SplitPV1 As Double
Dim SplitPV2 As Double
Dim SplitDuration1 As Double
Dim SplitDuration2 As Double
Dim NumberOfRows As Integer
Dim VolatilitySlope As String

'Test for non-existing instruments
If IsEmpty(CashFlowRange.Cells(1, 1)) = False Then 'a

NumberOfRows = CashFlowRange.Rows.Count

Rem Turn-off screen updating
Application.ScreenUpdating = False

'Begin Main loop
```

```
For Each ac In CashFlowRange

  'Update the StatusBar
  Application.StatusBar = "Performing the Split, Row Number" _
      & ac.Row & "/" & NumberOfRows
  With ac
   'Load in Parameters
   Sigma1 = .Offset(0, 5).Value
   Sigma2 = .Offset(0, 6).Value
   Rho12 = .Offset(0, 7).Value
   Vertix1DTM = Val(Mid(.Offset(0, 1).Text, 4, Len(.Offset(0, 1).Text) - 3))
   Vertix2DTM = Val(Mid(.Offset(0, 2).Text, 4, Len(.Offset(0, 2).Text) - 3))

   If Vertix1DTM = Vertix2DTM Then 'Output Results for Exact Vertix Hit
     SplitFactor = (1# / 2#)
     .Offset(0, 8) = SplitFactor * .Value
     .Offset(0, 9) = (1 - SplitFactor) * .Value
     .Offset(0, 10) = 0
     Rate = .Offset(0, 3)
     PresentValue = .Value * Exp(-Rate * .Offset(0, -1) / 365#)
     Duration = -.Value * (.Offset(0, -1) / 365#) * Exp(-Rate * (.Offset(0, -1) / 365#))
   Else
     'Calculate Interpolated Yield and PV Between Vertices
     WeightOfVertix2 = (.Offset(0, -1).Value - Vertix1DTM) / (Vertix2DTM -
Vertix1DTM)
     WeightOfVertix1 = (Vertix2DTM - .Offset(0, -1).Value) / (Vertix2DTM -
Vertix1DTM)
     Rate = WeightOfVertix1 * .Offset(0, 3).Value + _
           WeightOfVertix2 * .Offset(0, 4).Value
     Sigma = WeightOfVertix1 * Sigma1 + WeightOfVertix2 * Sigma2

     'Assume Continuous Compounding For CashFlow Discounting
     PresentValue = .Value * Exp(-Rate * .Offset(0, -1) / 365#)
     Duration = -.Value * (.Offset(0, -1) / 365#) * _
     Exp(-Rate * (.Offset(0, -1) / 365#))

   If (Sigma1 = Sigma2) And (Rho12 = 1) Then 'Test for a degenerate case
     SplitFactor = _
     (((Vertix1DTM * Vertix2DTM / 365#) * PresentValue / Duration) +
Vertix1DTM) / _
         (Vertix1DTM - Vertix2DTM)
   Else
     'Calculate Two Quadratic Roots
     QuadraticCoefficient = Sigma1 * Sigma1 + Sigma2 * Sigma2 - 2 * Rho12 *
Sigma1 * Sigma2
     LinearCoefficient = 2 * Rho12 * Sigma1 * Sigma2 - 2 * Sigma2 * Sigma2
     Intercept = Sigma2 * Sigma2 - Sigma * Sigma
     Root1 = QuadraticRoot(QuadraticCoefficient, LinearCoefficient, Intercept, True)
     Root2 = QuadraticRoot(QuadraticCoefficient, LinearCoefficient, Intercept,
False)
```

```
   'Volatility Term Structure Shape
   If Sigma1 > Sigma2 Then
     VolatilitySlope = "downward"
   Else
     VolatilitySlope = "upward"
   End If

   'Select Meaningful Root
   If Root1 > 1 Then
        SplitFactor = Root2
   End If
   If (Root2 < 0) Then
        If VolatilitySlope = "upward" Then
        SplitFactor = Root1
        End If
        If Abs(Root2) > 1 Then
           SplitFactor = Root1

        Else
        SplitFactor = -Root2
        End If
   End If
 End If

 Duration1 = SplitFactor * Duration
 Duration2 = (1 - SplitFactor) * Duration

 .Offset(0, 8) = -Duration1 * _
   Exp(.Offset(0, 3).Value * Vertix1DTM / 365#) * 365# / Vertix1DTM
 .Offset(0, 9) = -Duration2 * _
   Exp(.Offset(0, 4).Value * Vertix2DTM / 365#) * 365# / Vertix2DTM
 PresentValue1 = .Offset(0, 8) * Exp(-.Offset(0, 3).Value * Vertix1DTM / 365)
 PresentValue2 = .Offset(0, 9) * Exp(-.Offset(0, 4).Value * Vertix2DTM / 365)
 .Offset(0, 10) = PresentValue - PresentValue1 - PresentValue2

End If

 Rem Output Diagnostics
 .Offset(0, 11) = PresentValue
   SplitPV1 = .Offset(0, 8) * Exp(-.Offset(0, 3).Value * Vertix1DTM / 365)
   SplitPV2 = .Offset(0, 9) * Exp(-.Offset(0, 4).Value * Vertix2DTM / 365)
 .Offset(0, 12) = SplitPV1 + SplitPV2 + .Offset(0, 10)
 .Offset(0, 13) = Duration
   SplitDuration1 = -.Offset(0, 8) * (Vertix1DTM / 365) * _
        Exp(-.Offset(0, 3).Value * Vertix1DTM / 365)
   SplitDuration2 = -.Offset(0, 9) * (Vertix2DTM / 365) * _
        Exp(-.Offset(0, 4).Value * Vertix2DTM / 365)
 .Offset(0, 14) = SplitDuration1 + SplitDuration2
 .Offset(0, 15).Formula = "=" & .Offset(0, 11).Address(False, False) & "-" & _
```

```
      .Offset(0, 12).Address(False, False)
   .Offset(0, 16).Formula = "=" & .Offset(0, 13).Address(False, False) & "-" & _
      .Offset(0, 14).Address(False, False)
   .Offset(0, 17) = SplitFactor
   .Offset(0, 18) = Rate
   .Offset(0, 19) = Sigma
  End With
Next ac

End If 'a

Rem Turn-on screen updating
Application.ScreenUpdating = True
Application.StatusBar = False
End Sub
```

CURRICULUM VITAE

Eray Peker was born on December 13, 1980 in Edirne. He is graduated from Edirne Science High School in 1998. He achieved Bachelor Degree in Industrial Engineering at Marmara University, Istanbul in 2003.

Eray Peker has been working in a small to mid-sized bank in Turkey at Risk Mangement field. Eray currently lives in İstanbul, and he is married since 2006.

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