Consultative Paper

Credit Stress-Testing

31 January 2002

Monetary Authority of Singapore

PREFACE

The last decade saw an increase in the number of shocks that financial markets were subjected to. These shocks have also shown a greater tendency to spread to other financial markets, aided by improved financial infrastructure and lower barriers to international capital flows. The anticipation and management of these financial crises are among the most pressing problems faced by financial institutions.

Stress-testing offers financial institutions a systematic methodology to prepare for financial crises. In this regard, MAS has prepared a consultative paper that aims to provide risk managers with some guidance in constructing and conducting credit stress tests.

Although banks that possess counter-party risk rating and credit portfolio risk management tools can take better advantage of the techniques outlined in this paper, the principles contained therein are equally applicable to banks that have yet to build quantitative credit risk management systems.

The guidelines are neither prescriptive nor are they the minimum requirements that banks adopting the Internal Ratings Based (IRB) approach under the New Basel Capital Accord are required to meet in respect of stress testing. They do, however, reflect market best practices that banks should aspire towards.

A working draft of this paper is available at www.mas.gov.sg/. We welcome your feedback and comments and would appreciate receiving them by 1 May 2002. Please write to us at:

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SECTION A: STRESS-TESTING - WHAT & WHY

1.0 INTRODUCTION

In finance, risk is defined as uncertainty of returns from a portfolio[1]. The uncertainty is gauged by the volatility of a portfolio's returns, with higher volatility indicating higher risk. The volatility of returns is directly or indirectly influenced by numerous variables, which are called risk factors. For example, an equity index is one of the risk factors that influences the value of an equity portfolio while the prime rate is one of the risk factors that affects the value of a loan or bond portfolio. Even simple portfolios made up of a few basic financial instruments are influenced by numerous risk factors.

One of the risk manager's primary objectives is to measure the influence of each risk factor on the volatility of portfolio returns and to manage the composition of the portfolio so that the volatility of its returns is reduced. Further, the risk manager must also measure the influence of the risk factors on each other[2]. Disentangling the effects of multiple risk factors and quantifying the influence of each is a fairly complicated undertaking.

There is a distinct difference in the behaviour of risk factors during normal business conditions and during stressful conditions such as financial crises. In ordinary business conditions the behaviour of risk factors is relatively less difficult to predict because their behaviour does not significantly change in the short to medium term. Therefore, future behaviour can be predicted, to an extent, from past performance. However, during stressful conditions the behaviour of risk factors becomes far more unpredictable and past behaviour offers little help in predicting future behaviour.

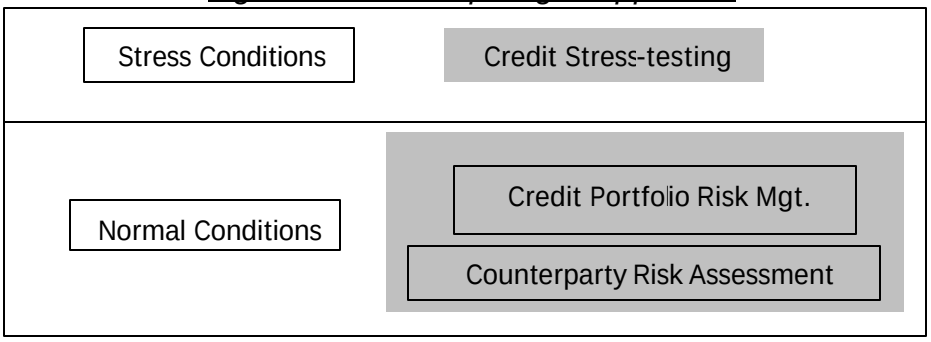
[1] A portfolio could be made up of just one security.

[2] The statistical measure of which is the 'Covariance'.

This is why risk managers are well-advised to adopt a two-pronged approach to risk management, where on the one hand they use various qualitative and quantitative techniques to measure risk in ordinary business conditions, while on the other, they use stress-tests to quantify likely losses under stress conditions. We examine more closely below, the two-pronged approach that may be adopted for comprehensive credit risk management.

1.1 Two-pronged approach to Credit Risk management

Figure 1: The two-pronged approach



Normal Business Conditions

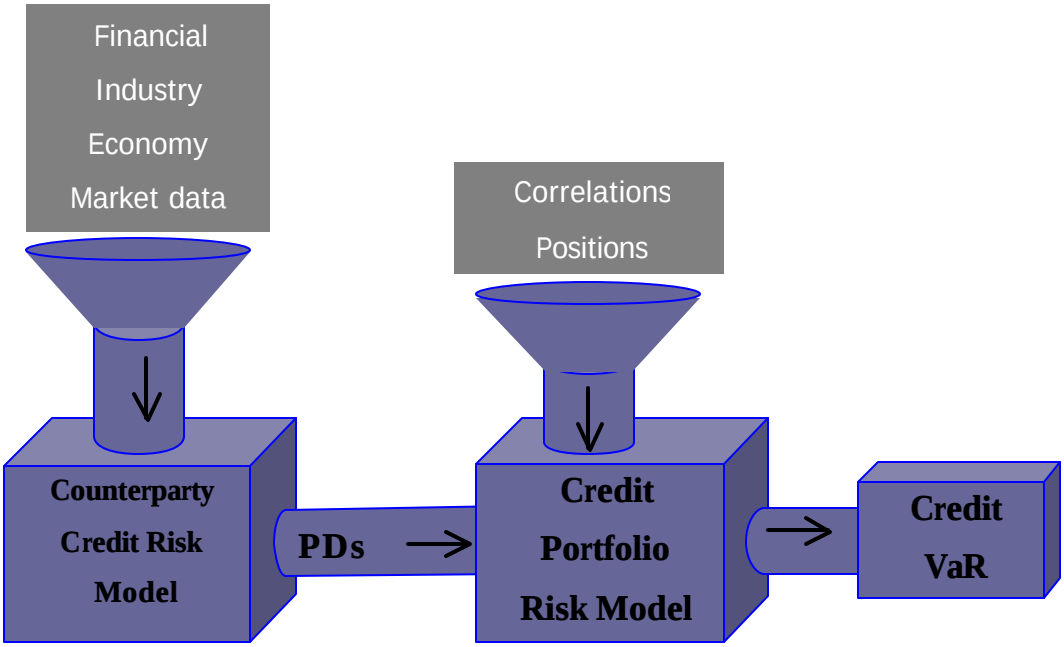
Most banks manage Credit Risk* in ordinary business conditions at two levels, the counterparty level and the portfolio level. Qualitative credit risk assessment at the counterparty level is one of the oldest functions of banking and is a mature discipline, but quantitative management of credit risk at the counterparty and portfolio levels is still in a nascent stage.

A quantitative credit risk model enables a bank to arrive at a numeric measure of the likelihood that a counterparty will default. This numeric measure is called the Probability of Default (PD).

*Please refer to the Glossary

A Credit Portfolio Risk Management System (CPRMS) uses the PDs and several other factors, including the correlation between the risk factors, to arrive at the Credit Value at Risk (Credit VaR). This process is illustrated in Figure 2 below.

Figure 2: The Credit Risk Management Process



Stress Conditions

Most risk monitoring systems, whether quantitative or qualitative, are best suited for normal business conditions because they use the past behaviour of risk factors to predict future behaviour.

Further, quantitative portfolio management systems like Credit VaR models, predict the maximum loss of a portfolio, at a specific probability level, over a given time interval, in normal business conditions. For example, a 1-day VaR of SGD1million at a 99% probability level indicates that expected losses would not be greater than SGD1million in 99 days out of every 100. However, VaR

does not specify the magnitude of loss that could be incurred on the remaining 1 day. That 1 bad day is all that may be required to break a bank.

This is why banks should consider adopting a two-pronged approach to credit risk management whereby day-to-day risk is managed with quantitative and qualitative counterparty and portfolio risk management systems, while exceptional risk is managed through stress-testing.

1.2 What is Stress-testing

The BIS committee on the global financial system (BCGFS) (2000) defines 'Stress-testing' as – "a generic term describing various techniques used by financial firms to gauge their potential vulnerability to exceptional but plausible events".

The techniques that determine the effects of stress events on the Credit Risk borne by an institution are called Credit Stress-Tests.

The two key words used to define a stress event are 'exceptional' and 'plausible'. Stress-testing assesses effects of only exceptional (that is, low probability) events rather than of ordinary 'bad news'. However, while stress events must be low-probability incidents, they should not be so far-fetched as to stretch the limits of plausibility. This is because implausible stress-tests do not provide meaningful results on the strength of which risk managers can plan corrective action.

Recently however, stressful events have been occurring with alarming regularity and while they are no longer ‘low probability’ their impact is still severe. In the last 10 years alone there have been about 10 stress events, some examples of which are the Gulf War, the Asian Crisis and the Russian

Default[3]. The most recent of these crises were the terrorist attacks of September 11th and the Argentine default.

1.3 Features of Previous Stress Events

A review of some features of previous stress events will help to underscore the importance of credit stress-testing and illustrate the need for the two-pronged approach.

1.3.1 Correlation Breakdowns

One of the main objectives of risk management is to diversify portfolios (make sure that all eggs are not in one basket) so as to reduce portfolio volatility. This objective is met by trying to ensure that securities with the least correlation (or where possible, negative correlation) are chosen for the portfolio. However, the most significant effect of stress events is that the correlations that prevail in ordinary conditions cease to exist and risk managers are confronted with new correlations that lead to unexpected concentrations of risk. Likewise, banks may have diversified their loan portfolios by giving loans to different industries/currencies etc. However, during a stressful event, all these industries may register higher likelihood of default, thus nullifying the objective of diversification.

1.3.2 Illiquidity

To make matters worse, in a stress event, once a risk manager recognises that there is a concentration of risk, he is unable to unwind positions because many crises are characterised by an abrupt lack of liquidity in financial markets. Thus even if risk managers want to sell their securities to rebalance their portfolios, they are unable to find buyers. The predicament of loan portfolios is even worse because even in ordinary business conditions these portfolios are relatively less liquid than market portfolios.

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[3] For details see 4.5.2 – Historical Scenarios.

1.3.3 Hedging Techniques Fail

Most risk managers hedge their portfolios to alleviate risk. However, hedging instruments may be rendered invalid during stress events because key assumptions built into their pricing models may cease to be applicable.

1.3.4 Speed in Spread of Shocks

Globalisation and the introduction of state-of-the-art technology in financial markets have helped to improve efficiency of markets. However, they have also helped to spread shocks rapidly across all markets. Therefore, when a stress event strikes even a related market, it spreads rapidly, giving the risk manager very little time to react. This is why stress-tests and risk mitigating mechanisms need to be well-entrenched to facilitate prompt remedial action.

1.4 Relevance of Stress-tests to Emerging Markets

Recent history shows us that stressful events occur with higher frequency in emerging markets as compared to developed financial markets because these markets are not only susceptible to financial risk factors, but also to macroeconomic, sociological and political factors. The recent economic crisis in Asia was a good example of this phenomenon when plunging exchange rates, in a vicious cycle, destabilised political regimes leading to still steeper falls in exchange rates which in turn led to even more political uncertainty.

The BCGFS (Feb 2001) survey points out that stress-tests are more relevant for banks with exposure to emerging markets because these markets are less liquid and have relatively lower quality data to allow for proper calculation of PDs. According to the survey, among the various regional scenarios stress-tested by banks, emerging market scenarios are the most widely used.

Many banks with Asian exposures paid a heavy price for the lack of a two-pronged approach during the Asian Economic crisis of 1997-98. Prior to the

crisis, banks deemed the credit worthiness of most of their borrowers to be satisfactory, using their traditional expertise in counterparty risk assessment.

However, this assessment was applicable only to normal business conditions. As soon as the exceptional event – the crisis – struck, the entire foundation on the basis of which the counterparties were adjudged to have been credit-worthy changed, resulting in extreme losses. Rating agencies also assigned high corporate and sovereign ratings to counterparties in Southeast Asia before the crisis, on the basis of their excellent export performance and macroeconomic and political stability. However, once the crisis struck, even ratings of corporates with sound business prospects were downgraded because of the deterioration in macroeconomic and socio-political conditions. The credit quality of portfolios was also severely eroded by extreme movements in the equity and FX markets that had, hitherto, not received much importance in counterparty credit assessment procedures.

This illustrates the importance of a two-pronged approach to credit risk management. If banks had had sound qualitative and quantitative counterparty credit risk assessment systems, a CPRMS and a credit stress-testing programme, they may have been able to estimate likely losses in a crisis and make appropriate contingency plans.

Since the most significant proportion of the total risk of most banks is engendered by credit risk[4], it is cause for concern that many banks neither quantitatively measure credit risk at the counterparty and portfolio levels nor conduct credit stress-tests.

[4] For example, a leading well-diversified global bank calculates that 60% of its total risk is due to credit risk – 1999 Annual Report

1.5 Why Publish Stress-testing Guidelines

1.5.1 Introduce Stress-testing

Our objective in publishing these guidelines is to help credit risk managers appreciate the importance of credit stress-tests and to provide them a guideline with which to construct and conduct credit stress-tests. A bank's credit risk management efforts are incomplete if they do not include a comprehensive stress-testing programme.

1.5.2 Asian Markets Volatility

As mentioned in 1.4, a stress-testing programme assumes more importance for banks operating in Singapore because Asian financial markets are more volatile than those of developed markets and are more susceptible to stressful events. Financial market volatility not only directly affects the credit risk of a trading portfolio but also the credit risk of the loan book. For example, a good credit stress-test for Argentinean banks would have been a breakdown of the Peso-USD peg. Likewise, any risk manager who has been through the turbulent Asian economic crisis ('97-'98) needs no convincing about the importance of credit stress-testing.

1.5.3 IRB Approach to Capital Adequacy

The Basel Committee on Banking Supervision (BCBS) also recognises the importance of credit stress-testing.

Regulators require banks to set aside adequate capital to buffer expected losses. Since banks are more likely to become insolvent during times of stress rather than in ordinary business conditions, regulators seek to ensure that banks have a comprehensive stress-testing programme, besides a good internal risk rating methodology. BCBS (1995) had used the same line of reasoning to insist that banks that use the internal models approach for market risk capital requirements have in place a rigorous and comprehensive stress-testing programme.

The second consultative document issued by the BCBS on the new Basel Capital Accord (2001), also specifically mentions that banks that adopt the IRB approach for calculating capital requirements must undertake stress-testing. To quote: -

(c) Stress-tests used in assessment of capital adequacy

297. A bank must have in place sound stress-testing processes…Stress-testing should involve identifying possible events or future changes in economic conditions that could have unfavorable effects on a bank's credit exposures and assessment of the bank's ability to withstand such changes….

Thus, as regulators move towards setting internal rating based capital adequacy norms, financial institutions may be obliged to conduct credit stress-tests. This guideline seeks to assist risk managers to prepare for such a prospect.

The rest of this report is structured as follows. In 2.0 we examine the features of good credit stress-tests and in 3.0 the tools that would help risk mangers conduct more precise stress tests. Section 4.0 examines the procedure by which to construct and conduct stress-tests and 5 .0 its applications.

SECTION B: STRESS-TESTING - HOW

2.0 WHAT ARE THE ELEMENTS OF A GOOD CREDIT STRESS-TESTING PROGRAMME

Before discussing the procedure by which a bank can construct credit stress-tests, we examine the features of good stress-tests.

2.1 Large Moves

A stress-test should measure the effect of only large moves in risk factors because day-to-day risk management takes care of small moves. One must bear in mind BIS' definition of stress-testing that specifies that stress events should be ‘exceptional’.

2.2 Related to Portfolio and Economic environment

The most important test of the suitability of a stress-test is its appropriateness to the securities in the portfolio as well as to prevailing economic and political factors. Good stress-tests take into account current positions and probe for portfolio-specific weaknesses.

To take an example, if a fixed income trading book contains linear positions then a stress-test involving a straight increase or decrease of a given number of basis points in interest rates would make a sufficient stress-test. However, the same stress-test for a non-linear book may be inappropriate.

Also, risk managers are more likely to enhance the appropriateness and plausibility of their stress-tests if they survey as many experts as possible, including front line managers, economists, external industry experts and academics.

2.3 Includes all Related Risk Factors

While at the trading desk or relationship manager level a stress-test involving a large move in one risk factor may be appropriate, comprehensive stress-testing programmes should include scenarios that stress several factors at the same time because when stress events occur in the real world, they are more likely to involve collective adverse moves in several risk factors.

2.4 Top management Buy-in / Plausibility

The BIS definition of stress-testing specifies that stress-tests should be plausible. The lack of plausibility causes the biggest problem in 'selling' stress-test results to senior management. Top management should have active knowledge of, and where possible, involvement in the process of designing stress-tests, stress limits and in drawing up plans for remedial action.

2.5 Report few Stress-Test Results

Most risk managers have found that formal reporting of only a few stress-test results, helps top management digest the results quickly and take remedial action promptly. Off the stress-tests reported, at least a few must be of tests that are regularly conducted, so as to allow management to understand the changing risk profile of the portfolio.

2.6 Remedial Measures/ Granularity

Each stress-test should be accompanied by a clear set of pre-agreed plans of remedial action. These remedial measures could include unwinding or restructuring of positions or portfolios, entering into hedging transactions etc. Such actions will be possible only if stress-test results are granular and can pinpoint the causes for the stress losses.

2.7 Update Stress-Tests Regularly

Stress-tests should also be updated regularly because new financial instruments are being introduced all the time. For example, if a bank begins to use credit derivatives including options, it can consider using new stress-tests that incorporate stressing volatilities. Further, regulatory changes as well as macroeconomic policy decisions may change the assumptions that lie behind existing stress-tests. For example, if Hong Kong were to scrap the Hong Kong dollar's peg to the US dollar, then portfolios where the Hong Kong dollar is a risk factor would be seriously affected. Therefore, existing stress-tests would have to be re-designed to take into account a free float of the Hong Kong dollar[5].

2.8 Documented Policy

Lastly, the objectives, procedures, authorities, responsibilities and all other aspects of the stress testing programme should be drafted as a policy paper and authorised at the highest levels of the bank, so that the stress-testing programme is institutionalised.

[5] Lifting of the Hong Kong dollar's peg to the US dollar would, per se, make a good stress-test.

3.0 CREDIT STRESS-TESTING FOR THE LOAN BOOK* - TOOLS

Banks that possess the following tools will be able to conduct stress-tests more easily. Those that do not do so can also conduct stress-tests, though they may face some obstacles.

3.1 Counterparty Rating System

For a bank to conduct credit stress-tests, the primary requirement is a consistent rating system to rate the credit-worthiness of counterparties. A credit rating/credit grade is the banks' assessment of the likelihood of default by the counterparty, which not only takes into account the ability and the willingness of the counterparty to pay its dues, but also the type of facility, collateral etc. The most important feature of a rating system is consistency. That is, all counterparties assigned the same risk grade must have a similar likelihood of default. Only a consistent rating system will enable a bank to group counterparties by risk grades, for further analysis.

3.1.1 Quantitative Rating models

A quantitative credit rating system allows a bank to arrive at a numerical measure of the probability of default (PD) of each rating. The PD enables a bank to estimate the probability that a counterparty will default. For example, if Standard & Poors rates a counterparty AAA, then the probability that it will default is 0.05%[6].

Internal Ratings

Some banks construct their own rating scale and calculate PD for each rating. Such a task presupposes the existence of a vast body of credit histories at the banks' end, because only a sufficiently large volume of data will give accurate estimates of the PD for each risk grade. Further, the data must cover several

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* Please refer to the Glossary

[6] Standard & Poor's (1999)

economic/industry cycles so that consistency and validation of ratings over time is ensured.

Once a bank has built its own rating scale, it must check whether the counterparties that have been assigned various ratings, do in fact default in a manner consistent with the predicted PD, by periodically back-testing the output of the model. If they do not default as per the predicted PD, then the rating process should be amended to ensure that rating is being done in a manner consistent with the predicted PDs.

External Ratings

Banks that do not have the vast body of counterparty data required to predict PDs may use the ratings and PDs calculated by rating agencies. One method of using external PD data is to map the bank's internal rating scale to that of an external rating agency, with some adjustments if necessary. Once such a mapping is done, the bank can use the external rating agencies' PD data for its own portfolio. However, the bank should ensure that in future, it continues to grade its counterparties in the same manner as when the mapping was originally done. Using a rating agency's PD data may be advantageous because the agency is likely to use a larger pool of counterparties than a bank, leading to more precise estimates of PD. While using external data, banks must ensure that the data used by the rating agencies is similar to the bank's own portfolio.

3.1.2 Qualitative Rating Scales

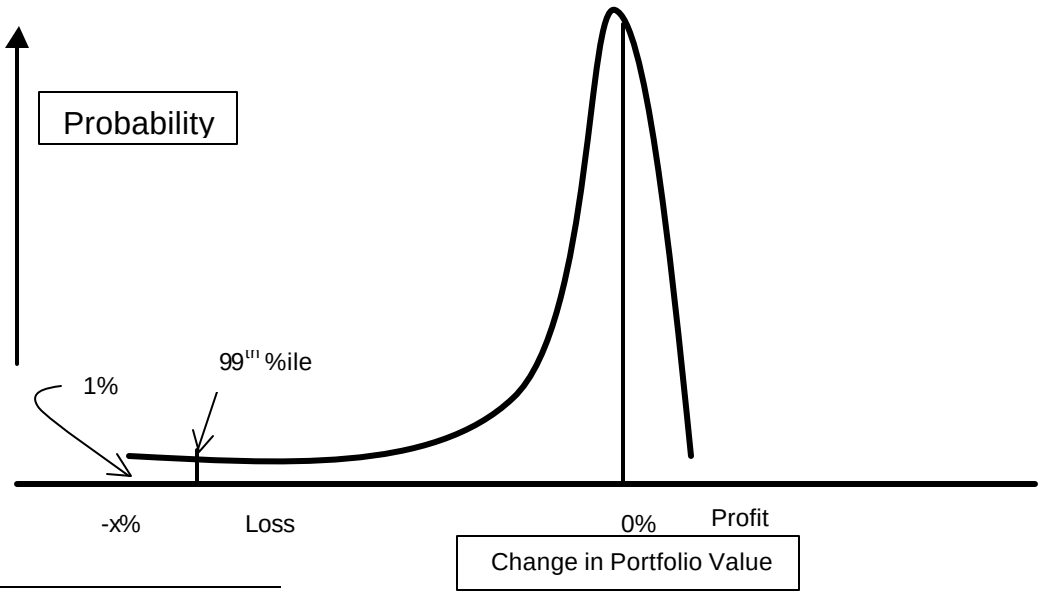
Many banks have not yet adopted quantitative credit risk models that can calculate PD of counterparties. The qualitative rating systems that they use depend on the subjective judgement and expertise of their credit analysis team. In light of the fact that quantitative credit risk models are still fairly new, almost all banks prefer to depend heavily on the skills of their credit analysts. Quantitative risk models are used as aids in deciding the final risk grade, which is as it should be.

3.2 Credit Portfolio Risk Management System (CPRMS)

Once a bank is able to generate consistent credit ratings and calculate PDs, it can then use them as the main input into a CPRMS. A CPRMS calculates the credit value-at-risk (VaR) of a Credit Portfolio* after taking into account PDs of individual counterparties, market factors like exchange interest rate etc., as well as the correlation between risk factors. Since CPRMS' engage almost all the risk factors that affect the value of the credit portfolio, they provide the leverage with which to collectively stress all risk factors.

CPRMS enable banks to not only conduct credit stress-tests but also to calculate Credit VaR, allocate Risk Capital[7], calculate Risk-adjusted return on capital (RAROC), identify concentrations and facilitate trading of credit risk through credit derivatives, securitisation etc. Credit VaR models, like Market VaR models, build a probability distribution of all the likely changes in the value of the credit portfolio. A probability distribution of likely portfolio values is shown in figure 3.

Figure 3: Probability distribution of likely changes in value of credit portfolios



*Please refer to the Glossary

[7] Also known as Economic Capital.

Unlike the probability distribution of a market portfolio that is bell-shaped (normal distribution), the distribution of a credit portfolio is highly skewed. This is because the returns of a credit product, say a loan, has a limited upside in terms of the interest that the bank is likely to earn on the loan, but the downside is that the entire principal amount of the loan can be lost. Using the probability distribution, it is easy to calculate the likely loss at any level of probability. All one has to do is to decide the probability, say the 99th%ile level, and then use the probability distribution to calculate the maximum likely loss of the portfolio at that probability. In this case, the 99th%ile loss represents a –x% change in the value of the credit portfolio, therefore the loss is the negative change.

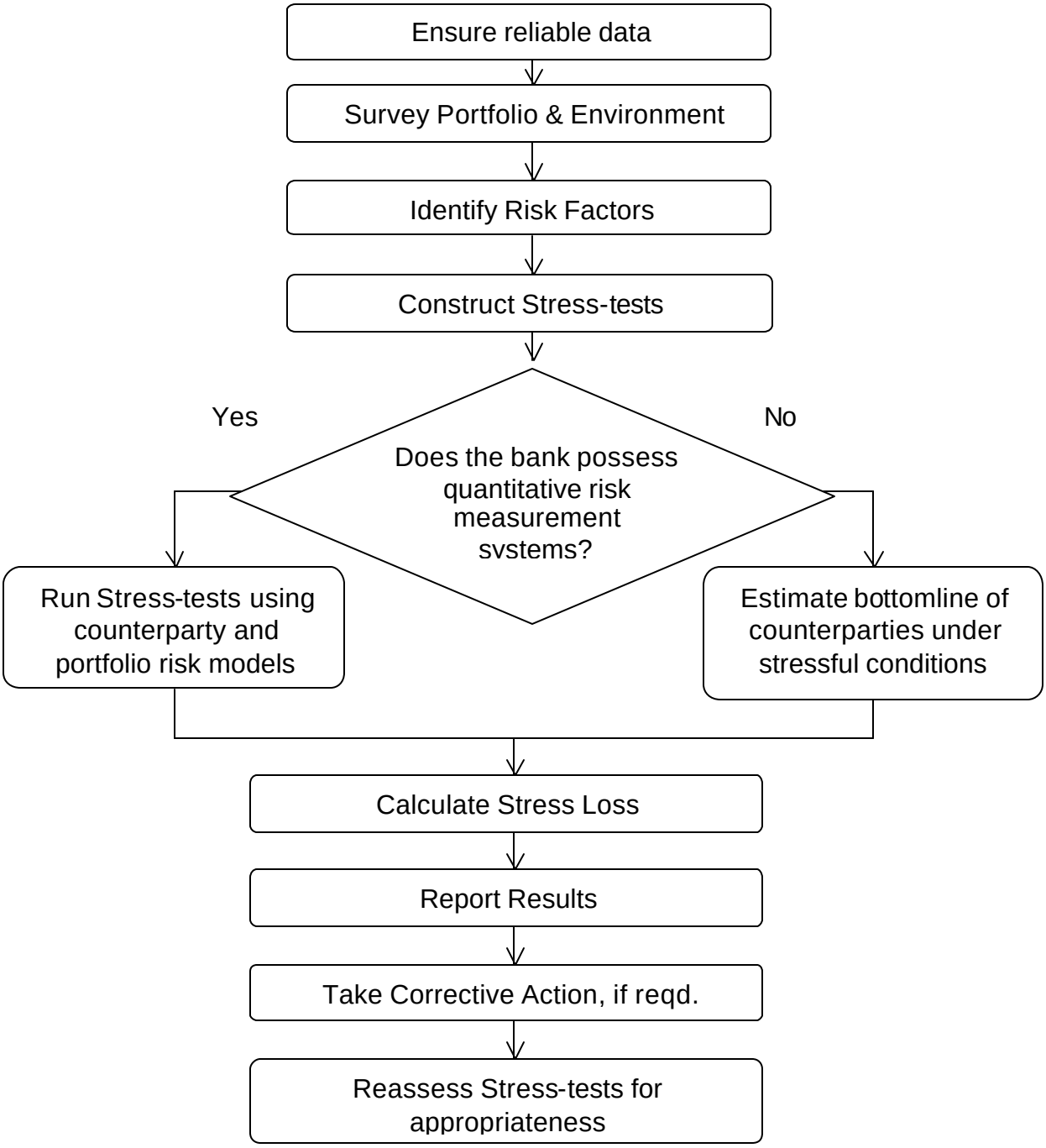
Banks that have yet to install quantitative risk rating and credit risk portfolio models can also conduct credit stress tests. The only caveat is that the qualitative rating systems should rate counterparties in a consistent manner. The only impediment to using qualitative risk rating systems is that stress-tests are time-consuming to conduct because loan analysts have to re-rate and calculate stress loss for every counterparty, given a particular stress scenario and then tot up the stress loss for the entire portfolio. If a quantitative risk model were used, it would be easier to calculate stress loss after changing a few input variables. The bigger handicap of using only a qualitative risk rating system is that the correlation between various loans/securities in the portfolio is ignored.

Despite these problems, banks that use only qualitative rating systems still have a lot to gain from conducting stress-tests.

4.0 CONSTRUCTING A STRESS-TESTING PROGRAMME

Having seen the importance of stress-testing in risk management and the features of a good stress-test, we suggest below the procedure for constructing a sound stress-testing programme.

Figure 4: Flowc hart for building a Stress-Testing programme



The bank must document the above process in detail, in the form of a stress-testing policy. The top management of the bank must approve this policy.

Each step of this process is explained below.

4.1 Ensure Reliability of Data

One of the most important steps in credit stress testing is to ensure that the data being used in risk management is accurate and timely. The data includes all aspects of the bank's credit portfolio, market data relating to the risk factors as well as risk analytics that are used by risk models.

4.1.1 Credit Position Data – Trading Book

Some instruments in the trading book such as bonds and swaps engender credit risk. Since trading activity in a bank's treasury department is rapid, the data system should be capable of promptly capturing trades, processing them and then transferring the data to the risk management system where calculation of VaR and other analytics can take place.

The more advanced banks have been able to perform this entire procedure real-time so that as soon as a trade takes place it is automatically processed and transmitted to the risk model where VaR and other risk analytics are calculated[8]. Some banks include stress-tests in their risk models and can compute losses under pre-specified stress conditions along with the VaR numbers. This facility enables banks to institute stress-test limits that traders must adhere to.

4.1.2 Credit Position Data – Loan Book

The speed of transactions in credit portfolios (of the loan book) is far slower than that of market portfolios. However, timeliness of data is very important

[8] This is called Straight-Through Processing.

here as well. The bank should ensure that reliable data is being captured for all particulars of every credit exposure, such as the principal, amounts repaid, interest rates, fees, collateral details etc. The bank must also be able to measure credit risk of each exposure by means of a consistent rating system and/or an accurate PD for each rating. Further, the bank should consider obtaining a sound CPRMS to calculate portfolio credit risk.

4.1.3 Market Data

The bank should also have access to accurate and timely market data about various risk factors such as interest rates, exchange rates, equity indices, swap rates etc. Accurate data for each of these risk factors is required to estimate the value of each investment in the bank's credit portfolios especially those in the trading book.

4.1.4 Risk Analytics

Apart from the position and market data, risk analytics that are crucial for calculating the risk of credit portfolios should also be available to the bank. The most important are price volatilities of each financial instrument and the correlation between the prices of each pair of financial instruments. Volatility and correlation data are among the most important inputs into any credit VaR model.

Most vendors of VaR models supply both market data as well as risk analytics. If VaR vendors do not supply such data, banks can easily access the same from data vendors. The key here is to ensure that the data used by the data vendors is appropriate, considering the nature of the bank's portfolio.

4.2 Survey

4.2.1 Portfolio

As mentioned earlier, a stress-test should be related to the specific features of the bank's credit portfolios. A list of the various financial instruments present in these portfolios, as well as likely future inclusions, must first be prepared. An exhaustive list of all the risk factors that influence each financial instrument should also be drawn up.

Once the risk factors influencing each financial instrument have been identified, they should be ordered by importance and grouped on the basis of similarity. That is, each group should consist of risk factors that significantly influence one another in ordinary or in stress conditions. When stress-tests are designed, such groups will ensure that when individual risk factors are shocked, other relevant stress factors are not left unstressed. For example, if interest rates are stressed, we can refer to the group of risk factors that interest rates belong to (such a group may include exchange rates) and then ensure that the stress-test stresses exchange rates as well. This process of ordering and grouping risk factors helps to ensure that the most important risk factors, as well as those related to them, are stressed.

4.2.2 Environment

Having surveyed the portfolio the next step is to survey the social, industrial, economic and political environment to spot potential stressful events[9]. This is a very important part of the stress-testing programme. Experts from inside and outside the bank will have to be consulted at this stage. Although it is impossible to predict the exact nature of potential stressful events[10], every effort must nevertheless be made to identify as many scenarios as possible.

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[9] Considering the damage that natural disasters can bring about, the geological (earthquakes) and meteorological (typhoons and hurricanes) environment should also be surveyed.

[10] After all, no one could have predicted September 11th.

4.2.3 Widespread Consultation

During the process of identifying risk factors and likely stress scenarios, risk managers should involve other experts in the bank such as relationship managers, economists and traders.

During the course of trading in bonds and swaps, traders usually develop good instincts about the effects of changes in risk factors on the prices of these financial instruments. They will thus be able to spot implausible stress-tests and give valuable inputs in grouping risk factors.

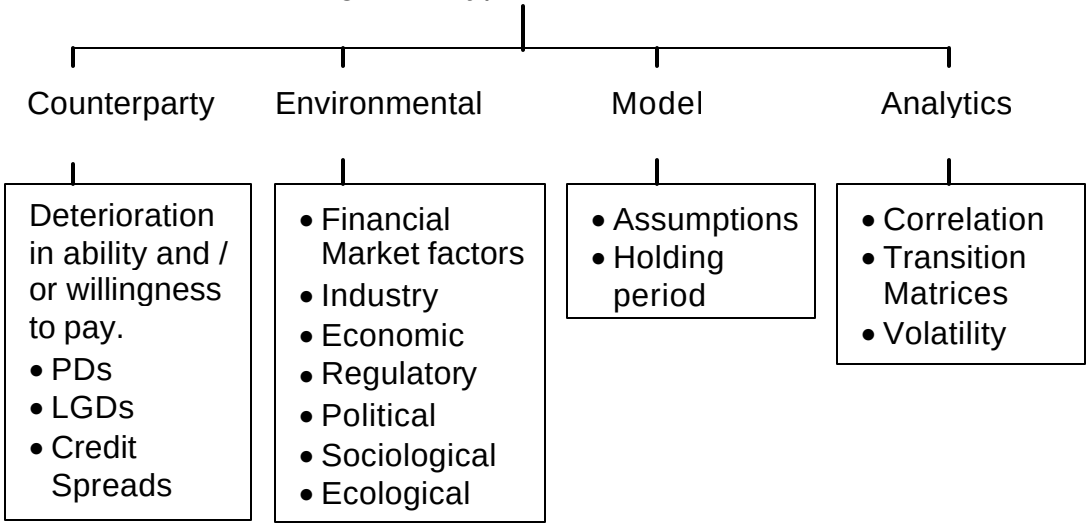
Relationship managers are also good sources of information as they deal directly with customers on a daily basis and have their ear to the ground.

Top management must also be consulted at every stage of the development of stress-tests to ensure that they buy-in into the process. Involving relationship managers and traders in building stress-tests will ensure that there is less opposition when the time comes to take remedial measures on the basis of stress-tests, especially when such remedial measures involve unwinding profitable positions. Further, top management buy-in will rule out internal disagreements and ensure that remedial actions are implemented even when traders or relationship managers oppose such actions.

4.3 Types of Risk Factors

Some of the main risk factors that risk managers can use to build stress-tests are as follows: -

Figure 5: Types of Risk Factors



4.3.1 Credit Risk Factors– Loan Book

Most quantitative models that measure credit risk calculate likely credit loss using the following formula: -

Credit Loss per exposure = EAD x LGD X PD

EAD stands for Exposure at Default, which is the amount that stands to be lost if a counterparty defaults. LGD, that is Loss Given Default, stands for the percentage of the EAD that is likely to be lost if default were to take place. The LGD takes into account the guarantees that may have been procured when the loan was given as well as the value of any collateral that was taken from the counterparty. PD is the probability ofdefault and is related to the credit risk rating assigned to the counterparty.

Counterparty specific factors

Stress-tests can be conducted by stressing any of the counterparty specific factors mentioned above, namely, LGD and PD. Thus if the risk manager suspects that there will be a deterioration in the ability or willingness of any counterparty to service its debts, all he has to do is to reduce the counterparty's credit rating (PD) or increase its LGD to arrive at the new credit loss of the exposure.

Industry factors

CPRMS' take into account the correlations between the industries to which counterparties belong, while calculating the risk of the credit portfolio. Risk managers can stress the industry risk factors by grouping all the counterparties that belong to the industry and then reducing the credit rating of all these counterparties by the desired number of credit grade notches.

Take the example of a risk manager who suspects that counterparties belonging to the electronics sector are likely to face problems due to industry-specific cyclical factors. He estimates that these factors cause deterioration in such counterparties' PD. He also estimates that such deterioration is the equivalent of reduction by a single credit grade. Thus he reduces all electronic sector counterparties graded AAA to AA, AA to A and so on. Once this has been done the portfolio can be re-valued to calculate stress loss. Some CRPMS' give the risk manager the flexibility of reducing the industry rating directly and this new input is automatically fed into the rating of each counterparty belonging to that particular industry.

If the risk manager wants to stress for higher correlations between industries, most CPRMS provide the flexibility to manually insert new correlation figures, after which the portfolio can be re-valued.

Geographical factors

Similarly, if a risk manager believes that counterparties belonging to a particular country or a region will be adversely affected by geo-political factors such as war, then he may downgrade the risk ratings of all counterparties exposed to that region and re-value the portfolio.

Some CPRMS provides the risk manager the flexibility to change sovereign ratings and these are automatically fed into the risk rating of each customer. Most CPRMS also provide the flexibility of manually inserting new correlation

figures which is very useful because some stress events are characterised by 'contagion', which is the spread of panic from one country's market to another's, as was the case during the recent Asian economic crisis. During periods of contagion the correlation between risk factors increases.

Macroeconomic factors

Some quantitative credit risk models calculate the counterparties' PD using macroeconomic variables. These macroeconomic factors could include interest rates, foreign exchange rates etc. Where such models are used to calculate the PD, new estimates of macroeconomic factors can be directly input into the model and the credit portfolio re-valued. If such a facility is not available, the risk manager can estimate the effect of a move in macroeconomic variables on credit ratings, change the ratings of counterparties likely to be influenced by such a move and then re-value the credit portfolio. Macroeconomic effects on correlations can likewise be estimated and manually inserted into the correlation matrix.

Political factors

The effect of political factors on credit portfolios is especially relevant to emerging markets. While shocks to macroeconomic risk factors such as foreign exchange rates and interest rates can easily be stressed, political factors represent a bigger challenge. To stress political factors risk managers must get advice from political analysts and other relevant professionals on likely political scenarios. They must then get further inputs from economists on the likely impact of political scenarios on financial and/or macroeconomic risk factors.

4.3.2 Credit Risk Factors– Trading Book

Fixed income instruments like bonds and swaps* are amenable to both credit and market stress-tests because these instruments have credit risk (risk of

*Please refer to the Glossary

default by the issuer of the bond) and market risk (risk arising from change in market prices of fixed income instruments).

The effects of external events on the market and credit risk of a bond are at times indistinguishable. For example, if the price of a bond shows an increase in volatility following a downgrade in its credit rating, then the risk downgrade results in an increase in credit risk while the increase in volatility results in higher market risk. Combined market and credit stress-tests represent a new area of stress-testing and efforts are on to integrate the two. Banks that have the capability to conduct combined stress-tests will be able to ascertain the effects of stressful events far more accurately than they can from separate market and credit stress-tests.

Credit risk of fixed income instruments can be stress-tested by changing the rating of the issuers of the fixed income instruments in the CPRMS. The portfolio can also be re-valued after changing the credit spread of Yield and Swap curves*. The credit spread is the difference between the yield or swap curves for a particular rating class and the benchmark curve (usually the government curve). It indicates the credit quality of the rating class to which the yield curve belongs. For example, if the benchmark yield for a 1-year maturity is 5% and the yield on a corporate bond is 8%, then the credit spread is 3%. If the company that issues the corporate bond enjoys very high credit worthiness then the credit spread is very small but if the company is close to default, the credit spread is large. Figure 8 under section 4.5.1 shows the various methods of stressing the credit spread.

4.3.3 Model Risk Factors

Model related stress-tests are those that specifically test the modelling assumptions that lie behind the VaR or Pricing models. For example, some banks use pricing and hedging strategy models appropriate for developed

markets, in emerging markets. These models make assumptions about liquidity etc., which may not be relevant to emerging markets but which are masked in normal business conditions. Stress-tests must explicitly ascertain the nature of these assumptions and check whether the assumptions would hold true in a stress event.

Holding period

A common model related stress-test relates to increasing the holding period by a fixed number of days. When a VaR is described as a 'n'-day VaR, the 'n' refers to holding period of the asset involved[11]. A suitable stress-test may be to increase the number of holding period days in calculating VaR. Such a stress-test is appropriate because credit portfolios are less liquid than market portfolios and it is well-known that crises are characterised by illiquidity.

4.3.4 Other Risk Factors

Correlation

As mentioned earlier, many CPRMS give the risk manager the facility to stress-test the correlation structure between risk factors by manually inserting correlations into the correlation matrix, in lieu of those calculated by data vendors. Some of the types of changes in correlation structure that can be tested are correlation breakdowns and reversal of correlations.

Breakdowns in correlation refer to situations when historical correlations collapse during stressful events. The causes could be non-economic factors such as political disruptions and natural disasters.

Reversal of correlation is another phenomenon that has been observed during stress events. To take an example, during ordinary business conditions all

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[*] Please refer to the Glossary

[11] In Market Risk VaR calculations, a 1-day VaR is usually the norm.

bond prices, whether high quality (Treasury securities) or low quality (junk bonds) usually respond in a broadly similar manner to a change in interest rates, i.e., the correlation between them is quite high. However, during a crisis there may be a 'flight-to-quality' where investors shun all but the most high quality bonds leading to a rise in demand for high-quality bonds but a sharp drop in the demand for low-quality bonds, resulting in inverse correlation.

Transition Matrices

A transition matrix gives the probability of change in a credit rating over a chosen time interval. Figure 6 gives an example of a transition matrix. On the vertical axis is the existing risk grade while on the horizontal axis are the risk grades that a particular risk grade can migrate to, at the end of the time interval. The figures in the boxes of the matrix are the probabilities of each rating in the vertical axis becoming a rating in the horizontal axis.

Figure 6: Transition Matrix

	AAA	AA	A	BBB	BB	B	CCC	D
AAA	90.81	8.33	0.68	0.06	0.12	0.00	0.00	0.00
AA	0.70	90.65	7.79	0.64	0.06	0.14	0.02	0.00
A	0.09	2.27	91.05	5.52	0.74	0.26	0.01	0.06
BBB	0.02	0.33	5.95	86.93	5.30	1.17	0.12	0.18
BB	0.03	0.14	0.67	7.73	80.53	8.84	1.00	1.06
B	0.00	0.11	0.24	0.43	6.48	83.46	4.07	5.20
CCC	0.00	0.00	0.44	1.30	2.38	11.24	64.86	19.79

In figure 6, a BBB grade has a 86.93% probability of remaining a BBB and a 0.02% probability of attaining a AAA rating at the end of the one-year period.

The transition of ratings is a subject that has been widely studied. Bangia, Diebold and Schuermann (2000) conclude that macroeconomic conditions have a significant impact on transition probabilities in transition matrices. They separate the economy into two states, expansion and contraction and construct the migration matrix for each state. They then show that the loss distribution of credit portfolios can differ greatly between these states. Risk

managers can use this methodology to construct transition matrices under different stress conditions and then re-value their portfolios.

Nickell, Perraudin and Varatto (2000) measure the dependence of transition probabilities on the counterparty's industry, country and stage of business cycle. The ordered Probit approach used in this paper can be adopted to identify the incremental impact of each of these factors on transition probabilities and in comparing the importance of different risk factors. Such a test would also help in grouping risk factors as well as in constructing plausible stress-tests.

Volatility

Shocks to volatility of various risk factors including FX rates, credit spreads etc. are among the stress-tests that banks surveyed by BCGFS (Feb 2001) use. These 'volatility disruptions' are appropriate to portfolios that include options.

4.4 Magnitude of Factor Shock

Having examined the various types of risk factors the next question is to decide the magnitude of the shock that should be administered to each risk factor while conducting the stress test. One approach is to use the magnitude of shocks that actually occurred during historical stress episodes, while another is to use subjective judgement.

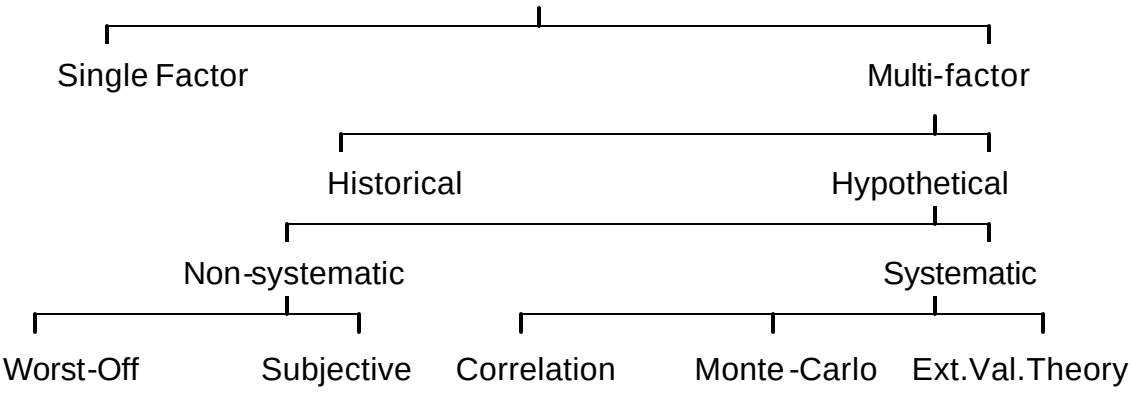
When using historical episodes, risk managers may settle on the size of the factor shock by taking the most adverse movement in the risk factor during a given time interval. The length of the time interval therefore assumes importance. Several banks pick the worst movement in the previous one-year period as the shock that is to be tested. This may not be optimal because the previous one-year may not include any stressful events.

Banks must therefore choose a longer time interval that includes at least one business cycle (appropriate to the portfolio) and as many stress events as possible. Once the time interval is chosen, either the difference between the start day value and the end of the period value of the risk factor or the maximum movement between any two periods of time within the time interval can be chosen as the magnitude of shock of the risk factor. The magnitude of a shock can also be decided using the banks' expertise.

4.5 Constructing Stress-Tests

There are essentially two types of stress-tests, single-factor and multi-factor stress-tests. As the name implies, only one risk factor is stressed in single-factor stress-tests while several risk factors (if not all) are stressed in multi-factor stress-test. The etymology of stress-tests is shown below in figure 7. Let us first examine single factor stress-tests.

Figure 7: Types of Stress-Tests



4.5.1 Single Factor Stress-Tests

Single factor shocks are appropriate at the desk or frontline level when a trader or a relationship manager would like to know the effect of a large move in a risk factor on his position or portfolio. However, when assessing a portfolio's exposure to stress events, a single factor shock is rarely

appropriate and would probably suffer from implausibility because when a stressful event occurs, seldom does it affect one factor alone.

Standardised Single Shocks

Standardised single-factor stress-tests have been issued by various organisations and can be adopted off-the-shelf.

DPG's Standardised Shocks

One example of standardised single-shock stress-tests are those prescribed by the Derivatives Policy Group (1995). Only some of these apply to credit risk arising from the trading book. The standard tests recommended by DPG are: -

i. Parallel yield curve shifts of 100 basis points up and down
ii. Steepening and flattening of the yield curves (for maturities of 2 to 10 years) by 25 basis points
iii. Each of the four permutations of a parallel yield curve shift of 100 basis points concurrent with a tilting of the yield curve (for maturities of 2 to 10 years) by 25 basis points
iv. Increase and decrease in all 3-month yield volatilities by 20% of prevailing levels
v. Increase and decrease in equity index values by 10%
vi. Increase and decrease in equity index volatilities by 20% of prevailing levels.
vii. Increase and decrease in the exchange value (relative to the USD) of foreign currencies by 6% in the case of major currencies and 20% of prevailing levels
viii. Increase and decrease in foreign exchange rate volatilities by 20% of prevailing levels and
ix. Increase and decrease in swap spreads by 20 basis points.

The advantage of using standardised stress-tests is that they have ready acceptability among traders as well as senior management. However, the

problem with standardised stress-tests is that they sometimes lose their relevance. Several of DPG's tests have been 'out-stressed' by subsequent episodes of extreme moves in the market.

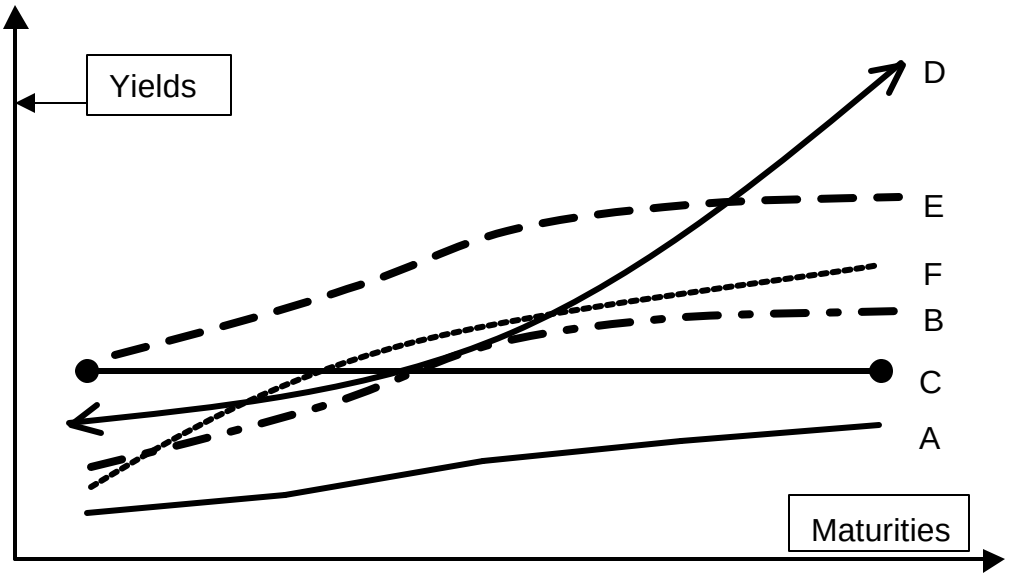
Subjective Choice

Banks can also subjectively choose to stress-test any factor shock as well as its magnitude. This, in fact, is the practice in many banks. When factors are chosen subjectively, risk manager should try to ensure that the factors as well as the magnitude of shocks are plausible and relevant to the portfolio.

Stress-testing the Trading book

Credit risk in the trading book arises primarily from such instruments as swaps and bonds. The main risk factor affecting these instruments is the credit spread, which was discussed in 4.3.2.

Figure 8: Stressing Yield Curves



A – Benchmark/Govt. Yield Curve	B - Yield Curve of Rating Class
C – Flattening	D – Steepening
E – Parallel Shift	F - Twist

Figure 8 shows the different methods of stressing the credit spread. 'A' represents the benchmark government bond yield curve and 'B' the yield/swap curves of the issuer's rating class. The spread is the distance between 'A' and 'B'. The spread between A and B can be stressed by changing the distance between the two curves. The yield/swap curve can be changed by substituting 'E' for 'B', which is derived by a parallel shift of 'B'. The bond is then re-valued at 'E'. Other stress-tests are 'C' which shows a flattening and 'D' which depicts a steepening. 'C' and 'D' are also called 'curve risk'.

The dotted line ‘F’ shows a twist, which is used to characterise a change in the spread at different maturity points along the yield curve. A twist will have the maximum impact on an interest rate portfolio that has significant maturity mismatches, that is, long and short positions at different maturities.

Expected changes in future interest rates and related factors play the most important part in deciding the type of change in the yield curve and spreads used in stress-tests. A bank's economists can give value-added inputs on interest rate expectations. Best (1998) estimates that parallel shifts in the yield curve account for around 80% of all yield curve movement and parallel shifts and twists together account for between 80%-90% of all yield curve movement. Risk managers may therefore wish to concentrate on these types of changes in yield curves.

The type of yield curve stress-test to be run also depends on the type of counterparty. For example, a high-yielding bond would require different stress-tests as compared to a corporate or sovereign bond. Many fixed income instruments which combine with options are exposed to still other types of risk such as volatility risk, which is the risk that the holder or seller of a standard or

embedded option incurs, if actual volatility or the market's expectations for future volatility changes[12].

4.5.2 Multi-factor Stress-Tests

As the name suggests, multi-factor stress-tests involve stressing several risk factors at the same time. As discussed previously, stressing one stress factor at a time may be appropriate at the desk level but single factor shocks by themselves, do not make for a comprehensive stress-testing programme because seldom is one risk factor alone affected during actual stress events. The BCGFS (Feb 2001) survey shows that internationally active banks have recognised this fact; of the 215 types of stress-tests run by these banks, 138 were scenario tests while 77 were single factor stress-tests.

Stress-tests can be conducted by simulating historical stress episodes (such as the Oct.13th 1987 drop in the Dow Jones Index) or by constructing hypothetical events built by stressing one or a group of risk factors. Stressing groups of risk factors together is also called Scenario Testing. Scenario testing can be conducted top-down, i.e., hypothesising the occurrence of a stressful event and then deciding the change in risk factors to mirror the event, or bottom up, i.e., deciding the change in risk factors without hypothesising a particular event.

Historical Scenarios

Historical scenarios can be conducted by re-valuing portfolios using values of risk factors that existed during historical stress events. Historical stress events have been occurring so often in the recent past that risk managers are likely to find at least a few episodes that have relevance to their portfolios. Given below in figure 9, from Wee and Lee (1999), are some of the stress events to hit financial markets in the last 15 years.

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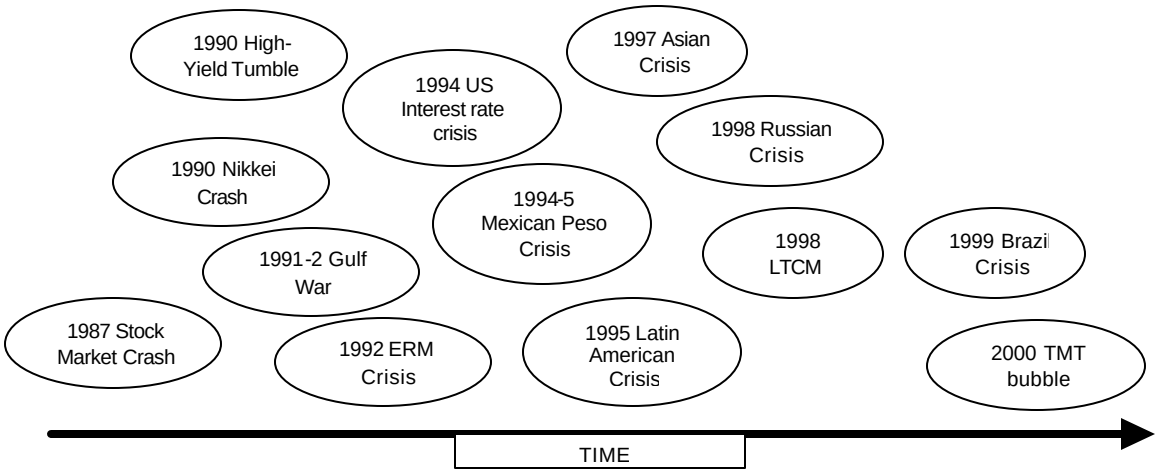
[12] Some compound, barrier, and average rate options can provide protection from various types of volatility risk.

The BCGFS (Feb 2001) survey shows that the Russian devaluation and default of August 1998 are the most popular credit scenarios that were stress-tested by the banks covered in the survey.

Figure 9: Recent financial market crises



Wee and Lee provide a short description of each crisis and mention that apart from the Russian crisis, the Mexican Peso, Asian Economic and Brazilian crises are also relevant for credit stress-tests.

The challenge in using historical scenarios is to choose a scenario that is appropriate for the bank's portfolio. This may be difficult because of the changed nature of financial markets or because of the introduction of new financial instruments that did not exist at the time of the historical stress event. Another charge levelled against historical scenarios is that since no financial crisis has resembled any of its predecessors, there is no point in conducting such tests, since they will most probably never occur again. As Breuer and Krenn (2000) point out, risk managers may, like military generals, be preparing to fight the last war!

Despite these deficiencies historical scenarios enjoy widespread usage mainly because of the ready acceptance that they find. No questions on the plausibility of historical scenarios can be raised because they have actually taken place (though whether they might take place again is another question.)

Shaw (1997) has proposed an alternative methodology for computing stress losses. The greatest loss of the portfolio is calculated and risk managers can subsequently examine which scenarios produced these extreme losses. This is similar to historical simulation in VaR models with the difference being that a longer time period can be chosen instead of the 1-year horizon usually selected for VaR computation.

An important question that arises while using historical scenarios is the number of days to be considered while measuring the change in risk factors. Historical stress events may take place over a matter of days or months, so different time periods can give different changes in values of risk factors. As Schachter (1998) points out – "there would be little argument in choosing October 13 for the 1987 crash, but the start and end to the 1994 bond market sell off is much less obvious. The ambiguity arises because not all affected markets go from peak to trough on the same days and because the move from peak to trough is not always smooth and uninterrupted." A useful rule of thumb, suggested in the same paper, is to choose dates based on the risk factors that represent the significant portfolio exposures to the event.

Hypothetical Scenarios

Risk managers can also construct hypothetical scenarios when no historical scenarios match the special features of their portfolios or when they would like to stress new combinations of risk factors.

When several risk factors are stressed at the same time, care must be taken to ensure that no relevant risk factor is omitted and that the shocks applied to

combinations of risk factors, collectively make economic sense and are plausible.

'Worst-off' Scenarios

One common method used to conduct a stress-test of multiple risk factors is to combine the most adverse movement in different risk factors, in a certain time interval and then re-value the portfolio. This is one of the least plausible ways of conducting a stress-test because it completely ignores the correlation between risk factors and will most likely lead to implausible scenarios that do not make economic sense. Unfortunately, this is one of the more common scenario building methods adopted by banks.

Ignoring Peripheral risk factors

Some banks conduct stress-tests by changing a few risk factors and leaving all the other relevant risk factors unchanged. Such stress-tests are likely to be unreliable and are similar to the 'worst-off' scenarios. The only difference is that in this case the risk manager chooses the magnitude of change in the stress factors whereas for worst-case scenarios the magnitude is the same as the worst historical change in a given time interval.

Subjective Scenarios

In a subjective search for scenarios, risk factors are first chosen in the same manner as mentioned under 4.2. These risk factors are then stressed after getting expert inputs from various people in and outside the bank including traders, top-management, consultants etc.

The main problem with this approach is that despite the best efforts of experts, such subjective stress-tests may omit some risk factors or mis-specify the correlation. The number of risk factors in a well-diversified portfolio could number in hundreds and it is quite impossible to subjectively configure a correlation matrix for them.

Systematic Scenarios

A systematic search for stress scenarios tries to ameliorate the above weaknesses by trying to ensure that all relevant risk factors, like liquidity etc., are appropriately changed in an economically consistent manner. Several new methodologies (details in the technical annexure, 7.0) are being developed to construct scenarios systematically. Risk managers can assess these methodologies and adopt those that they think are most appropriate for their portfolios.

4.6 Conducting Stress-tests

Once scenarios have been constructed and the magnitude of the shock on the risk factors has been decided, the stress-tests should be run and the portfolios re-valued. As discussed earlier, if the bank has quantitative counterparty and portfolio risk management systems and models, the stress-tests can be run by inputting the stressed values of the risk factors into the models. The new portfolio values can then be easily recalculated given the new data.

Banks that do not possess quantitative tools can also conduct stress-tests. However, the process is more laborious. Such banks could follow a three-step procedure in conducting stress-tests.

In the first step they survey the portfolio and also identify likely stress events. Then the credit analysts of the bank go through the financial statements of each counterparty and using their judgement, estimate the bottom line of each counterparty contingent on the stressful event occurring. Once the new bottom line for each counterparty has been estimated, the total stress loss that the bank is likely to incur, given the stressful event, is calculated.

The drawbacks of this procedure are that the correlation between counterparties is ignored and the process of re-estimating the bottomline of

each counterparty is laborious and time-consuming. However, if a bank does not possess a quantitative counterparty and portfolio risk measurement model, it still stands to get substantial benefits from conducting stress-tests in the above manner.

4.7 Reporting Stress-Test Results

Once scenarios have been constructed and portfolios re-valued, a brief summary of results showing details of scenarios and likely losses for each stress scenario should be reported to appropriate managers for action. As mentioned in 2.5, as few stress-tests as possible should be reported, although any number can be conducted. It is recommended that the set of reported stress-test results include a few routine stress-tests and a few tests appropriate for the prevailing environmental conditions. The stress-tests that require action must show a high degree of granularity so that problem loans / positions / portfolios / trading and hedging strategies can be identified and appropriate pre-agreed risk mitigating actions taken.

4.8 Systematically reassessing appropriateness of Stress-Tests

Lastly, stress-tests must be systematically refreshed because financial markets, instruments, regulatory policies and macroeconomic and political environment are changing all the time. New stress-tests will help identify new risks even as old stress-tests are rendered obsolete. Stress tests should be reviewed at least half-yearly, or more frequently, if the portfolio or the environment changes significantly.

SECTION C –STRESS-TESTING - APPLICATIONS

5.1 Identifying Risk Concentrations

Stress-tests help to identify concentrations in credit portfolios that may not be apparent in normal business conditions. For example, during stressful events, the exchange rate of a country may start falling due to the contagion effect, despite there being no significant economic linkages between that country and its neighbours. Regional currencies thus represent new concentration risks that are triggered by contagion. These concentration risks do not exist in ordinary business conditions.

5.2 Restructuring Positions / Hedging

Once risk concentrations are identified, stress-tests help plan risk mitigating action including unwinding or hedging positions and re-balancing portfolios. Credit exposures in the loan book cannot be unloaded as easily as those in the trading book because most loans involve contractual relationships with counterparties. Also, banks build relationships with customers over a long period of time with great effort and are chary of recalling loans. However, new financial instruments like credit derivatives and securitisation enable banks to take problem loans off their balance sheets while still maintaining their relationship with customers.

5.3 Monitoring Stress Loss Limits

Stress-tests help banks to limit their exposure to stress losses. Stress-test results are monitored against stress limits. For example, in the example in 5.1, if the bank has a stress loss limit on the currencies of its neighbours and if the stress-test reveals a stress loss greater than the stress limit, then the bank can dilute its positions or hedge its exposure. The bank will thus be protected should a crisis involving contagion occur.

5.4 Spur Discussion

Perhaps the most important benefit of possessing a well-defined stress-testing programme is to spur discussion about the nature of the portfolio among the bank's risk managers, account managers/traders and the top management. The process of periodically surveying the bank's portfolio, identifying the most important risk factors, scanning the horizon for potential stressful events, calculating their likely impact and taking corrective action leads to a lot of debate in a bank and helps it to be much more aware of all aspects of its portfolio. If such a stress-testing programme were not instituted then it is likely that no one would be assigned the specific task of sizing up a portfolio and the potential risks, and even elementary stress events may not be spotted and prepared for.

This is the reason why banks stand to benefit from having a stress-testing programme no matter how simple and non-quantitative their risk measurement systems might be.

6.0 CONCLUSIONS

Since credit risk engenders the largest proportion of the total risk of any well-diversified bank, it is imperative that banks adopt a comprehensive approach to managing it. Such a comprehensive approach involves managing credit risk at the counterparty and portfolio levels as well as stress-testing credit risk.

While it is encouraging to note that many banks have made progress with installing quantitative risk rating and portfolio models, they are still some distance away from using these systems to allocate economic capital, calculate RAROC and manage portfolio credit risk. They are also yet to institute credit stress-tests.

We hope that this report encourages risk managers and the top management at banks to start building a credit stress-testing programme. We have been careful to avoid prescribing any off-the-shelf stress-tests because stress-tests must be designed only after taking into account the idiosyncrasies of each portfolio. Further, some of the most important benefits of constructing a stress-testing programme come from the intense discussions that take place within a bank, while analysing the features of the portfolio and while building scenarios and setting limits.

As mentioned before, the lack of quantitative credit risk tools need not constrain risk managers from conducting credit stress tests. The absence of these tools may make the conduct of such tests cumbersome, but the benefits from conducting even rudimentary stress tests are still substantial.

We hope that this report serves to give risk managers a broad overview of the credit stress-testing process and enables them to build a comprehensive credit stress-testing programme.

7.0 TECHNICAL ANNEXURE

Some of the new systematic scenario building techniques are described below.

7.1 Correlation Matrix

Kupiec (1999) has introduced a methodology where a few risk factors (which play "starring" roles) are stressed and all the others (peripheral factors) are adjusted using historical volatilities and correlations. The stress loss (which he calls StressVaR) is then calculated using the same methodology as that used in variance-covariance VaR calculations. Although we have seen that using historical data for stress events is inappropriate, Kupiec shows that for broad-based portfolios, the standard VaR normality assumption and the use of historical volatility and correlation patterns do not seem to introduce distortion in stress event loss measures. While it is true that Kupiec's paper addresses market risk, it may be applied to credit portfolios as well to the extent that historical volatilities and correlation can be used to construct more plausible stress-tests.

However, several studies including Longin and Solnick (1999) have pointed out that correlations breakdown during crisis periods, which means that use of historical volatilities and correlations to adjust peripheral factors may not be appropriate except under special conditions.

Kim and Finger (2000) assume that correlations breakdown in crises and deal with this problem by first estimating correlation levels in volatile periods and then applying these 'stressed' correlations to specify changes in peripheral factors. The stress losses calculated using this method have the benefit of introducing an element of probability into stress-testing.

7.2 Monte Carlo Simulations

In the methodologies that we have seen so far, a stress-test is first constructed and the stress loss is then calculated. A different approach is to specify the stress loss and then examine the scenarios that could cause such losses.

Breuer and Krenn (2000) use Monte Carlo simulation to first calculate portfolio values in different scenarios and then to identify those scenarios that result in losses greater than a certain threshold. The scenarios where the threshold is exceeded can then be examined to determine what movements in risk factors caused the extreme losses and appropriate risk mitigation can be performed. Breuer and Krenn also provide a methodology for explicitly measuring the plausibility of the scenarios that are generated by the Monte Carlo process.

7.3 Extreme Value Theory

The last methodology that we consider for systematically constructing scenarios is called EVT, that is, Extreme Value Theory. VaR models for market risk, especially those that use variance-covariance methods assume that the probability distribution of portfolio changes is well approximated by a normal distribution. However, it has been found that actual returns distributions display a higher level of probability for extreme events than that supposed by the normal distribution. This is the reason why the actual distributions are said to have 'fat tails'. EVT is a theory that models these fat tails.

Univariate EVT deals with the issue of tail modelling while multivariate EVT addresses the correlation or risk-aggregation of assets from different financial instruments. Longin (1999) explains how one might apply EVT to stress-testing.

All the above methods, as pointed out in Schachter (2000), incorporate historical data in some way into the stress-test. This may make the stress-test lose plausibility because it is probable that in an actual stressful event, the risk factors will not behave as they did in the past.

Nevertheless, as Kupiec (1999) argues, stress scenarios that use historical volatilities and correlations are more plausible than scenarios that ignore correlations altogether.

8.0 GLOSSARY

Credit Risk	The risk of default or deterioration in credit quality short of default, of a counterparty in a financial transaction.
Credit Portfolio	The credit portfolio of a bank consists of all the financial instruments that engender credit risk. The Credit portfolio consists of financial instruments from both the trading as well as the loan book.
Credit Spread	The difference between the interest rate paid for funds of a given maturity by a sovereign issuer and the rate required of a less creditworthy borrower.
Loan Book	In this report, the loan book is defined as being made up of all loans and off-balance sheet that engender credit risk to the bank.
Market Portfolio	A bank's Trading book which is made up of all financial instruments that are traded in financial markets including equity shares, bonds, swaps etc.
Market Risk	The risk arising from the change in the value of financial instruments quoted in financial markets.
Spread Curve	The yield curve constructed by adding the credit spread applying to the credit quality of the counterparty, to a fixed income instrument to the government yields, for different maturities.
Swap	A contractual agreement to exchange a stream of periodic payments with a counterparty. The traditional interest rate swap agreement is an exchange of fixed interest payments for floating rate payments. A generic currency swap is an agreement to exchange one currency for another at a forward exchange rate or at a sequence of forward rates.
Swap Curve	A yield curve illustrating the relationship of swap rates at various maturities. Based on the zero coupon yield curve.
Swap Rate	The market interest rate on the fixed rate side of a swap. At the time the swap is initiated, the swap rate will typically be the same as the fixed rate payment (adjusted for any negotiated premium or discount). As rates move, the swap rate may differ materially from the fixed rate exchanged under a specific swap agreement.

Trading Book	The trading book consists of all the financial instruments that are traded in financial markets. This includes financial instruments that give rise to credit risk such as bonds as well as market risk such as equities.
Value at Risk	Measures the worst expected loss, over a given time interval, under normal conditions, at a given confidence interval.
Risk-free Yield Curve	A graph illustrating the level of interest rates as a function of time-obtained by plotting the yields of all default-free coupon bonds in a given currency against maturity or, occasionally, duration.

9.0 LIST OF ABBREVIATIONS

BIS	Bank of International Settlements – Basle, Switzerland
CPRMS	Credit Portfolio Risk Management System
DPG	Derivatives Policy Group
EVT	Extreme Value Theory
EAD	Exposure at Default
LGD	Loss Given Default
PD	Probability of default
RAROC	Risk Adjusted Return on Capital
VaR	Value at Risk

10.0 REFERENCES

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In the financial world, risk management is the process of identification, analysis, and acceptance or mitigation of uncertainty in investment decisions.Â Beta, also known as market risk, is a measure of the volatility, or systematic risk, of an individual stock in comparison to the entire market. Alpha is a measure of excess return; money managers who employ active strategies to beat the market are subject to alpha risk. 1:49. What is Risk Management? Understanding Risk Management. Risk management occurs everywhere in the realm of finance. Monetary and Capital Markets Department. This report is based on the work of the Financial Sector Assessment Program (FSAP) mission that visited Singapore in May 15â€“22 and July 25â€“ August 7, 2013. The Article IV consultation mission took place June 26â€“July 8, 2013.Â Â· The mission met MAS Managing Director Ravi Menon, and other senior officials and staff of MAS, the Ministry of Finance, the Ministry of National Development, the Housing and Development Board, the Urban Redevelopment Authority, Singapore Exchange Limited (SGX), banks, other financial institutions, and professional bodies. Â· FSAPs assess the stability of the financial system as a whole and not that of individual institutions. Sources of Financial Risk and Risk Assessment. Peter Moles. FK-A3-engb 1/2013 (1011).Â His main research interests are in financial risk management, the management of financial distress and in how management decisions are made and the difficulties associated with managing complex problems. He is author of the Handbook of International Financial Terms (with Nicholas Terry, published by Oxford University Press) and Corporate Finance (published by John Wiley & Sons).Â 6/2 6/11 6/17 6/17. vi Edinburgh Business School Financial Risk Management. Module 7.