Chapter - 1
Risk Management: An Introduction

"A business has to try to minimise risks. But if its behaviour is governed by the attempt to escape risk, it will end up by taking the greatest and least rational risk of all: the risk of doing nothing."

-Peter Drucker[1]

Introduction

We live in a world of risk. Some risks are totally unexpected. The September 11, 2001 World Trade Centre attacks in the US, the Tsunami of December 2004, Hurricane Katrina of August 2005, and the Mumbai terrorist strikes of November 2008 are good examples. Other risks can be identified but the magnitude and extent are difficult to estimate. The sub prime crisis is a good example. Not all risks are so unpredictable or unexpected or difficult to estimate. By closely monitoring the business environment and streamlining internal systems and processes, companies can anticipate the risks associated with changing technology, changing customer tastes, changing interest and currency rates, changing competitive conditions, etc. This book provides a conceptual framework for dealing with some of these risks in a systematic and coordinated way across an organization. To keep the scope of the book manageable, the focus will be on financial risks. Other risks will be considered in passing.

Exhibit.1.1

Major upheavals in recent years		
1971	:	Breakdown of Bretton Woods
1973	:	Oil shock
1987	:	US Stock market crash
1989	:	Crash of the Nikkei Index
1994	:	Mexican Peso crisis
1997	:	Asian currency crisis
1998	:	Russian rouble crisis/collapse of LTCM
2000	:	Dotcom bust
2001	:	WTC terrorist attack
2007	:	Sub Prime Crisis
2008	:	Collapse of Bear Stearns, Lehman, AIG,

Understanding risk management

Risk management has returned to the top of the agenda in the wake of the sub prime meltdown. Lehman Brothers, Bear Stearns and Merrill Lynch no longer exist. The US government has acquired a major equity stake in Citibank, while the UK government has done so in the case of Royal Bank of Scotland. Many European banks are in trouble and might well have collapsed but for government intervention. For all practical purposes, much of the British banking system has been nationalized. In a few days during October

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[1] Managing for Results

2008, the entire banking system in Iceland collapsed and was taken into public ownership. The country's average income fell from 160% of that of the US in 2007 to 80% by 2009. And as the credit crisis has spread from banking to other sectors, we have seen corporates also getting sucked into the whirlpool. The American automotive giants, General Motors (GM), Ford and Chrysler are in big trouble. President Barrack Obama has announced comprehensive bail out plans for GM and Chrysler. Companies like Toyota and Sony have declared losses for the first time in several years. Toyota the Japanese car manufacturer, with an impressive track record of revenue and profitability growth over the years, announced in the last week of August 2009 that it would slash worldwide production.

Quite clearly, risk management systems failed to deliver the goods during the recent crisis. And the price paid by the global economy has been heavy. It is evident that financial institutions and companies need to develop and apply a far more robust and integrated risk management framework that can inspire the confidence of shareholders. From identifying risk to measuring it and controlling it, the entire risk management process will have to undergo a major overhaul in the coming years.

To start with, top management will have to be hands on when it comes to understanding and managing risk. This is not a new concern. As the *Economist*[2] once put it: "Top managers often fail to understand properly the firm's sensitiveness to different types of risk……. managers and boards too often regard risk management as a matter for financial experts in the corporate treasury department rather than as an integral part of corporate strategy." But recent incidents such as the collapse of Bear Stearns where CEO Jimmy Cayne was enthusiastically taking part in bridge tournaments while the bank was collapsing, have reinforced this concern. Similarly, the Swiss bank, UBS had admitted on its website that its top management should have asked more probing questions when the bank's traders were building huge positions in sub prime mortgages.

Another concern is the way in which companies deal with different risks in a piecemeal fashion. For example, many banks dealt with credit and market risk separately in the build up to the sub prime crisis. The credit risk in case of many sub prime assets became market risk as market indices moved, leading to heavy mark-to-market losses.

An organization wide view of risk management can greatly improve efficiencies, generate synergies and most importantly result in a deeper understanding of risk exposure. Which is why banks like UBS have now started to integrate the management of credit risk and market risk. That is also why many companies are taking a serious look at Enterprise Risk Management (ERM), which addresses some fundamental questions:

- What are the various risks faced by the company?
- What is the magnitude of each of these risks?
- What is the frequency of each of these risks?
- What is the relationship between the different risks?
- How can the risks be managed to maximize shareholders' wealth?

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[2] February 10, 1996.

We will examine the theme of integrated risk management in more detail in a later chapter.

Risk identification at Pitney Bowes

While risk management is critical for financial institutions, corporates too are realizing the importance of risk management. Pitney Bowes, the postal machine maker is a good example. In recent years, this company has started to take risk management very seriously. The company's enterprise risk management system identifies and prioritizes potential risks to the business – financial, environmental and societal. These risks are assessed in terms of probability, severity and status of mitigation plans. Sixteen categories of risk have been identified. The risks identified are reviewed by a senior management Risk Steering Committee and the Board of Directors. Each risk is assigned to a senior executive. The firm has taken the view that risk management is a philosophy, not merely numbers. As a senior executive mentions[3], "We have a much more holistic discussion about a business and why we have it. It becomes strategic, instead of simply, do we get insurance to cover a potential loss?"

The benefits of risk management

What is the rationale for risk management? Does risk management really benefit the shareholders? After all many of the risks a company faces, are specific to it. Portfolio theory argues that shareholders are rewarded only for systematic risk. Unsystematic risk, i.e., risk specific to a company can be diversified away by purchasing shares in a reasonably large number of companies. If shareholders can manage risk more efficienty on their own, by buying shares in various corporations, should companies really manage risk? The answer is an emphatic yes.

Exhibit.1.2

How Risk Management adds value
▪ Enterprise Risk management creates value at both a "macro" or company-wide level and a "micro" or business-unit level.
▪ At the macro level, ERM creates value by enabling senior management to quantify and manage the risk-return tradeoff that faces the entire firm.
▪ At the micro level, ERM becomes a way of life for managers and employees at all levels of the company.
▪ Incorporating risk in decision making ensures optimal use of capital.

Source: Brian Nocco, Rene Stultz, "Enterprise Risk Management: Theory & Practice[4]."

For starters, shareholders do not have all the information needed to manage the risks a company faces. Moreover, even if they had, individual shareholders would find it inefficient and expensive to manage risks on their own. The transaction costs would be too high if a large number of small hedging transactions are undertaken. Finally, distress situations are eminently avoidable. During such situations, significant value destruction takes place as the assets of the company trade at unrealistically low prices. Recall the collapse of Bear Stearns in March 2008 and Lehman Brothers in September 2008.

Prudent risk management ensures that the firm's cash flows are healthy so that the immediate obligations and future investment needs of the firm are both adequately taken

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[3] Time, 22 December 2008, company website, www.pb.com
[4] Journal of Applied Corporate Finance, Fall 2006.

care of. Firms typically run into cash flow problems because they fail to anticipate or handle risks efficiently. These risks include *market risks* such as vulnerability to interest rate, stock index, commodity price and exchange rate movements. Then there are *credit risks* which arise because of excessive investments in the same asset class or lending to the same customer segment. They also include *liquidity risks* such as liquidity black holes, which result when the entire market shifts to one side, with sellers finding it difficult to find buyers. Firms may also fail to anticipate *business risks* when the demand suddenly falls or a rival starts taking away market share aggressively with a new business model or technological innovation. Then there are various examples of companies failing to manage *operational risk* effectively because of poor systems and processes.

Risk management helps in sustaining the staying power of an organization. In 1993, Metallgesellschaft which tried to cover the risk associated with its long term contracts through oil futures ended up losing a huge amount. The star studded team at hedge fund, Long Term Capital Management could do little as unexpected interest rate and currency movements brought the fund to the edge of bankruptcy in 1998. In both the cases, the positions taken were fundamentally sound. But there were serious doubts about their ability to tide through the crisis. Indeed, much of the sub prime crisis has been about liquidity. Under the circumstances, liquidity has become the most potent weapon in many sectors. Liquidity gives the comfort to sustain day-to-day operations and more importantly make those vital investments that are needed to sustain the company's competitiveness in the long run. Sound risk management goes a long way in ensuring that the organization has the required liquidity to function effectively even in bad times.

Categorising uncertainty
Organisations face various types of uncertainty. Milliken[5] has classified uncertainty into three broad categories.
- *State Uncertainty*: This refers to the unpredictability of the environment. Causes of state uncertainty are:
  - a) Volatility in the environment
  - b) Complexity in the environment
  - c) Heterogeneity in the environment
- *Effect Uncertainty:* This is the uncertainty about the impact of external events on the organization.
- *Response Uncertainty:* This refers to the unpredictability of the organization's responses to external developments.

Oliver Williamson[6], well known for his work on transaction cost economics and the 2009 Economics Nobel Prize winner has drawn a distinction among *environmental / external uncertainty*, *organisational/internal uncertainty* and *strategic uncertainty*.

- Environmental uncertainty arises due to random acts of nature and unpredictable changes in consumer preferences.

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[5] Academy of Management Review, 1987, Volume 12.
[6] "Handbook of Industrial Organization," Volume I, 1989.

- Organisational uncertainty refers to the lack of timely communication among decision-makers, each of whom has incomplete information. This leads to lack of coordination and consequently, poor decisions.
- Strategic uncertainty is created by misrepresentation, non-disclosure and distortion of information and results in uncertainty in the relations a firm has with suppliers, customers and competitors.

Exhibit 1.3

Prioritising Risks
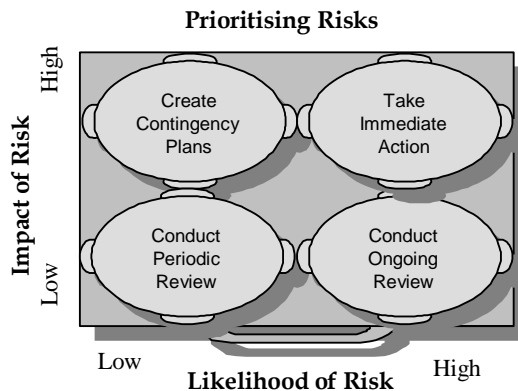
The great Peter Drucker, identified four types of risk[7]:
- The risk that is built into the very nature of the business and which cannot be avoided.
- The risk one can afford to take
- The risk one cannot afford to take
- The risk one cannot afford not to take
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Exhibit 1.4

Challenges in implementing Integrated Risk Management
▪ Risk management as a discipline has evolved unevenly across different functional areas.
▪ In finance, the preoccupation has been with hedging and discount rates. Little attention has been paid to the upside.
▪ In strategy, the focus has been on competitive advantage and barriers to entry.
▪ Risk management at most organizations is splintered.
▪ There is little communication between those who assess risk and those who make decisions based on those risk assessments.

The Economist Intelligence Unit divides risks into four broad categories.
- *Hazard risk* is related to natural hazards, accidents, fire, etc. that can be insured.
- *Financial risk* has to do with volatility in interest rates, exchange rates, stock markets and commodity markets, defaults on loans, asset-liability mismatch, etc.
- *Operational risk* is associated with systems, processes and people and deals with issues such as succession planning, human resources, information technology, control systems and compliance with regulations.
- *Strategic risk* stems from an inability to adjust to changes in the environment such as changes in customer priorities, competitive conditions and geopolitical developments.

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[7] Managing for Results

Exhibit 1.5

The Enterprise Risk Management process
▪ Identify the risk.
▪ Quantify the risk to the extent possible.
▪ Prevent or avoid the risk wherever possible.
▪ Transfer the risk if holding it is not consistent with the company's business strategy.
▪ If the risk is core to the business, hold it and manage it by modifying the operations, processes.
▪ Diversify the risk where appropriate by building a portfolio of businesses.
▪ Insure the risk, if it has to be held but is difficult to manage internally.
▪ Increase capital if the risk has to be held and is difficult to transfer.
▪ Assess the risk intelligently and decide whether it is more important to preserve the possibility of extremely good outcomes or to reduce the possibility of very bad outcomes.

The method of classifying risks is not as important as understanding and analysing them. Indeed, the very nature of uncertainty implies that it is difficult to identify all risks, leave alone classify them. Each company should carefully examine its value chain and come up with its own way of categorising the uncertainties associated with its important value adding activities. Then, it can quantify these uncertainties to the extent possible and decide which risks to hold and which to transfer.

In this book, we will concentrate on banks and financial institutions. We will look at the following risks in detail:
- ▪ Market risk
- ▪ Credit Risk
- ▪ Operational risk
- ▪ Liquidity risk

Exhibit 1.6
Risk Categories at Credit Suisse

Management risks	Strategy risk	Outcome of strategic decisions or developments
	Reputation risk	Damage of our standing in the market
Chosen risks	Market risk	Changes in market factors such as prices, volatilities, correlations
	Credit risk	Changes in the creditworthiness of other entities
	Expense risk	Difference between operating expenses and income in a crisis
Consequential risks	Operational risk	Inadequate or failed internal processes, people and systems; or external events
	Liquidity risk	Inability to fund assets or meet obligations at a reasonable price

Source: Credit Suisse Annual Report, 2008.

A brief history

Risk management is not exactly a new idea. One of the earliest examples of risk management appears in the Old Testament of the Bible. An Egyptian Pharaoh had a dream. His adviser, Joseph interpreted this dream as seven years of plenty to be followed by seven years of famine. To deal with this risk, the Pharaoh purchased and stored large quantities of corn during the good times. As a result, Egypt prospered during the famine. Similarly, in Matsya Avatar, Lord Vishnu asked Sage King Satyavratha to put one pair of each species safely on board the ship that would help them escape the deluge the Lord was planning to unleash. This ensured the perpetuation of different flora and fauna.

The modern era of risk management probably goes back to the Hindu Arabic numbering system, which reached the West about 800 years back. The Indians developed the system while the Arabs played a key role in spreading the knowledge to the west. Without numbers, it would have been impossible to quantify uncertainty. But mathematics alone was not sufficient. What was needed was a change in mindset. This happened during the Renaissance, when long-held beliefs were challenged and scientific enquiry was encouraged. The Renaissance was a period of discovery, investigation, experimentation and demonstration of knowledge. As theories of probability, sampling and statistical inference evolved, the risk management process became more scientific. Many risk management tools used by traders today originated during the 1654-1760 period. The pioneers of the Renaissance age included Luca Pacioli, Girolamo Cardano, Galileo, Blaise Pascal, Pierre de Fermat, Chevalier de Mere and Christiaan Huygens.

Strangely enough, gamblers played a major role in the advancement of probability theory. A landmark problem they tried to solve was how to estimate the probability of a win for each team after an unfinished game of cards. These ideas were later supplemented by advances such as the regression to the mean by Francis Galton in 1885 and the concept of portfolio diversification by Harry Markowitz in 1952.

More sophisticated risk management tools have been developed in recent decades. These include models for estimating value-at-risk, volatility, probability of default, exposure at default and loss given default. A landmark event in the history of risk management was the development of the Black Scholes Merton Option Pricing Model in 1973. Thanks to better understanding of various domains, quantitative models and the availability of computing power, it has become possible to quantify risk to a large extent. Yet, as the recent sub prime crisis has demonstrated, these numbers are of little use if mature human judgment is not exercised, by the people involved.

For a more detailed account of the history of risk management, please see annexure at the end of this chapter.

Risk fundamentals

There are some fundamentals about risk that need to be carefully understood.

Risk can neither be avoided nor eliminated completely. Indeed, without taking risk, no business can grow. If there were no risks to take, managers would be without jobs!

The Pharaoh in the earlier example was obviously taking a risk in the sense that his investment would have been unproductive had there been no famine. Microsoft has laid huge bets on its next operating system, Windows 7. But without this investment, Microsoft realises it may lose its market share as the threat from Google intensifies. Similarly, Tata Motors has made a huge investment in buying out Daewoo's truck division in South Korea. The Tatas have also purchased the luxury marque, Jaguar, realising that without this kind of investment they may become a marginal player in the global automobile market.

In short, risk management is as much about managing the upside as the downside. But as John Fraser and Betty Simkins[8] mention, *the upside should not become a distraction* and dilute the focus of tactical risk management. The upside should be dealt with during periodic strategic planning exercises or when circumstances change in a big way. But once the strategy is in place, ERM should focus on the downside: "By keeping shifts in strategy and discussions of the upside apart from normal operations, companies avoid having their management and staff distracted by every whim or misunderstood opportunity."

Exhibit 1.7
Risk categories at Deutsche Bank

Credit Risk	This risk arises from all transactions that give rise to actual contingent or potential claims against any counterparty. The bank distinguishes three kinds of credit risk. Default risk, Country risk and Settlement risk.
Market Risk	This risk arises from the uncertainty due to changes in interest rates, equity prices, foreign exchange rates and commodity prices.
Liquidity Risk	This is the possibility of being unable to meet payment obligations when they are due or having to fund them at very high costs.
Operational Risk	This is the possibility of suffering losses in relation to employees, contractual specifications, technology, infrastructure failure etc. This definition includes legal and regulatory risk but excludes business and reputational risk.
Reputational Risk	This is the risk that publicity concerning a transaction, counterparty or business practice involving a client will a negative impact on the public's trust in the bank.
Business Risk	This is the risk arising out of potential changes in general business conditions, such as the market environment, client behavior and technological changes.

Source: Deutsche Bank Annual Report, 2008.

Risk management should not be viewed in absolute terms. It is often about making choices and tradeoffs between various kinds of risk. These choices and tradeoffs are closely related to a company's assumptions about its external environment. In the Indian pharma industry, players like Dr Reddy's Laboratories are challenging the patents of global players as the generics market in the US opens up with many blockbuster drugs going off patent. But another leading player, Nicholas Piramal (Nicholas), believes in a different approach - partnering with global majors. Nicholas does not want to challenge patents but wants to join hands with large players in various areas such as contract manufacturing. CEO Ajay Piramal believes that Nicholas' capabilities in managing

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[8] "Ten common misconceptions about Enterprise Risk Management," Journal of Applied Corporate Finance, Fall 2007.

strategic alliances with the big guns in the pharma industry will stand the company in good stead in the coming years.

Exhibit 1.8
Risk Management vs. Risk Hedging

	Risk Hedging	Risk Management
View of risk	Risk is a danger	Risk is a danger & an opportunity
Objective	Protect against the downside	Exploit the upside
Approach	Financial, Product oriented	Strategy/cross functional process oriented
Measure of success	Reduce volatility in earnings, cash flows, value	Higher value
Type of real option	Put	Call
Primary impact on value	Lower discount rate	Higher & sustainable excess returns
Ideal situation	Closely held, private firms, publicly traded firms with high financial leverage or distress costs	Volatile businesses with significant potential for excess returns

Ref: Aswath Damodaran, "Strategic Risk Taking – A Framework for Risk Management," Wharton School Publishing, 2008.

Risk Management should not be confused with the risk hedging. Risk management is more strategic, cross functional, process oriented and has the pay off of a call option. This means that while the downside is protected, opportunities are pursued for maximizing the upside. While risk hedging aims at reducing earnings volatility, risk management aims at maximizing the value of the firm. See Exhibit 1.8

All risks are not equally important. Without a clear understanding of the impact and frequency of different risks, some relatively unimportant risks may receive more attention than they warrant. As a result, there may be sub optimal utilization of corporate resources. Risks must be classified according to their frequency and potential impact, to facilitate prioritization.

Not all risks are external. Very often, the risks organizations assume have more to do with their own strategies, internal processes, systems and culture than any external developments. For example, the collapse of the Hyderabad based Global Trust Bank (GTB) in 2004 had more to do with poor management control systems than any other kind of risk. GTB took heavy risks while lending money to low credit worthy customers and investing money in the capital markets. The board failed to ask the right questions and impose the necessary checks and balances.

The crisis at UTI in 2001 was again due more to internal than external factors. UTI made a number of questionable investments in the late 1990s. There is considerable evidence that systems and processes were routinely violated when UTI's fund managers purchased risky stocks.

Every company needs to grow its revenues and generate adequate profits to survive in the long run. Unprofitable or stagnating companies are doomed to failure. So, investments, which are needed to stay ahead of competitors, cannot be avoided. And any investment does carry some amount of risk. Risk management ensures that these risks are identified, understood, measured and controlled. By understanding and controlling risk, a firm can take better decisions about pursuing new opportunities and withdrawing from risky areas.

Risk management cannot be completely outsourced. Companies must be clear about what risks to retain inhouse and what risks to transfer. In general, retaining risks makes sense when the cost of transferring the risk is out of proportion to the probability and impact of any damage. The first step for managers is to understand what risks they are comfortable with and what they are not. Often, companies are not comfortable with risks caused by volatile financial markets. This is probably why financial risk management, which deals with volatility in interest and exchange rates, has become popular among non banking organisations in the past few decades. Companies also tend to transfer those risks which are difficult to measure or analyze. A good example is earthquakes, where an insurance cover often makes sense. On the other hand, companies often prefer to retain risks closely connected to their core competencies. Thus, a software company like Microsoft would in normal circumstances, not transfer technology risk, but would in all likelihood hedge currency risk. These are only general guidelines. Ultimately whether to retain the risk or to transfer it should be decided on a case-to-case basis.

As Nocco and Stultz[9] mention, "… in making decisions whether to retain or transfer risks, companies should be guided by the principle of comparative advantage in risk bearing. A company that has no special ability to forecast market variables has no comparative advantage in bearing the risk associated with most variables. In contrast, the same company should have a comparative advantage in bearing information intensive, firm-specific business risks because it knows more about these risks than anybody else." Indeed, the paradox of risk management is that by reducing non core exposure, it gives companies the confidence to take more risk and exploit opportunities in their core business.

The approach towards quantifying risk is different from that used in valuation. A brief mention may be made here of the differences between the two approaches. While valuation focuses on the expected present value, risk management is concerned with the distribution of future value. While valuation concentrates on the centre of the distribution, risk management is more concerned with the tails. See Exhibit 1.9.

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[9] Journal of Applied Corporate Finance, Fall 2006.

Exhibit 1.9
Valuation & Risk Management approaches

	Valuation	*Risk Management*
Principle	Expected discounted value	Distribution of future value
Focus	Centre of distribution	Tails of distribution
Horizon	Current value, discounting	Future value
Precision	High precision needed	Less precision needed

Ref: Aswath Damodaran, "Strategic Risk Taking – A Framework for Risk Management," Wharton School Publishing, 2008.

Behavioral Issues in Risk Management

Behavioral issues play an important role in risk management. Studies have shown that many New York taxi drivers, set themselves a daily income target. Once they reach their target, they close shop for the day. This tendency to work less on a busy day when easy money is there to be made, defies rational logic. Indeed, such anomalies drive the point home, that while taking decisions with financial implications, logic often takes the backseat. Indeed, that is how the field of Behavioral Finance has developed. This is a new approach to finance that argues that some financial phenomena can be better understood by considering that human beings are not always rational. Behavioral finance has two building blocks[10]. The first is limits to arbitrage. Market dislocations may persist and may not be corrected quickly by arbitrage as traditional finance theory would suggest. The second is psychology which sustains deviations from fall rationality.

The behaviours of people are strongly guided by perceptions. Two components of risk influence people's perceptions – the *fear factor* and the *control factor*. When we are very much afraid of the outcome or feel less in control, we perceive the risk to be more. On the other hand, when we are not afraid of the outcome or feel more in control, we perceive the risk to be less.

Scholars, Daniel Kahneman (the 2002 Nobel Prize Winner) and the late Amos Tversky, pioneers of behavioral finance make an important point about how people perceive gains and losses. When looking at a potential gain, people tend to be risk averse and when they look at a potential loss, they are more risk loving. They gain less utility from winning $1000 than what they would forgo if they lose $1000. This asymmetry is especially relevant in the case of a financial loss or gain but can also apply to other situations.

How people perceive gains and losses also depends on the frame of reference. For example, managers who have incurred a major loss may be quite happy if the loss is less than what they had expected. Similarly, the choice of a strategy may depend on the way the possible outcomes are presented.

Cognitive bias in decision making is also an important point to be considered. People tend to give greater weight to information which is more easily available or recalled. The tendency to focus more attention on a particular fact or event, just because it is more visible or fresh in our minds is called *availability heuristic*. According to Werner De

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[10] Nicholas Barberis, Richard Thaler, "A Survey of Behavioral Finance," Working Paper, September 2002.

Bondt and Richard Thaler, a significant proportion of market volatility is explained by overreaction to recent news.

People often hold beliefs which are plainly at odds with the evidence, usually because they have been held and cherished for a long time. This is referred to as *cognitive dissonance* or in more common parlance, *denial*. Many people also tend to be influenced by outsiders' suggestions. This may happen even when it is clearly known that the person making the suggestion is not necessarily well informed. Evidence indicates that people also tend to take bigger gambles to maintain the status quo.

People often have an exaggerated notion of their ability to control events. Consequently, they do not pay adequate attention to extreme possibilities. When people think they are in control of circumstances, when they are actually not, they underestimate the risks involved. The tendency on the part of people to think they have a greater influence on events than is actually the case is called *magical thinking*. Conditions that encourage illusion of control include stress, too much focus on results (without a periodic reflection of what is going on) and a series of positive outcomes.

N Barberis, M Huang and T Santos[11] point out another behavioral anomaly, the *house money effect*. Individuals are more willing to take risks with found money (money obtained easily) than with earned money.

Another behavioural issue which has an adverse impact on risk management is misinterpretation of past events. Once something happens, people tend to think that they could easily have predicted it. This is called *hindsight bias*. When something happens and people condition themselves into believing they predicted it, when they actually did not, it is called *memory bias*.

Exhibit 1.10

Risk management: First principles
▪ *Risk is everywhere*: Our biggest risks will come from places that we least expect them to come from and in unanticipated forms.
▪ *Risk is threat and opportunity*: Good risk management is about striking the right balance between seeking out and avoiding risk.
▪ *We are ambivalent about risks and not always rational*: A risk management system is only as good as the people manning it.
▪ *Not all risk is created equal*: Different risks have different implications for different stakeholders .
▪ *Risk can be measured*: The debate should be about what tools to use to assess risk than whether they can be assessed.
▪ *Good risk measurement should lead to better decisions*: The risk assessment tools should be tailored to the decision making process.
▪ *The key to good risk management is deciding which risks to avoid, which ones to pass through and which to exploit*: Hedging risk is only a small part of risk management.
▪ *The pay off to better risk management is higher value*: To manage risk right, we must understand the value drivers of the business.

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[11] "Prospect Theory and Asset Prices," Quarterly Journal of Economics, Vol. 116, 2000, pp. 1-53.

▪ *Risk management is part of everyone's job*: Ultimately, managing risks well is the essence of good business practice and is everyone's responsibility.
▪ *Successful risk taking organizations do not get there by accident*: The risk management philosophy must be embedded in the company's structure and culture.
▪ *Aligning the interests of managers and owners, good and timely information, solid analysis, flexibility and good people is key*: Indeed, these are the key building blocks of a successful risk taking organization.

Ref: Aswath Damodaran, "Strategic Risk Taking – A Framework for Risk Management," Wharton School Publishing, 2008.

The tendency to believe that past patterns will repeat themselves in the future is another pitfall in risk management. People are adept at finding patterns even when they do not exist. This phenomenon of treating events as representative of some class or pattern is called *representativeness heuristic*.

Thaler points out the role of *mental accounting* which refers to the way individuals and households keep track of financial transactions. People tend to evaluate risks separately than in an integrated fashion. If these risks were evaluated with a broader perspective, investors would be less risk averse. Shlomo Benartzi and Richard Thaler[12] have used this concept to explain why equity shares command such a high premium over bonds in the capital markets. Investors tend to focus more on the short-term volatility of shares than their long-term returns. Consequently, they demand a premium as compensation. Instead, if they concentrated on the long term returns offered by shares, they would not perceive them to be much riskier than comparable bonds. In the case of Metallgesellshaft, the German oil refiner, though the long term position was hedged, the top management became pretty much concerned about short term losses. Which is why, they decided to unwind their futures positions even though they were working fine on a long term basis.

J C Cicchetti and J A Dubin[13] (1994) studied customers who were prepared to pay 45 cents per month as insurance against having to incur a telephone wiring repair cost of $55 with only a .005 profitability. The expected loss in the event of a repair was only (.005) (55) or approximately 28 cents per month. Millions of customers in the US have been known to buy similar protection. If utility-maximising customers had rational expectations about the probability of needing repair, it is unlikely that they would buy the protection.

There are various other behavioral anomalies, a brief mention of some of which is in order here. *Contamination effects* allow irrelevant but proximate information to influence a decision. The *affect heuristic* allows preconceived value judgments to interfere with our assessment of costs and benefits. *Over confidence in calibration* leads us to underestimate the confidence intervals within which our estimates will be robust. *Bystander apathy* makes us abdicate individual responsibility when in a crowd. The *problem of induction* makes us generalize on the basis of insufficient information.

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[12] "Myopic Loss Aversion and the Equity Premium Puzzle," Quarterly Journal of Economics, Vol. 110.1, 1995, pp. 73-92.
[13] A Microeconometric analysis of risk aversion and the decision of self insure," Journal of Political Economy, Vol. 102, 1994, pp. 169-186.

Risk management must take into account all these behavioral issues. Ultimately, risks are identified, measured and controlled by people. So human psychology cannot be separated from risk management. It is important to note that "normal" rather than "rational" behaviours are at work while taking risk.

One way to resolve the problem of individual biases is to ask employees to operate in cross functional teams. The advantage of a collective approach to beliefs about risk and the frame of reference is that individual biases can be minimised and team members can exercise a restraining influence on each other. Goldman Sachs developed the tradition of partners coming together to evaluate major risks and approve important decisions. This has no doubt contributed to the bank's strong risk culture.

Concluding Notes

In their seminal paper, "The Balanced score card – Measures that drive performance"[14] Robert Kaplan and David Norton have emphasised the need for evaluating the performance of an organisation from four different angles – customer perspective, internal perspective, innovation and learning perspective and shareholder perspective. The Balanced ScoreCard considers financial measures that represent the outcome of past actions. At the same time, it incorporates operational measures relating to customer satisfaction, internal processes and attempts at innovation and improvement, all of which drive future financial performance. Similarly, when we talk of risk management, the various business risks which organisations face must be considered along with the financial risks. *Ultimately, financial risks are the outcome of business strategy. The role of financial risk management is to minimise uncertainty regarding cash flows; but the very source of these cash flows is the type of business which the company runs and the type of strategic decisions it makes*. While much of this book is about financial risks, we will from time to time illustrate through examples the linkages between business risk and financial risk.

Till the early 1990s, in most organisations across the world, an integrated approach to risk management was lacking. The formation of risk management departments was mainly aimed at reducing the total insurance premium paid or the transaction costs incurred while hedging risk. From the mid-1990s onwards, this philosophy has been changing. The range of risks which companies have to manage has widened. Various strategic and operational risks have become more important than insurable risks. The need to take a company wide view of risks is becoming increasingly felt.

Boards are realizing that each major initiative needs to be examined on the basis of a risk return framework. That is why risk-adjusted-return-on-capital and capital allocation across businesses are being emphasized by banks. As US Federal Reserve governor Randall Kroszner remarked[15], "Assessing potential returns without fully assessing the corresponding risks to the organization is incomplete and potentially hazardous, strategic analysis," But in the run up to the sub prime crisis, this principle was conveniently

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[14] Harvard Business Review, January – February, 1992.
[15] Time, 22 December 2008.

violated. Credit Default Swaps (CDS) and Collateralized Debt Obligations (CDO) were used merrily without understanding the risks involved. Rational analysis would have indicated that the meager excess returns which these instruments promised, were not justified in relation to the risk involved. But with compensation by and large linked to sales and not risk adjusted returns, risk management took a back seat.

Looking back, it is clear that during a boom, risk managers who play the devil's advocate are often not taken seriously enough. But a few CEOs have demonstrated their vision. CEO Ed Clark decided to withdraw Toronto-Dominion, the Canadian bank from structured products because he did not fully understand these products.   As he remarked,[16] "I am an old school banker. I don't think you should do something that you don't understand, hoping there is somebody at the bottom of the organization who does." A similar philosophy helped Jamie Dimon, the CEO of J P Morgan Chase avoid the problems which many other banks ran into because of sub prime mortgages.

Let us end with this chapter with two quotes. The more recent quote is from Niall Ferguson, one of the foremost finance historians[17], in the world. Ferguson emphasizes the importance of being prepared for surprises. "The history of risk management is one long struggle between our vain desire to be financially secure and the hard reality that there really is no such thing as 'the future'…... There are only multiple, unforeseeable futures, which will never lose their capacity to take us by surprise."

Risk management should not be equated with caution, conservatism or cynicism or inaction.   The great American president Theodre Roosevelt's famous remarks were recalled by CEO Jamie Dimon of JP Morgan Chase in the bank's 2008 annual report: "It is not the critic who counts; not the man who points out how the strong man stumbles …. The credit belongs to the man who is actually in the arena, whose face is marred by sweat and blood, who strives valiantly: who errs, who comes short again and again because there is no effort without error and shortcoming."

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[16] Time, 22 December 2008.
[17] The Ascent of Money, Allen Lane, 2008.

Annexure 1.1 - Risk Management: A historical perspective[18]

While anecdotal evidence of risk management exists since ancient times, it would be fair to state that by and large, till the time of *Renaissance*, the common man took most of his decisions by instinct and believed in luck. The Renaissance, a time of discovery, encouraged investigation, experimentation and demonstration of knowledge. As mathematical advances took place, man became confident about measuring and controlling risk. Gradually, risk management began to evolve as a science. A historical account of the various advances in risk management in the past 600 years follows.

In the early 1400s, the Medici family, one of the earliest bankers of Medieval times, created a flourishing market for bills of exchange in Italy. Creditors could draw bills on debtors and use the bills as a means of payment or obtain cash at a discount from a banker willing to act as a broker. The Medici family also gave a boost to the double entry system of accounting. Their balance sheets systematically listed liabilities on one side and assets on the other. The Mediccis, succeeded by increasing the size and spread of their operations. Thanks to their enterprise, the Italian banking system became the benchmark for many other European nations.

In 1494, *Luca Pacioli* wrote a remarkable book which covered the basic principles of algebra. Pacioli drew attention to the problem of dividing the stakes between two players after an unfinished game of cards. This was one of the earliest attempts to quantify risk.

A sixteenth century physician *Girolamo Cardano* published a book *Ars Magna* (The Great Art) in 1545. The book covered advanced topics such as solutions to quadratic and cubic equations and square root of negative numbers. Cardano wrote another book *Liber de Ludo Alea* (Book on Games of Chance), probably the first scientific attempt to develop the principles of probability. Cardano defined probability as the number of favourable outcomes divided by the total number of possible outcomes.

Galileo, born in 1564 and considered the father of modern science, also worked in the area of probability. He dealt with the problem of throwing one or more dice and estimating the probability of the various outcomes. Interest in the subject also spread to other countries like Switzerland, Germany and England. Within 50 years of Galileo's death, major problems in probability analysis had been solved.

Central banking, which has assumed the primary responsibility in many countries for monitoring the risks posed by the financial system originated in the middle of the 17th century. The Swedish Riksbank, set up in 1656 pioneered the concept of fractional reserve banking. Bulk of the deposits mobilized by banks could be profitably lent out to those in need. The Bank of England was set up in 1694, primarily to assist the government with war financing. In 1742, the Bank of England was given a partial

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[18] The quotes in this section are drawn from Peter Bernstein's book, "Against the Gods," unless otherwise mentioned. The annexure itself draws heavily from this book. Another insightful book which helped in preparing this note is Niall Ferguson's, "The Ascent of Money," a history of finance which takes us back almost 4000 years in time.

monopoly on the issue of non interest paying bank notes that could be used to settle payments. Other countries established central banks much later. Thus the Banque de France came into existence in 1800, the German Reichsbank in 1875, the Bank of Japan in 1882, the Swiss National Bank in 1907 and the US Federal Reserve in 1913.

The bond market was also an invention of the Italian Renaissance. Italian City states at war needed money to finance their mercenary armies. Florence floated bonds to wealthy citizens and paid interest as compensation. These bonds could be sold to others in case the investors were in need of liquidity. By the early 14th century, two thirds of households in Florence were financing the public debt. From Italy, bond market innovations passed on to other countries in Europe. By the mid 18th century, there was a thriving bond market in London where liquid Government consols were the dominant securities traded. The consols were essentially perpetual bonds. By the late 18th century, two kinds of consols dominated – 3% and 5% coupon bonds. The bond market soon emerged as an institutional mechanism for providing immediate feedback on government policies. Indiscriminate spending and government borrowing meant punishment in the form of higher interest rates on government bonds.

Three French men, *Blaise Pascal, Piere de Fermat* and *Chevalier de Mere* made immense contributions to the development of probability theory. When Chevalier raised the problem of how to divide the stakes in an unfinished game of cards, Fermat turned to algebra while Pascal used a combination of geometry and algebra. Pascal's work later evolved into decision theory. Seven letters exchanged by Pascal and Fermat between July and October of 1654 formed the genesis of probability theory. The Dutch scientist, Christian Huygens, based on this correspondence, published the first book on probability in 1656.

In 1662, a book was published by some associates of a monastery with which Pascal was associated. The book referred to probability explicitly and explained how to calculate it. The ideas in this book led to the important conclusion that a decision depends on the strength of one's desire for a particular outcome as well as one's estimate of the probability of that outcome.

Meanwhile, sampling was also emerging as an important subject. One of the earliest applications of sampling was in the testing of coins produced by the Royal Mint in England. The coins were selected at random and compared to a standard to ensure that the variation was within specified limits.

In 1662, *John Graunt* published a book covering statistical and sociological research. Graunt was the first person to condense data into tables and to do descriptive statistical analysis. Graunt was supported in his efforts by an Irish intellectual, William Petty. Graunt and Petty can be called the founders of modern statistics. Graunt did a lot of work on the causes of death. He made a scientific estimate of the population of London and explained the importance of demographic data. Graunt's work gradually led to concepts such as sampling, averages and the notion of what is 'normal'. Without being aware of it, Graunt laid the foundation of sampling theory. The line of analysis pursued by Graunt is

today known as statistical inference, i.e., drawing conclusions about a population using a sample.

In 1692, *John Arbuthnot's* translation of Huygens' work became the first publication on probability in the English language. The book had a long title "Of the laws of chance or a method of calculation of the hazards of game, plainly demonstrated and applied to games as present most in use".

Edmund Halley, the famous British astronomer also made a significant contribution. He developed tables that facilitated the calculation of annuities. These tables were published in a work called "Transactions" in 1693. Halley's work became the basis for the modern life insurance business.

Towards the end of the 17th century, insurance products began to emerge. A coffee house which *Edward Lloyd* opened in London in 1687 was the birth place of Lloyd's, the famous insurance company. In 1696, he prepared the Lloyd's list, which provided details about the arrival and departure of ships and conditions at sea. Ship captains frequented the coffee shop and compared notes on the hazards associated with different sea routes. The London insurance industry grew rapidly, fuelled by various innovations. Underwriters wrote policies to cover various types of risk. In 1771, 79 underwriters came together to set up the Society of Lloyd's.

In the late 17th century, a dedicated insurance market began to develop in London. Some 14 years after the Great Fire of 1666 which destroyed more than 13,000 houses, Nicholas Barbon established the first insurance company. The Sun Insurance Office, a fire insurance specialist, was set up in 1710. In 1720, the Royal Exchange Assurance Corporation and the London Assurance Corporation were set up. These companies provided life and maritime insurance. All the three were limited liability companies. But the problem with all these firms was that they operated on a "pay-as-you-go" basis. There was always the danger that payouts might exceed the premiums collected.

The first modern insurance fund was pioneered by Scottish ministers, Robert Wallace and Alexander Webster, along with Colin Maclaurin, a mathematics professor. The fund was based on modern actuarial principles. Earlier, the window of a deceased minister of a Scottish Church received only half a year's stipend. Webster and Wallace came up with a scheme in which premiums would be collected from ministers annually and profitably invested. Windows would be paid out of the returns on the investment and not out of the premiums as was the earlier practice. Webster and Wallace came up with fairly accurate calculations of how many beneficiaries there would be in the future and how much money could be generated to support them. The establishment of the Scottish Ministers' Widows fund was a major milestone in the history of risk management. In the next 20 years, similar funds were established both in England and the American colonies – the Presbyterian Ministers' Fund of Philadelphia (1761), English Equitable Company (1762), United Incorporations of St Mary's Chapel (1768). Over time, insurance companies became major investors in the stock markets. (Insurance premiums rose as a proportion

of GDP in the developed countries from around 2% on the eve of the first world war to about 10% in 2007).

As trade expanded, judgments about consumer needs, pricing and cost of financing became important. For these adventurous traders, business forecasting became important. Indeed, business forecasting was a major innovation of the late 17th century. Till then, the principles of probability had been applied only to applications like gambling, far removed from business.

In 1713, *Jacob Bernoulli* came up with the law of large numbers. Under similar conditions, the occurrence of an event in the future will follow the same pattern as in the past. He showed how probabilities and statistical significance could be inferred from limited information. According to the law, if we throw up a coin, the ratio of the number of heads to the total number of throws will tend towards 0.5 as the number of throws becomes large. In statistical terms, increasing the number of throws will increase the probability that the ratio of heads to the total number of throws will vary from 0.5 by less than some stated amount. Interestingly, the Indian mathematician, Brahmagupta (598-668) had stated without proof that the accuracy of empirical statistics tends to improve with the number of trials. Poisson, Chebyshev, Markov, Borel, Centelli and Kolmogorov were the other mathematicians who contributed to the law of large numbers.

In 1738, the Swiss mathematician *Daniel Bernoulli* published a paper that covered both the subject of risk as well as human behavior. Bernoulli introduced a very important idea. The value of an item must not be based on its price, but rather on the utility that it yields. The utility resulting from any small increase in wealth will be inversely proportional to the quantity of wealth previously possessed. For example, all people want to become rich but the intensity to become rich reduces as they become richer. While probability theory set up the choices, Bernoulli considered the motivations of the person who did the choosing. Rational decision makers attempt to maximise expected utility, not expected value. Risk management works well because utility varies across individuals and organizations. It is the differences in utility that make possible the existence of various risk transfer mechanisms. As Bernstein puts it so well, "If everyone valued every risk in precisely the same way, many risky opportunities would be passed up. Venturesome people place high utility on the small probability of huge gains and low utility on the larger probability of loss. Others place little utility on the probability of gain because their paramount goal is to preserve their capital. Where one sees sunshine, the other finds a thunderstorm. Without the venturesome, the world would turn a lot more slowly… We are indeed fortunate that human beings differ in their appetite for risk."

A French mathematician, *Abraham de Moivre* made impressive contributions to the field of risk management, documented in his 1713 book, *The Doctrine of Chances*. De Moivre demonstrated how observations distribute themselves around their average value. This led to the concept of the normal distribution. De Moivre also developed the concept of standard deviation. This made it possible to evaluate the probability that a given number of observations would fall within some specified bound. De Moivre also showed the normal distribution to be an approximate form of the binomial distribution. To quote De

Moivre, "Though chance produces irregularities, still the odds will be infinitely great that in the process of time, those irregularities will bear no proportion to recurrency of that order which naturally results from original design."

In the 1760s, an Englishman, *Richard Price* did some pioneering work in the construction of mortality tables. Based on the work of Halley and de Moivre, Price published two articles on the subject. In 1771, he published a book titled "*Observations on Reversionary Payments*". For this work, Price is generally acknowledged as the founding father of actuarial science. Price's work however, had some errors. He overestimated mortality rates at younger ages and underestimated them at later ages. He also underestimated life expectancies. Consequently, life insurance premia were much higher than they needed to be.

Thomas Bayes, an Englishman born in 1701 worked on determining the probability of the occurrence of an event given that it had already occurred a certain number of times and not occurred a certain number of times. In other words, Bayes focussed attention on using new information to revise probabilities based on old information. In a dynamic environment, characterised by a high degree of uncertainty, this can be a very useful tool. As more and more information becomes available, earlier probabilities can be revised. Bayes' most well known paper was "Essay towards solving a problem in the doctrine of chances." The Bayes' theorem of conditional probability was first published in 1763.

Carl Friedrich Gauss, probably the greatest mathematician of his time, published *Disquisitiones Arithmeticae* in 1801, which dealt with the theory of numbers. One of his early attempts to deal with probability was in the book *Theoria Motus* (Theory of Motion) published in 1809. In this book, Gauss made attempts to estimate the orbit of heavenly bodies based on the path that appeared most frequently over many separate observations. Gauss was also involved in geodesic measurements, the use of the curvature of the earth to improve the accuracy of geographic measurements. These measurements involved making estimates based on sample distances within the area being studied. Gauss noticed that the observations tended to distribute themselves symmetrically around the mean.

In 1810, *Pierre Laplace* spotted the weakness in Gauss' work. Before Laplace, probability theory was mostly concerned with games of chance. Laplace applied it to many scientific and practical problems. In 1809, Laplace also framed the Central Limit Theorem. It states that the sampling distribution of the mean of different samples drawn from a population, approaches the normal as the sample size increases. In 1812, Laplace published his book, *Theorie analytique des probabilities*. It was only in 1901 that the importance of the central limit theorem was understood when Russian Mathematician Aleksandr Lyapunov defined it in general terms and proved precisely how it worked.

Simeon Denis Poisson came up in 1914 with a distribution named after him. The Poisson distribution is quite useful in situations where a discrete random variable takes on an integer value. The distribution can be used to estimate the probability of a certain number of occurrences (usually a very small number) in situations such as the number of

telephone calls going through a switchboard system per minute, the number of patients coming for a check up at a hospital on a given day or the number of accidents at a traffic intersection during a week. Today the Poisson distribution is used in Credit Risk Plus, a widely used credit risk model to predict the occurrence of default events.

In 1867, *Pafnuty Chebyshev*, developed another important theorem in statistics. No matter what the shape of the distribution, at least 75% of the values will fall within (plus minus) two standard deviations from the mean of the distribution and at least 89% of the values will lie within (plus minus) three standard deviations from the mean.

Francis Galton tried to build on the foundation provided by Gauss and others. In 1885, his work led to the formulation of a general principle that has come to be known as regression or reversion to the mean. Galton worked on intriguing problems such as estimating the rate at which tall parents produced children who were tall relative to their peers but shorter relative to their parents. Galton also studied the average diameter of 100 seeds produced by different sweet pea plants. He found that the smallest pea seeds had larger offspring and the largest seeds had smaller offspring. Similarly, in another study he found that if parents were short, the children were slightly taller and vice versa. These experiments led Galton to develop the term regression, the process of returning to the mean.

Bernstein has explained the importance of Galton's work: "Regression to the mean motivates almost every kind of risk taking and forecasting. It's at the root of homilies like what goes up must come down, Pride goeth before a fall, and from shirtsleeves to shirtsleeves in three generations. Probably Joseph had this in mind when he predicted to Pharaoh that seven years of famine would follow seven years of plenty." In stock markets, regression to the mean is applied when we talk of over valuation and under valuation of stocks. We imply that a stock's price is certain to return to the intrinsic value. According to Bernstein, "Galton transformed the notion of probability from a static concept based on randomness and the Law of Large Numbers into a dynamic process in which the successors to the outliers are predestined to join the crowd at the centre."

In the late 19th century, many advances were made in statistical techniques including the standard deviation, correlation coefficient and the chi square test. In 1893, *Karl Pearson* introduced the concept of standard deviation. In 1897, he developed the concept of correlation coefficient. And in 1900, he presented the idea of the chi-square distribution, useful for understanding the similarity of different populations. For example, marketers would find the test useful in determining whether the preference for a certain product differs from state to state or region to region. If a population is classified into several categories with respect to two attributes, the chi-square test can be used to determine if the two attributes are independent of each other. The chi square test facilitates business decision making in the face of uncertainty. It is a handy tool for mitigating business risk though it is less used in the world of financial risk.

In 1908, *William Gosset* presented his work on the t distribution. The *t* distribution is typically used for estimation whenever the sample size is less than 30 and the population

standard deviation is not known. A *t* distribution is lower at the mean and fatter at the tails than a normal distribution. The fat tails of the distribution make it useful in some risk measurement situations, where the uncertainty is high.

From 1915, another period of development of statistical theory began, led by people like *R A Fisher*. They worked on sampling theory, development of distributions of many sample statistics, principles of hypothesis testing and analysis of variance. Analysis of variance is a technique to test the equality of three or more sample means and thus make inferences as to whether the samples come from populations having the same mean. Essentially, in this technique, the means of more than two samples are compared. In 1925, Fisher published his book, "*Statistical Methods for research workers*," the first textbook presentation of the analysis of variance.

Yet another period of development of statistical theory began in 1928. Led by *Jerzy Neyman* and *Egon Pearson*, the work of this period included concepts such as Type II error[19], power of a test and confidence intervals. Statistical quality control techniques were also developed during this period.

In 1939, *Abraham Wald* developed statistical decision theory. This is useful in situations where the decision maker wants to reach an objective, there are several courses of action each having a certain value, events are beyond the control of the decision maker and there is uncertainty regarding which outcome or state of nature will happen. Essentially, managers decide among alternatives by taking into account the financial implications of their actions.

Frank Knight, an economist at the University of Chicago published a book *Risk, Uncertainty and Profit*, in 1921, that dealt with decision making under uncertainty. Knight attempted to draw a distinction between uncertainty and risk: "Uncertainty must be taken in a sense radically distinct from the familiar notion of risk, from which it has never been properly separated…It will appear that a measurable uncertainty, or risk proper is so far different from an unmeasurable one that it is not in effect an uncertainty at all." Knight argued that it was difficult and not always appropriate to apply mathematical techniques for forecasting the future. He was also doubtful whether the frequency of past outcomes could be any guide to the future. As Knight put it: "(Any given) instance – is so entirely unique that there are no others or not a sufficient number to make it possible to tabulate enough like it to form a basis for any inference of value about any real probability in the case we are interested in."

In 1921, the famous economist *John Maynard Keynes* compiled a book, "A treatise on probability." Like Knight, Keynes was not in favour of taking decisions based on the frequency of past occurrences. He felt that there was no certainty an event would occur in the future just because a similar event had been observed repeatedly in the past.

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[19] The assumption being tested is called the null hypothesis. Rejecting a null hypothesis when it is true is called a Type I error and accepting it when it is false called a Type II error.

In the decades that followed, understanding of risk and uncertainty advanced in the form of game theory. The utility theory of Daniel Bernoulli had assumed that individuals made their choices in isolation. *Game theory*, on the other hand, accepted that many people might try to maximise their utility simultaneously. The true source of uncertainty lay in the intentions of others. Decisions were made through a series of negotiations in which people tried to minimise uncertainty by trading off what others wanted with what they themselves wanted. Since the potentially most profitable alternative often led to very strong retaliation by competitors, compromises made sense.

John von Neumann, who invented game theory first presented a paper on the subject in 1926. Later, Von Neumann teamed up with German economist *Oskar Morgenstern* and published a book, *Theory of Games and Economic Behaviour*. They advocated the use of mathematics in economic decision–making.

In 1952, *Harry Markowitz* published an article called 'Portfolio Selection' in the Journal of Finance. The article brought Markowitz the Nobel Prize for Economics in 1990. Markowitz's key insight was the important role of diversification. The return on a diversified portfolio of stocks is equal to the average of the rates of return on individual holdings but its volatility is less than the average volatility of its individual holdings. So, instead of going for a killing by investing in a single stock, investors could decrease their risk, by diversifying. Markowitz used the term efficient to describe portfolios that offered the best returns for a given risk. Each efficient portfolio gives the highest expected return for any given level of risk or the lowest level of risk for a given expected return. Rational investors can choose the portfolio that best suits their appetite for risk. Later, *William Sharpe* developed the Capital Asset Pricing Model which explained how financial assets would be valued if investors religiously followed Markowitz's instructions for building portfolios. *Sharpe* too won the Nobel Prize in 1990.

As we saw earlier in the chapter, two Israeli psychologists, *Daniel Kahneman* and *Amos Tversky,* pioneered the development of behavioral finance. They conducted in-depth research into how people managed risk and uncertainty. Their *Prospect theory*, which evolved in the mid-1960s, discovered behavioural patterns that had not been recognised by proponents of rational decision making. Kahneman and Tversky argued that human emotions and the inability of people to understand fully what they were dealing with stood in the way of rational decision making. One of the most important insights from Prospect theory was the asymmetry between decision-making situations involving gains and those involving losses. Where significant sums were involved, most people rejected a fair gamble in favour of a certain gain.

When Kahneman and Tversky offered a choice between an 80% chance of losing $400, and a 20% chance of breaking even and a 100% chance of losing $300, 92% of the respondents chose the gamble, even though the expected loss at $320 was higher. But when they had to choose between an 80% chance of winning $400 and a 20% chance of winning nothing and a 100% chance of winning $300, 80% of the respondents preferred the certain outcome.

According to Tversky: "Probably the most significant and pervasive characteristic of the human pleasure machine is that people are much more sensitive to negative than to positive stimuli… Think about how well you feel today and then try to imagine how much better you could feel… There are a few things that would make you feel better, but the number of things that would make you feel worse is unbounded."

Exhibit 1.11
Evolution of Analytical Risk Management tools

1938	Bond duration
1952	Markowitz mean variance framework
1963	Beta
1966	Multiple factor models
1973	Black Scholes, Greeks
1983	Risk adjusted return on capital
1986	Limits on exposure by duration
1988	Limits on Greeks
1992	Stress testing
1993	Value-at-Risk
1994	Risk Metrics
1997	Credit Metrics
1998	Integration of credit & market risk
2000	Enterprise wide risk management

Source: Philippe Jorion[20], "Value at Risk: the new benchmark for managing financial risk."

Kahneman and Tversky coined the term 'failure of invariance' to describe inconsistent choices when the same problem is expressed in different ways. For example, the way a question is framed in an advertisement may persuade people to buy something with negative consequences. In a 1992 paper summarising the advances in Prospect Theory, Kahneman and Tversky commented: "Theories of choice are at best approximate and incomplete… Choice is a constructive and contingent process. When faced with a complex problem, people… use computational shortcuts and editing operations."

Even as efforts continued to develop a better understanding of risk and new risk management techniques, the environment changed dramatically in the 1970s and 1980s. Financial deregulation, inflation, volatility in interest and exchange rates and commodity prices all combined to create an environment where the conventional forms of risk management were ill equipped. US dollar long-term interest rates, which had been in the range 2-5% since the Depression, rose to 10% by the end of 1979 and to more than 14% by the autumn of 1981. Economic and financial uncertainty also had an impact on commodity prices. The term "Risk Management" became more commonly used in the 1970s. The first educational qualifications in risk management were provided in the US in 1973. The US Professional Insurance Buyers Association changed its name to the Risk and Insurance Management Society (RIMS) in 1975.

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[20] McGraw Hill, 2007.

In the early 1970s, *Fischer Black* and *Myron Scholes* completed the development of their famous option pricing model. *Robert C Merton* made important additions to the model. The paper submitted by Black & Scholes was rejected by some reputed journals before being published in the May/June 1973 issue of the relatively unknown publication, *The Journal of Political Economy.* Black and Scholes constructed a risk free portfolio that replicated the pay offs of an European call option. By equating the return on the portfolio with the risk free return and by making suitable assumptions about the distribution of stock prices, they were able to set up a differential equation and develop their famous model. Merton played a key role in solving the differential equation.

As stock options began to be traded at the Chicago Board of Exchange and electronic calculators came into the market, the Black Scholes Model found rapid acceptance. The model made a number of simplifying assumptions. The stock paid no dividends during the option's life. Options were of the European type. Markets were efficient. No commissions were charged. Interest rates remained constant and known. Returns were lognormally distributed.

In 1973, Merton relaxed the assumption of no dividends. Three years later, Jonathan Ingerson relaxed the assumption of no taxes and transaction costs. In 1976, Merton removed the restriction of constant interest rates. For their pioneering contribution, Scholes and Merton won the Nobel Prize in 1997. Unfortunately, Black died before the award was announced. Even though Black did not win the Nobel Prize, he played a stellar role in taking many academic concepts to Wall Street. Closely associated with Goldman Sachs, Black played a crucial role in strengthening that investment bank's quantitative abilities.

Even in the late 1980s, despite the several advances made and the development of exciting computational techniques, risk management remained unsystematic in large companies. The establishment of risk management departments in the late 1980s and early 1990s was mainly to cut costs. Non financial risk management essentially meant managing insurable risks such as physical hazards and liability risks.

Meanwhile, the use of derivatives by corporates, banks and speculators increased, resulting in some classic cases of misuse and fraud. Between 1984 and 1995, the actions of trader, Toshihide Iguchi, while trading in US bonds, cost Daiwa Bank more than $1 billion. Due to unauthorised dealing by Peter Young, Deutsche Morgan Grenfell lost a similar amount. Three famous case studies Metallgesellschaft, Barings and Sumitomo, merit a more detailed examination.

Metallgesellschaft offered customers contracts to supply heating oil and gasoline over a 5/10 year period at a fixed price. Customers could exit the contract if the spot price rose over the fixed price in the contract. Then the company would pay the customer half the difference between the futures prices and the contract price. Customers would exercise the option if they did not need the product or if they experienced financial difficulties. These contracts essentially created for Metallgesellschaft a short position in long term forward contracts. To hedge this exposure, the company bought futures contracts with

the same expiry date. Prior to the delivery, the firm would liquidate the futures and buy another set of futures with longer expiration. Metallgesellschaft had to use such a strategy because there were no alternatives in the forward market and long term futures contracts were illiquid. Unfortunately, the company incurred losses on its futures positions for which margin calls had to be met immediately. Whereas the gains on the customer contracts would not be realized for years. Thus, even though the positions were fundamentally sound and hedged, the company ran into funding liquidity risk.

In 1995, Barings, Britain's oldest merchant bank went bankrupt because of the risky deals of a reckless trader, Nick Leeson. The problems at Barings were the result of poor checks and balances. Leeson succeeded in grossly misrepresenting his situation. In 1994, Leeson lost an estimated $296 million but reported a profit of $46 million to the management. Leeson's trading had two broad planks – selling straddles on Nikkei 225 and taking advantage of the different prices of Nikkei futures contracts trading on different exchanges. Later, Leeson shifted to a speculative long position on Nikkei futures. When the Nikkei plunged, following the Kobe earthquake of January 1995, Leeson's losses mounted. Leeson was able to get away with his erratic behaviour because he was in charge of both the front office and the back office. He used his clout to ensure that Baring's top management did not come to know about his activities.

The actions of Yasuo Hamanaka, who tried to manipulate copper prices cost Sumitomo Corporation dearly. Hamanaka took a long position in futures contracts and simultaneously purchased copper in the spot market. His aim was to establish a stranglehold on the copper market and create an artificial shortage so that the price of copper would have to go up. People with short positions would have to pay a large premium to unwind their positions. Hamanaka also sold put options. But plummeting copper prices resulted in a $2.6 billion trading loss and a $150 million fine for Sumitomo, from the Commodity Futures Trading Commission. Lack of proper internal controls had cost Sumitomo dearly.

From the mid-1990s, a new approach to risk management began to take shape in many corporates. The focus shifted from external hazards to business risks. Risk management also attempted to become more proactive and to ensure better cross-functional coordination. The range of risks companies faced also increased significantly. Branding, mergers and acquisitions, succession planning, intellectual property rights and antitrust rules are all areas where sophisticated risk management has become crucial in recent times.

Thus, we have come a long way in our attempts to develop new and more sophisticated techniques of dealing with risk. Yet, as Bernstein puts it[21], mathematical innovations are only tools. And tools must be handled carefully. "The more we stare at the jumble of equations and models, the more we lose sight of the mystery of life – which is what risk is all about. Knowing how and when to use these tools is the introduction to wisdom." The sub prime crisis has adequately demonstrated that if mathematical models are mechanically used without exercising judgment and intuition, the result can be disaster.

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[21] Financial Times Mastering Risk, Volume I.

In other words, there is no magic formula yet available to eliminate risk. No model will be able to predict the future correctly. Managers will continue to be respected for their intuitive skills. But the aim of risk management is to ensure that intuition is backed by numbers wherever possible.

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Chapter - 2
The Global Financial System: A macro view of risk

"Specific national banking crises in the past have been more severe – for instance the collapse of the US banking system between 1929 and 1933. But what is unique about this crisis is that severe financial problems have emerged simultaneously in many different countries and that its economic impact is being felt through the world, as a result of the increased interconnectedness of the global economy."
    The Turner review – A regulatory response to the global banking crisis, March 2009.

Introduction

The sub prime crisis has generated considerable debate about the risks in the global financial system and how they need to be managed. Why did the crisis assume such huge proportions? What went wrong with policy making and regulation? Why did it take such a long time to bring the situation under control? Why did banks make such unprecedented losses? What could banks have done to contain if not avoid completely the damage? What are the structural problems with the global financial system? How can they be addressed? These are the questions which are being discussed today by journalists, academics, practitioners and policy makers.

Before we attempt to find answers to these questions, it is a good idea to look at how the modern financial system has evolved in the past 600 years or so. For obvious reasons, we will look at only some epochal events.

We will draw here heavily, from a crisp and insightful article, "Link by Link," which appeared in the October 18, 2008 edition of the *Economist* and a survey of the world economy which appeared in the October 11, 2008 edition of the same magazine. We will also draw heavily from the work of Niall Fergusson, whose recently published book, "The ascent of money," is a must read for all those who want to understand how the financial system has evolved over time.

Money & Banking[22]

For thousands of years, because they were available, affordable, durable, fungible, portable and reliable, metals such as gold, silver and bronze served as money. Coins have been traced to 600 BC at the Temple of Artemis at Ephesus (modern Turkey). By the time of the Roman Empire, coins were made in gold, silver and bronze. A standardized coin was introduced in China in 221 BC. Silver coins were used during the time of Charlemagne. But a shortage of silver created problems in the circulation of money. Indeed, one of the objectives of the *Crusades* was to overcome the shortage of money. Similarly, the Spanish conquistadors plundered silver in Mexico. Today of course, we are less dependent on precious metals. We use mostly paper money and electronic money, thanks to the establishment of a sophisticated banking and clearing system.

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[22] Pg. 1- 6 draw heavily from Niall Fergusson's highly insightful book, "The Ascent of Money."

Money and banking go together. While banks have existed in some form or the other since ancient times, the evolution of modern banking can be traced to the Renaissance. In the early 14th century, finance in Italy was dominated by the three Florentine houses of Bardi, Peruzzi and Acciaiuoli.   But it was the Mediccis who made a huge impact on the business environment during the time of the Renaissance. Starting off as foreign exchange dealers, they began to use *Bills of Exchange* in a big way. If a sum could not be paid in cash until the conclusion of a transaction, the creditor could draw a bill of exchange on the debtor. The bill could be used as a means of payment or to obtain cash at a discount from a banker willing to act as a broker. *Bill discounting* was an important innovation. The Church condemned the charging of interest but approved bill discounting transactions. The Mediccis built upon their success and made their banks bigger and more diversified than any previous financial institutions. The banking system that the Mediccis pioneered in Italy became a model for other countries in Northern Europe.

The next wave of financial innovation occurred in Amsterdam, London and Stockholm. The Amsterdam Exchange Bank, set up in 1609, introduced the system of cheques and direct debits/transfers. A merchant could make a payment to another simply by debiting his account at the bank and crediting the counterparty's account. But the Exchange bank maintained close to 100% ratio between its deposits and reserves.

It was the Swedish Riksbank set up in 1656 that introduced *credit creation*. By lending amounts in excess of its metallic reserves, the bank pioneered the concept of *fractional reserve banking*. Since depositors were unlikely to ask back their money en masse, only a fraction of the money was needed to be kept as reserve at any point of time.

The Bank of England was set up in 1694 to assist the British government with war finance. The Bank had a partial monopoly on the issue of bank notes. These were essentially promissory notes that did not bear interest and were designed to facilitate payments without the need for both parties in a transaction to have current accounts. The Bank of England's discount rate increasingly became the benchmark interest rate in the money market.

With the growing popularity of cashless transactions, fractional reserve banking and central bank monopolies on note issue, the nature of money evolved in an important way. Credit was quite simply the total of the bank's assets (loans). Most of it existed in the form of bank notes and token coins recognized as legal tender along with the invisible money that existed only in deposit account statements.

Banks were realizing that increasingly the critical success factors were information gathering and risk management. Banks had to maximize the difference between the returns on their assets and the costs incurred on their liabilities while taking care to maintain adequate reserves and avoid a run on the bank. Banks also realized the need to specialize and develop capabilities in specific areas. Several kinds of banks emerged in Europe. Bill discounting banks helped finance domestic and international trade by discounting the bills of exchange drawn by one merchant on another. For example, Barings specialized in transatlantic merchant banking. After 1858, the restrictions on

joint stock banking were lifted. This paved the way for the emergence of large commercial banks like London & Westminster (1833), the National Provincial (1834) the Birmingham and Midland (1836), Lloyds (1884) and Barclays (1896).

Meanwhile, many European countries set up central banks – Banque de France (1800), German Reichsbank (1875), Bank of Japan (1882) and Swiss National Bank (1907). Compared to other western nations, the US was quite late to establish a central bank. The country followed a laissez faire model that encouraged large numbers of under capitalized banks. The fragmented system was essentially a recipe for financial instability. Panics were a regular feature of American economic life. Only after the Federal Reserve System (Fed) was set up in 1913, following the crash of 1907, a strong regulatory framework emerged.

The Great Depression was the next watershed event. The Fed's role during the Great Depression became controversial. By sterilizing the large gold inflows into the US and preventing them from increasing money supply, the Fed did prevent the bubble from growing bigger. But later, the Fed did too little to counter the credit contraction caused by banking failures. In November and December 1930, 608 banks failed. The Fed made matters worse by reducing the amount of credit outstanding. Banks started selling assets in a frantic dash for liquidity, driving down the bond prices. When Britain abandoned the Gold standard in September 1931, foreign banks were in a rush to convert their dollar holdings into gold. The Fed raised its discount rate in two steps to 3.5%. This halted the external drain but caused many more bank failures. Between 1929 and 1933, commercial bank deposits and loans reduced, while the cash in public hands increased significantly. No wonder, the conditions were ripe for a deflation.

The introduction of deposit insurance in 1939 went a long way towards preventing bank runs. However, the American banking sector remained fragmented till 1976 when inter state banking was legalized. And it was only after the Savings & Loan crisis (1993) that the number of national banks fell below 3600 for the first time in nearly a century.

By the 1980s, central banks seemed to have learnt from experience and looked quite equipped to handle financial bubbles. For example, on October 19, 1987, the Dow Jones fell by 23%. But in about a year, the Dow came back to where it had been before the crash, thanks to the Fed's response. Fed chairman, Alan Greenspan announced the Fed was ready to serve as a source of liquidity. The Fed injected cash into the system and reduced the cost of borrowing by nearly 2% in a space of 16 days. In the two decades that followed, Greenspan and other central bankers maintained their awesome reputation for keeping inflation in check and maintaining steady growth of the global economy barring some minor slow downs. But the particularly benign period 2003-07 proved to be a lull in the storm.

Exhibit 2.1

Expansion of central bank balance sheets

(percent of GDP)

Source: IMF International Financial Statistics, Bank of England.

Note: As at end of December.

Ref: Reserve Bank of New Zealand Financial Stability Report, May 2009, www.rbnz.govt.nz

After the sub prime crisis, the role of central banks has come for intense scrutiny and debate. The functioning of commercial and investment banks is also likely to undergo a major overhaul. How should they manage risk? How much capital must they have? What kind of business model makes sense? Should banks be focused or should they develop a diversified business portfolio? These are some of the questions being debated intensely.

Bond and Equity markets

If the creation of credit by banks marked the first revolution in the ascent of money, the birth of the bond market was the second. Bond markets play a crucial role in the financial system. These markets, which are much larger than the equity markets not only attract bulk of the savings but also set long term interest rates for the economy as a whole.

Strangely enough, it was wars that fuelled the rise of bond markets. Financial strength often determined who won a war. The concept of financing wars through Government debt was pioneered by Italy. The Italian city states contributed in a big way to the rise of the bond market. Soon the innovation spread to other parts of Europe. In London, by the mid 18th century, there was a thriving bond market in which government consoles (perpetual bonds) were the dominant securities traded.

Nathan Rothschild, one of the pioneers of investment banking established himself as the master of the London bond market through a combination of audacity and luck. Rothschild had accumulated a lot of gold for the Battle of Waterloo, anticipating huge funding requirements. But the battle got over too quickly. Rothschild who was long on gold was almost at the point of being financially wiped out, since the gold market looked all set to crash. But he also saw that British government borrowing would reduce,

leading to a rise in prices of British bonds. Rothschild piled up plenty of UK government bonds and sold them at a profit of £ 600 million after the prices had gone up by 40% by 1817. This paved the way for the emergence of a well capitalized investment bank which would spread its tentacles across Europe.

The American Civil war was another defining moment in the history of bond markets. The Rothschilds played an important role in deciding the outcome of the Civil War, by deciding not to back the south. The bonds of the south were marketed on the backing of the cotton crop in the region. The south also successfully engineered a rise in the price of cotton by restricting supply. But when New Orleans fell, doubts about the ability of the south to ship cotton grew. The south's cotton backed bonds had few takers. Those who had invested in the Confederate bonds ended up losing everything since the victorious North decided not to honour the debts of the south. The south was forced to print money leading to a run away inflation.

With a strong capital base and an excellent information network, the Rothschilds were the preferred investment bank to place many bond issues of European governments. Typically, the Rothschilds would buy a tranche of bonds outright from a government and charge a commission for distributing these bonds to a network of brokers and investors throughout Europe.   They enjoyed a good spread between the price paid to the government and the price paid by investors. Global bond issues were not unknown even those days.   For example, the initial public offering of Prussian bonds was made simultaneously in London, Frankfurt, Berlin, Hamburg and Amsterdam.

Exhibit 2.2
Volatility in Stock Markets
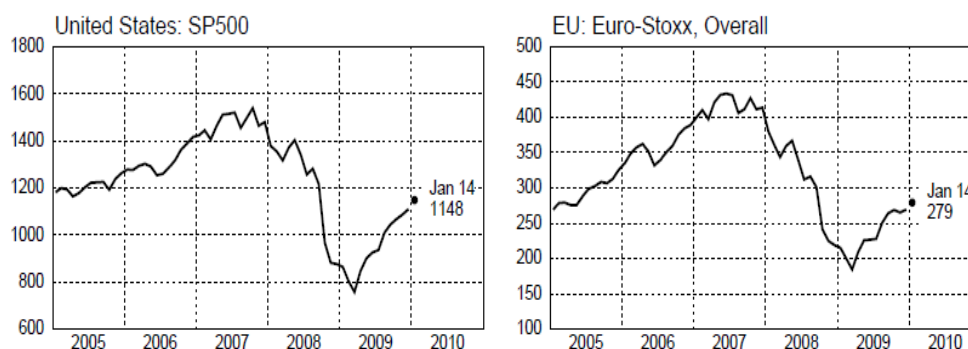
Source: New York Fed. www.newyorkfed.org

In the past 10 years, the bond markets have exploded in scale and complexity. Between 2000 and 2010, the US bond market debt nearly doubled in size. As we shall see shortly, this boom was atleast in part due to the savings glut in Asia which flooded the US financial system with excess liquidity. Financial innovations introduced by the quants, including credit derivatives and collateralized debt obligations facilitated the repackaging and trading of debt more actively than ever before. Indeed, investor demand for various innovative debt instruments lowered the cost of consumer loans and helped fuel a credit bubble. Despite the burst of the bubble, following the financial crisis, the debt markets, continue to be a beehive of activity. In 2008 and 2009, governments and central banks

have flooded the financial system with liquidity as a desperate measure to keep away deflation. So banks like Goldman Sachs have capitalized on lucrative trading opportunities to borrow at very low rates and invest in high yield assets. At the same time with banks cutting on lending, companies have rushed to tap the bond markets. Meanwhile, the bourgeoning budget deficits of several western nations have prompted governments to issue sovereign bonds. In 2009, some $12 trillion worth of sovereign bonds were issued by developed nations.

After banking and bond markets, the next step in the evolution of modern finance was the rise of the joint stock limited liability corporation, whose shares traded on the markets. The share prices were determined by investors' perceptions about the quality of management, appeal of the company's products and future prospects for the firm. These markets also began to tell a lot about where the economy was headed. A rising stock market often signaled an economic boom while a falling one indicated a recession was likely ahead.

In the 400 years since share trading began, there have been several booms and busts, one of the more recent ones being the dotcom bust of the early 2000s. In 2000, the equity markets seemed to be headed for good times. In the years preceding the new millennium the stock markets had risen smartly aided by the internet revolution and a wave of mergers and acquisitions. Since then equity markets have produced less than satisfactory returns. A dollar invested in the S&P 500 Index in 2000 would only be worth 89 cents today.

Typically bubbles start when some change in economic circumstances creates new and profitable opportunities for some companies. Rising expected profits lead to a rise in stock prices. The prospect of easy capital gains attracts first time investors and fly by night operators. At some point, the insiders realize that expected profits cannot justify the exorbitant prices of shares and begin to book profits by selling. As share prices fall, investors head for the exit and the markets begin to crash. Bubbles are more likely to occur when capital can flow freely across countries. Bubbles are also facilitated by easy credit creation. Many bubbles have been the result of the policies of central banks.

Insurance
The history of insurance[23] is fascinating. How many of us are aware two Church of Scotland ministers invented the first true insurance fund more than 250 years ago in 1744? We will examine how this happened a little later.

By the late 17th century, conditions favourable to the emergence of a dedicated insurance market had emerged in London. After the Great Fire of 1666, fire insurance took off. As global trade picked up and international voyages increased, a specialized marine insurance market began to develop around Edward Lloyd's Coffee House on London's Tower Street. In 1774, the Society of Lloyd's was established to bring together 79 life members each of whom paid a £ 15 subscription. The liability of the underwriters was

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[23] We covered this briefly in Chapter 1.

unlimited. The financial arrangements could be described as pay-as-you-go. The aim was to collect sufficient premiums in a year to cover that year's payments and leave a margin of profit.

Most of the insurance schemes which existed early on were adhoc and poorly designed. No adequate theoretical basis existed for evaluating the risks that were being covered. Then there were some major breakthroughs. Blaise Pascal and Pierre de Fermat developed important concepts in probability. In 1662, John Graunt published his landmark findings on mortality statistics. Later, Edmond Halley recorded the life tables. In 1705, Jacob Bernoulli developed the law of large numbers. Inferences could be drawn with a degree of certainty from sufficiently large samples. Meanwhile, Abraham de Moivre came up with the normal distribution.

It was not merchants but mathematicians who came up with the innovations that were needed for insurance to take off. And it was clergymen not merchants who first converted theory into practice. Ministers Robert Wallace and Alexander Webster, along with Colin Maclaurin, a professor of mathematics concluded that having ministers pay an annual premium which could be used to take care of their widows and orphans was not a sustainable arrangement. They realized that the premiums must be profitably invested to generate adequate returns. The beneficiaries would be paid out of the returns on the investment. What was needed was an accurate projection of how many beneficiaries there would be in the future and how much money would be generated to support them.

The Scottish Ministers' Widows Fund was a major milestone in financial history. Soon similar funds were set up in other parts of the English speaking world. Over time, insurance companies became some of the biggest investors in the world's financial markets. As insurance companies became bigger, it became easier by the law of averages, to predict the pay out each year. The development of actuarial science facilitated the calculation of the likely life expectancies of a large group of individuals with great precision.

Today we have other sophisticated derivatives like credit default swaps to insure against credit risk and weather derivatives to offset the effects of extreme temperatures. Along with a number of exchange traded instruments, various OTC derivatives have also been launched.

The real estate market
The real estate market, which trigged off the recent global meltdown is unique. For most people, the home is the most precious possession. And for banks, mortgage lending is very attractive. After all, the borrower can be expected to do whatever is necessary to prevent the house from being seized by the banker in the event of a default. Indeed, in finance, the conventional wisdom is that there is nothing safer than lending money to people with property. If people default on the loan, the house can be repossessed. And even if people run away, the house will remain where it is! From 1959, total mortgage debt outstanding in the US rose seventy five fold, at the height of the sub prime boom.

By the end of 2006, American owner occupiers owed a sum equal to 99% of US GDP, compared to 38%, about 50 years back.

The US must take much of the credit for the democratization of home ownership. Till about 100 years back, housing was the exclusive privilege of an aristocratic elite. Before the 1930s, only about 40% of American households belonged to owner occupiers. Mortgages were short term, usually for three to five years. People paid interest and the principal was returned at the end of the tenure of the loan. The people who borrowed money to buy homes in the 1920s, found themselves in deep trouble when the Great Depression arrived.

President Roosevelt's New Deal radically increased the opportunity for Americans to own homes. The Home Owner's Loan Corporation was set up to refinance mortgages on longer terms upto 15 years. The Federal Home Loan Bank Board, set up in 1932, encouraged a new breed of institutions called Savings and Loans that mobilised deposits and gave loans to home buyers. Federal deposit insurance was introduced to prevent bank runs. By providing federally backed insurance for mortgage lenders, the Federal Housing Administration (FHA) sought to encourage large fully amortized and low interest loans. And by standardizing long term mortgages and creating a national system of official inspection and valuation, the FHA laid the foundation for a national secondary market.

Three other institutions helped the US mortgage market to grow in size and importance. Fannie Mae was set up to issue bonds and use the proceeds to buy mortgages from Savings and Loans. In 1968, Fannie Mae was split into the Government National Mortgage Association (Ginni Mae) to serve less affluent borrowers like military veterans and a redefined Fannie Mae which acting as a privately owned but government sponsored enterprise could buy conventional as well as government guaranteed mortgages. A couple of years later, the Federal Home Loan Mortgage Corporation (Freddie Mac) was set up.

With the Community Reinvestment Act of 1977, American banks came under government pressure to lend to the poorer minority communities. And as the average monthly payment on a mortgage came down, home ownership became a realizable dream for Americans. The boom looked all set to continue when, a temporary set back to the system came in the 1980s in the form of the Savings and Loans (S&L) crisis.

A brief note on the S&L crisis is in order here. Till the 1980s, the relatively high inflation prevailing, ensured a really good time for borrowers. Even as the real value of loans declined, property prices almost tripled between 1963 and 1979. The S&Ls thrived due to the favourable circumstances. When the Fed started to tighten its monetary policy under Chairman Paul Volcker, in a bid to cut inflation, the S&Ls were at the receiving end. They were losing money on long term fixed mortgages because of inflation. At the same time, they were losing fixed deposits to higher interest paying money market funds. The S&Ls were given freedom to invest in various instruments. At the same time, their deposits were insured. This gave them a reprieve but created a moral hazard problem.

Many S&Ls collapsed because of reckless lending. The final cost of the S&L crisis between 1986 and 1995 was $153 billion or 3% of GDP of which tax payers had to foot $124 billion. This was the most expensive financial crisis since the Depression, though in terms of magnitude, it was quite manageable. Certainly far more manageable than the recent meltdown!

The S&L crisis could not dampen the animal spirits for long. Indeed, the fall of S&Ls gave birth to another idea – securitization. Lewis Ranieri of Salomon Brothers pioneered the concept of bundling thousands of mortgages together and repackaging them into new securities that could be sold at attractive yields compared to government and corporate bonds. After the mortgages were bundled, the interest payments could be sub divided into strips with different maturities and credit risks. Thus came into being collateralized mortgage obligations (CMO). The first CMO issue happened in June 1983. Since bulk of the mortgages enjoyed an implicit guarantee from the Government sponsored enterprises (GSE), Fannie Mae, Freddie Mac and Ginnie Mae, the bonds used to securitise were perceived as government or investment grade bonds. Between 1980 and 2007, the volume of GSE backed mortgage backed securities grew from $200 million to $4 trillion. When private bond insurers emerged, even mortgages without GSE guarantees could be securitized. In 1980, only 10% of the home mortgage market had been securitized. By 2007, this had risen to 56%. Indeed, sub prime mortgages could not have taken off without securitization.

A word on sub prime mortgages is in order here. (Please see Chapter 3 for a more detailed account.) These mortgages were aimed at people with a poor credit history ie., borrowers who did not have a track record and who typically did not have the income to service a mortgage loan. But they were hoping that house prices would go up enabling them to refinance the loans under more attractive conditions. In return, the lender "softened up" the initial lending terms. Many of these mortgages were adjustable rate mortgages where the interest rates would vary according to changes in short term lending rates. Most had introductory teaser periods when the interest rate was kept artificially low.

The political leadership played no small role in giving an impetus to the sub prime market. President George Bush's American Dream Down Payment Act of 2003 began to subsidise first time house purchases by lower income groups. Lenders were encouraged not to press borrowers for full documentation. Pressure was also put on Fannie Mae and Fraddie Mac to support the sub prime market.

The sub prime market worked fine as long as interest rates stayed low, the economy continued to boom, people retained their jobs and real estate prices continued to rise. Subprime lenders pocketed fat commissions and then sold the loans to Wall Street banks who bundled them into securities and repackaged them as CDOs. Investors all over the world bought these instruments for a few additional basis points return on their capital. Securitization received the implicit support of regulatory authorities. It seemed to be an effective mechanism for allocating risk to those best able to bear it. But actually, risk was passed on to people who understood the least about it. The people, who dealt

directly with the borrowers and knew the most about the loans, bore the least amount of risk.

Looking back, the real estate market had become a big bubble which had to burst at some point of time. In cities all over the world, house prices soared far above levels that could be justified in terms of rental income or construction costs. There was irrational exuberance about real estate and the capital gains it could yield. Politicians fuelled the boom by encouraging home ownership and introducing suitable policy measures. And many middle class households defied the basic principles of risk management to put virtually all their income into one big highly leveraged investment.

The rise and fall of Bretton Woods[24]

We now turn to how the global financial markets have evolved in the past 100 years. The first and second world wars created a period of instability. And the end of the second world war marked a turning point in geo politics. Global economic and military leadership passed from Britain, till then the colonial super power, to the United States. This transition was marked by the replacement of the sterling by the dollar as the world's reserve currency. The Bretton Woods deliberations in which most leading countries of the world took part, gave a final seal of approval to this arrangement. Effectively, the outcome of Bretton Woods was that the currencies of the world were pegged to the US Dollar. The US in turn stood ready to convert dollars into gold on demand. Clearly, the system depended heavily on the credibility of the dollar as an international reserve currency.

But Bretton Woods had some inherent contradictions. Slowly but surely, the "Triffin paradox" began to operate. In a world where transactions were to be conducted largely in dollars, all countries other than the US had a strong incentive to accumulate dollars by running trade surpluses with the US. The Yale economist Triffin predicted this would lead to a bourgeoning and unsustainable trade deficit for the US. As this happened, the supply of dollars in the global financial markets would keep increasing and the credibility of the dollar would be eroded. So Bretton Woods would become increasingly difficult to sustain.

Thanks to relative stability in the global economy and the overwhelming dominance and confidence of the US, war ravaged nations like Japan and Germany rebuilt their economies through a policy of exports. And the Bretton Woods arrangement continued satisfactorily for a long time. The credibility of the dollar remained high. For countries all over the world, the dollar was as good as gold. But as predicted by Triffin, over time, the US piled up huge trade deficits, leading to a global imbalance. Strangely enough, while countries outside the US were happy to play along, it was the Americans who began to realise they were being taken for a ride. The Americans began to ask a fundamental question: "Why are we running a huge trade deficit for others and in the process losing jobs?" In 1971, Richard Nixon sought to solve the problem by suspending

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[24] Pg. 9-12 draw heavily from the article, "Link by Link," *The Economist,* October 18, 2008.

the dollar's convertibility into gold. The dollar quickly depreciated. The end of Bretton Woods marked a major turning point in the global financial system.

Exhibit 2.3
Volatility in the Forex Markets
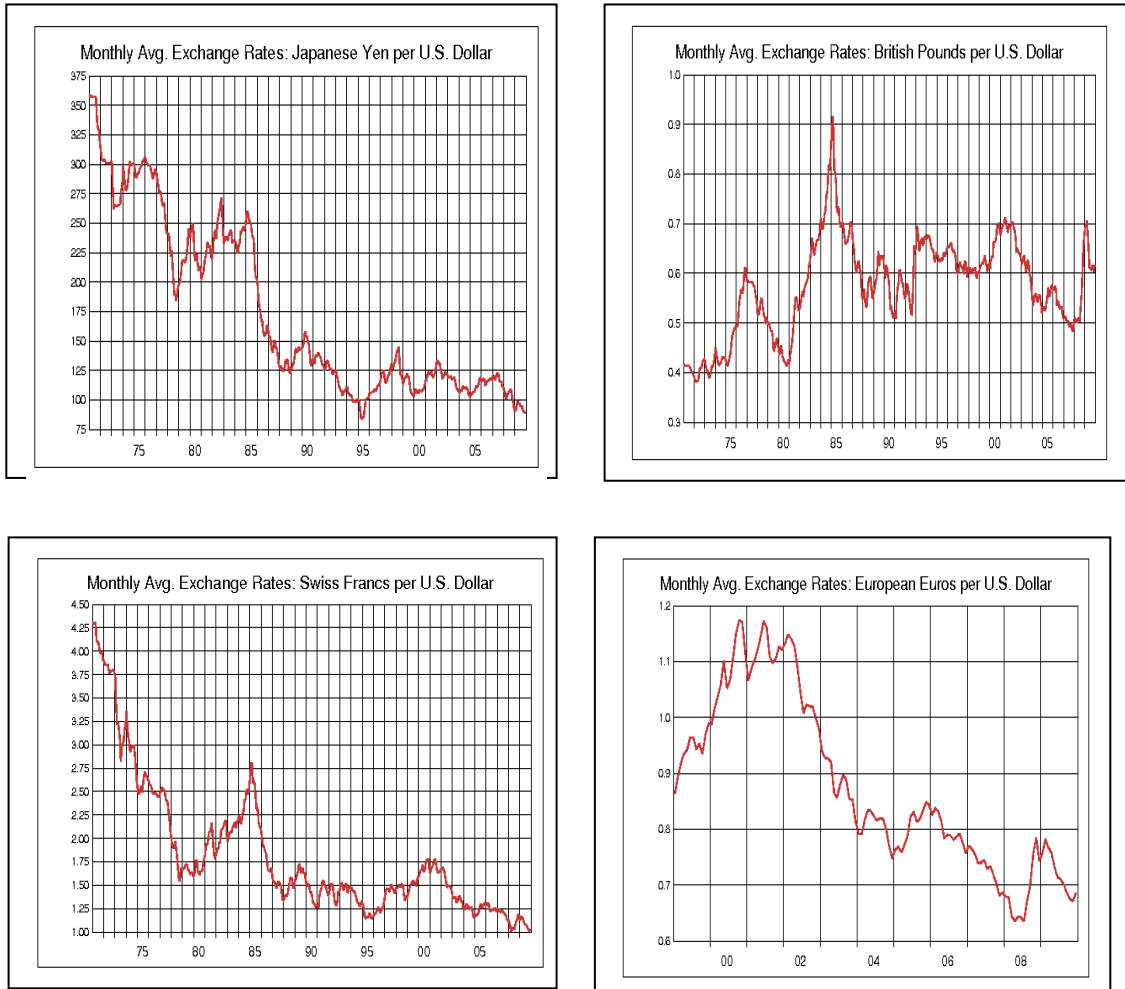
Source: Pacific Exchange Rate Service, Prof. Werner Antweiler, University of British Columbia, Vancouver BC, Canada, fx.sauder.ubc.ca.

When the dollar started to float, other countries soon followed. Once currencies began to float, the world changed. Companies with costs in one currency and revenues in another needed to hedge exchange-rate risk. And as currencies became convertible, cross border capital flows became a reality. While the integration of the global economy created various benefits, it also injected volatility into the system. Looking back, this phase marked another turning point in the history of global finance in general and risk management in particular.

Deregulation and innovation

Political leadership plays an important role in the way markets are shaped and regulations evolve. After the economic turmoil of the 1970s, the market economy found passionate champions in Ronald Reagan and Margaret Thatcher. Believing that freer markets would

bring economic gains, they took the plunge and abolished various controls. Both Reagan and Thatcher, with their no non sense approch had a lot of fan following. Liberalisation of the financial system soon became a major theme in many developed countries.

In London, the Big Bang of 1986 abolished the distinction between brokers and jobbers and allowed foreign firms, with more capital, into the market. These firms could handle larger transactions, more cheaply. The Big Bang undoubtedly played a big role in the emergence of London as a preeminent global financial centre. Meanwhile, the No.1 financial centre in the world, New York had already introduced a similar reform in 1975, following pressure from institutional investors.

These reforms had major implications for the business models of market participants. The fall in commissions contributed to the long-term decline of broking as a source of revenue. The effect was disguised for a while by a higher volume of transactions. But the broker-dealers (the then popular name for investment bankers) increasingly had to commit their own capital to deals. In turn, this made trading on their own account, or *proprietary trading,* a potentially attractive source of revenue. No bank made more impressive strides in this area, than Goldman Sachs.

Meanwhile, commercial banks faced intense competition in corporate lending. At the same time, retail banking required expensive branch networks. Naturally, commercial banks wanted to diversify into more lucrative "fee based" businesses. With their strong balance-sheets, they started to compete with investment banks for the underwriting of securities. Investment banks responded by getting bigger. As banks became more diversified, they also became more complex.

As the same time, there were major advances in risk management thanks to innovative financial instruments and sophisticated quantitative techniques. Option contracts have been known since ancient times but the 1970s saw an explosion in their use. The development of the Black Scholes Merton Option Pricing Model, for which Myron Scholes and Robert Merton later won the Nobel Prize, no doubt played an important role. While Black Scholes enabled options trading to take off, other derivatives also became rapidly popular. Currency swaps and interest-rate swaps enabled hedging and speculation in currency and interest rate risk respectively. More recently, credit derivatives have made possible the slicing and dicing of credit risk in ways which would have been unimaginable about 40 years back.

The concept of securitisation rapidly became popular. Securitisation was projected as a mechanism for spreading risk and creating new growth opportunities for banks by freeing up capital. Commercial banks did not have to depend on the slow and costly business of attracting retail deposits to fund their transactions. Of course, securitisation was also misused by some market participants. That is how the sub prime crisis was fuelled.

As deregulation gathered momentum, the global financial system faced crises from time to time. These included the failures of Drexel Burnham Lambert, which dominated the junk-bond market and the collapse of Barings. But these crises were regarded as

individual instances of mismanagement or fraud, rather than evidence of any systemic problem. The American savings-and-loan crisis, (mentioned earlier) which was a systemic failure was resolved with the help of a bail-out plan and easy monetary policy, and dismissed as an aberration. Even the Long Term Capital Management crisis of 1998 did not create any serious problems. A Fed sponsored bailout ensured that the markets continued to function normally.

But the recent financial meltdown has resulted in a lot of soul searching about the merits of aggressive deregulation. The melt down has been unprecedented in terms of magnitude and impact. The long drawn out crisis is a reflection of how complex and inter connected the world of finance has become. An array of financial instruments has emerged that make it possible to bundle, unbundle and rebundle risk in various ways. Deregulation, technology and globalization have transformed the world of finance beyond recognition. At the end of 2007, the notional value of all derivative contracts globally was estimated at $600 trillion or 11 times the world GDP. Ten years back, it had been $75 trillion or 2.5 times the world GDP.

Clearly, finance has grown much more rapidly than the underlying, "real" economy. That probably explains why regulation has become so difficult. Regulation is indeed, the next topic of this chapter.

The regulatory framework
Regulation is an integral part of financial services. We shall examine regulatory issues in more detail later in the book. But it is a good idea at this stage to understand some of the high level issues in banking regulation. There is complete unanimity among academics and practitioners that regulation has a crucial role to play in preventing a crisis of the sort we saw in 2007 and 2008.

Regulation is important in all industries. But in no industry, is it as critical as in banking. We need to understand why this is so. Both in terms of size and the way it operates, banking occupies a special place. Bank assets can be a significant proportion of the GDP of a nation. (See figure). Moreover, the very nature of their business makes banks vulnerable. Commercial banks accept deposits from investors. They loan out the money to borrowers. The spread, i.e., the difference between the borrowing and lending rates, is what makes banks thrive. Banks operate on the principle of fractional reserve. They lend out most of the deposits, keeping only a small amount to meet the needs of depositors who want to withdraw their money. If depositors start doubting the credibility of a bank, they may start withdrawing money simultaneously. This is called a "run on the bank."

To avoid bank runs and protect the stability of the banking system, governments and central banks all over the world have introduced the concept of deposit insurance. Small depositors, upto a certain amount which varies from country to country, are guaranteed that they will get their money back in case something goes wrong with a bank[25]. This guarantee minimises the probability of depositors queing up in front of ATM machines

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[25] In the US, currently this amount is $250,000.

and drawing out money in panic. Needless to say, this kind of guarantee also creates the possibility of moral hazard. Banks might take too much risk, knowing that if things went wrong, depositors would be bailed out. And depositors being blissfully aware that they would get their money back, may have little incentive to monitor the banks. To counter moral hazard, regulators insist on banks being adequately capitalised. For the past several years, the widespread consensus across the world has been a capital level equal to 8% of the total risk weighted assets. But this figure is likely to increase in the aftermath of the sub prime crisis.

In the past two decades, the Basel accord has been the main driving force behind banking regulation. Basle is a small city in Switzerland but its reputation and standing in banking circles are far   more than what its size would suggest.   The Basle framework has established various norms for capital adequacy and prescribed methods for computing capital. As mentioned earlier, these norms and methods are being debated, in the wake of the sub prime crisis.

Looking back, it is clear that liberalisation of the financial system has proceeded far more extensively and deeply than anyone could have imagined about 20 years back. Regulators have struggled to keep pace. Often, they have been simply trying to catch up with the markets. But bankers and traders have always been one step ahead of the regulators. Whenever regulations have been introduced, the bankers have come up with ingenious ways of getting around regulations.

Indeed, one major reason for the financial crisis was that the regulators did not adequately understand complex financial instruments like collateralized debt obligations (CDOs) and credit default swaps (CDS). The valuation of these instruments and the predictability of their cash flows were things that regulators did not appreciate till the crisis had gone out of control. As George Soros has written[26]: "The super boom got out of hand when new products became so complicated that the authorities could no longer calculate the risks and started relying on the risk management methods of the banks themselves.   Similarly the rating agencies relied on information from originators of synthetic products. It was a shocking abdication of responsibility."

A key feature of the modern financial system is the growing importance of systemic risk. Because the players and markets have become so inter-connected, risks that appear to have been successfully transferred, may reappear elsewhere with potential to do much greater harm. That is why a systems approach to regulating risk has become important. It is now clear that in the run up to the sub prime crisis, regulators missed the big picture and failed to take an integrated view of what was happening in the markets in the name of securitization. As David Mcllroy[27] has mentioned, securitization failed to stabilise the financial system by diminishing the concentration of risk and spreading it across the system. Effective distribution of risk is possible only if market participants can price risk accurately and identify which market participants bear what degree of risk. The markets

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[26] "Worst financial crisis in 60 years marks end of an era," *Financial Times* on January 22, 2008.
[27] "Regulating risk: A measured response to the banking crisis," Journal of Banking Regulation, Vol 9, 4, 284-292.

froze during late 2008 because it became impossible to price the risk attached to many of the CDOs that had been sold.

Central banks are probably the most critical component of the regulatory framework. They have played a key role in the past 300 years in the running of the financial system. They hold enormous powers and are always the subject of media attention, even in emerging markets like India. During his heydays, Fed Chairman, Alan Greenspan's statements had a greater impact on the markets than those of the US president! Central banks seemed to have brought inflation under control and stabilised the financial system. But the sub prime crisis has challenged the general philosophy of central bankers. Indeed, the overall approach of central banks towards managing the financial system is undergoing intense scrutiny after the real estate bubble burst in 2007. The exclusive focus on consumer price inflation to the point of ignoring asset prices has been sharply criticised.

In particular, the US Federal Reserve in general and Greenspan in particular, have been severely criticised for not having done enough to prevent the formation of the sub prime bubble. The Fed, seeing that inflation was under control kept interest rates too low for too long. Looking back, it is clear that the Fed and other central bankers focused on conventional measures of inflation and did not consider a potential asset bubble seriously enough. With inflation under control, there was little incentive to raise interest rates. A prolonged period of low interest rates, which encouraged indiscriminate borrowing and lending, drove the mortgage markets into a frenzy. We will now examine the factors which helped to keep interest rates low.

The story behind the global economic imbalances

At the heart of the sub prime crisis lies the huge global economic imbalances that have developed in recent years. In the past decade, emerging markets have grown impressively by exporting to the western countries especially the US in a big way. As Raghuram Rajan[28] has mentioned, this was a response to a wave of crises that swept through the emerging markets in the late 1990s. East Asia, Russia, Argentina, Brazil, and Turkey all went through a period of economic turmoil during the 1997-98 currency crisis. As a result, these countries became far more circumspect about borrowing from abroad to finance domestic demand. They cut back on investment and reduced consumption. Formerly net absorbers of financial capital from the rest of the world, many of these countries started to record trade surpluses and became net exporters of financial capital.

Many of these emerging markets were also characterised by high savings rates. In mid-2008, emerging-economy central banks held over \$5 trillion in reserves, a five fold increase from 2000. These surplus funds had to go somewhere. Bulk of these funds were parked in safe government securities in the US. This flood of capital helped in pushing long-term interest rates down. (See Exhibits 2.4, 2.5).

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[28] "The Credit crisis and cycle proof regulation," Federal Reserve Bank of St. Louis *Review* September/ October, Part 1 2009. pp. 397-402.

Exhibit 2.4
Current account balance: The Global Scenario

Country	Current account balance (Latest 12 months, $12 billion)
USA	-628.3
Japan	+115.3
China	+426.1
Britain	-52.5
Canada	-3.9
France	-58.3
Germany	+159.9
Italy	-62.8
Spain	-117.2
Norway	+79.6
Russia	+55.3
India	-29.8
Brazil	-17.9
Saudi Arabia	+134.0

Source: *The Economist,* August 29, 2009. p.82.

Exhibit 2.5

Global imbalances
(current account balances, percent of world GDP)
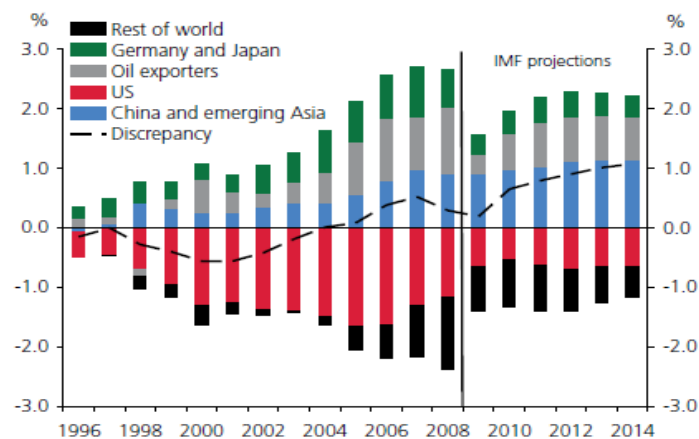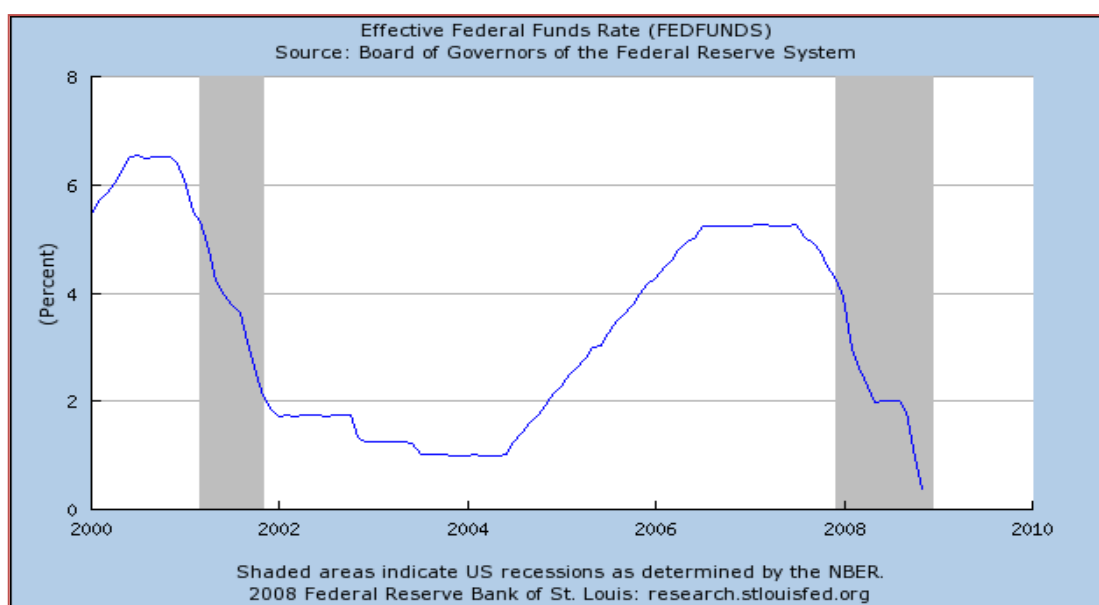
Source: IMF *WEO*.
Note: 'Rest of world' category differs from that presented in the IMF *WEO*. Discrepancy represents inconsistency between aggregate surpluses and deficits.

Ref: Reserve Bank of New Zealand Financial Stability Report, November 2009, www.rbnz.govt.nz

At the same time, the rise of China and India not only made many products cheaper but also added vast pools of cheap and skilled labour to the global economy. So inflationary pressures remained low, enabling the Fed to manage the economy with low interest rates. The Fed's simple argument was: Why raise interest rates and thereby threaten the growth prospects of an impressively performing economy when inflation is under control?

In a speech in Beijing on December 9, 2008, Lorenzo Bini Smaghi[29] of the European Central Bank explained how a marked asymmetry in the global financial system aggravated the economic imbalances. In the developed countries, rapid financial innovation and sophisticated financial products encouraged easy financing and consequently indebtedness. On the other hand, relatively rudimentary financial systems in the emerging markets encouraged the recycling of current account surpluses and savings into developed countries, especially the US to fund their growing deficits. At the same time, economies like India and China "managed" their currencies by buying dollars and dollar denominated assets. If they did not do so, their currencies would have appreciated, making exports more difficult.

Exhibit 2.6

Effective Federal Funds Rate (FEDFUNDS)
Source: Board of Governors of the Federal Reserve System

Shaded areas indicate US recessions as determined by the NBER.
2008 Federal Reserve Bank of St. Louis: research.stlouisfed.org
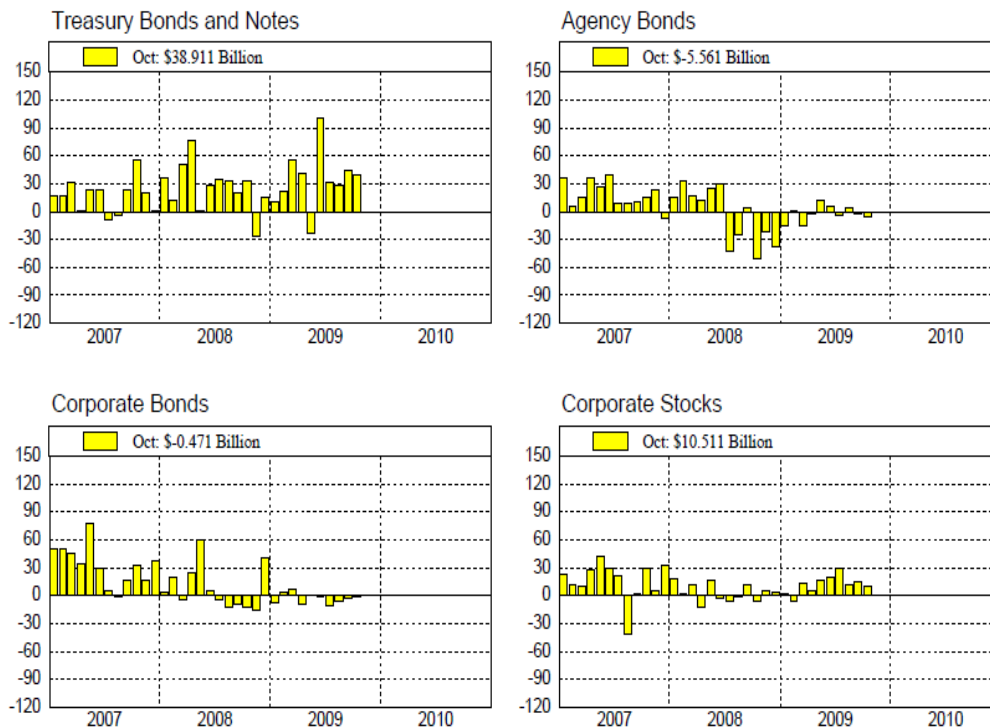
Low interest rates, (See Exhibit 2.6) justified by the prevailing low inflation, created a bubble in the real estate market. They spurred off an unprecedented demand for homes and home loans. Raghuram Rajan[30] has explained how the surplus capital might have landed in the real estate sector. Corporations in the US and industrialized countries initially absorbed the savings of emerging markets by expanding investment, in areas such as information technology. But this proved unsustainable. The investment was cut back sharply after the collapse of the information technology bubble. And as monetary policy continued to be accommodative, these funds moved into interest sensitive sectors such as automobiles and housing. This triggered off a housing boom. (See Exhibit 2.7, 2.8).

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[29] "The financial crisis and global imbalances – two sides of the same coin."
[30] "The Credit Crisis and cycle proof regulation," Federal Reserve Bank Of St. Louis *Review* September/ October, Part 1 2009. pp. 397-402.

Exhibit 2.7
Net Purchase of Long-Term US Securities
All Foreign countries

Treasury Bonds and Notes — Oct: $38.911 Billion

Agency Bonds — Oct: $-5.561 Billion

Corporate Bonds — Oct: $-0.471 Billion

Corporate Stocks — Oct: $10.511 Billion

Source: Haver

Source: New York Fed. www.newyorkfed.org

But the housing boom had to collapse at same point of time. And only when it collapsed, did policy makers begin to appreciate the true significance of the global economic imbalances. Indeed, the sub prime crisis can be viewed as the consequence of the disorderly, unwinding of the economic imbalances that had accumulated in the global financial system over time. The disorderly adjustments have thrown the system out of balance. There has been a sudden escalation in risk aversion even as there have been corrections in prices of real estate, oil, various financial assets. There have also been sharp reversals in the direction of capital flows and exchange rates movements. The net consequence is that the global GDP growth has come down sharply.

Tackling the global imbalances will require a complete change in the mindset of the countries involved. And by no stretch of imagination, will it be an easy task. In mid August, 2009, a leading US Economic policy spokesman, Larry Summers called for a shift in the US economy from a consumption based one to an export oriented one. At the same time, American politicians have been putting pressure on China to revalue its currency, thereby reducing exports and increasing domestic consumption. Many commentators have argued that China's high savings – high investment economy (which suppresses consumption) is destabilizing for the world economy. Some progress has already been made since the onset of the financial crisis. The US trade deficit has already

come down from 6% of GDP at the peak to about 3% currently. At the same time China's current account surplus has shrunk from 11% of GDP to about 7.8% at the end of 2009[31]. But there is no guarantee that this trend will continue unless the US can tackle its huge budget deficit. At the G-20 meeting at Pittsburgh in September 2009, a lot of time was devoted to the issue of achieving balanced, higher global GDP growth. Progress may be slow because for countries like China, the short term benefits of an undervalued currency are more attractive than the long term ones. But the fact is that by allowing its currency to appreciate, the Chinese can enjoy several benefits in the long run. Currency appreciation would not only help to check inflation, always a major concern in rapidly growing economies, but also put pressure on exporters to become more competitive and focus on more value adding sectors. Unfortunately, the Chinese policy makers have taken the aggressive stance that the current exchange rate regime must continue to protect domestic output and employment.

Exhibit 2.8
Foreign-ownership of marketable US Treasury bonds as percentage
of total amounts outstanding
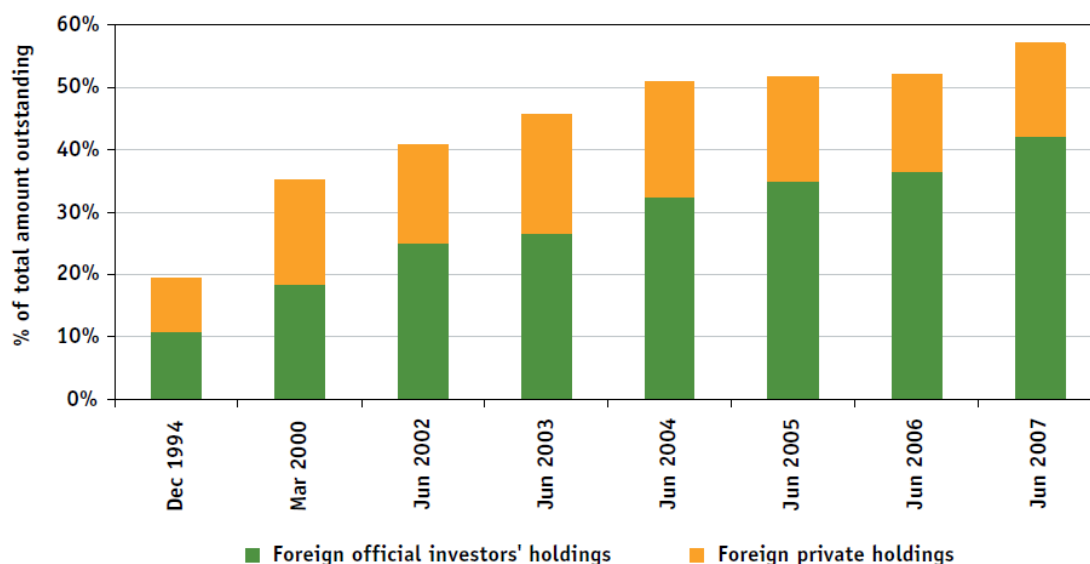
Source: IMF, US Treasury

Ref: The Turner Review - A regulatory response to the global banking crisis, published by: UK Financial Services Authority, www.fsa.gov.uk/pubs/other/turner_review; March 2009

From decoupling to recoupling

Britain was the colonial superpower of the world till the start of the 20th century. Following World War II, the US took over the global economic leadership. Japan and Germany became economically powerful as they became export powerhouses. Till about 30 years back, the G-7 countries (USA, Canada, Britain, France, Germany, Italy, Japan) dominated the global economic agenda. The developed countries did not really take the developing ones like India and China very seriously. These Asian giants were considered too poor and too insignificant and struggling to get their economies going. But since the

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[31] Financial Times, January 5, 2010.

late 1990s, China and India, thanks to economic liberalisation, have emerged as two of the most dynamic economies of the world. Many economists have argued that these emerging markets have grown to a point where they can more than compensate for any slowdown in western economies. This phenomenon has come to be called *decoupling*.

In the early months of the sub prime crisis, the champions of decoupling seemed to be winning the argument. China and India continued to grow smartly even as the economies of the Western nations went from bad to worse. In the initial stages, the capital flows to the emerging economies actually increased. In the case of India, for example, the net FII flows during the five-month period from September 2007 to January 2008 was US$ 22.5 billion as against an inflow of US$ 11.8 billion during April-July 2007, the four months prior to the onset of the crisis.

But as the crisis deepened in 2008, it became clear that emerging economies could not be completely insulated from the current financial crisis. There was a reversal of portfolio flows due to unwinding of stock positions by FIIs to replenish cash balances abroad. Withdrawal of FII investment led to a stock market crash in many emerging economies and many currencies plunged against the US dollar. In the case of India, the extent of reversal of capital flows was $ 15.8 billion during the five month period February-June, 2008.

The situation worsened, following the collapse of Lehman Brothers in mid-September 2008. The Lehman bankruptcy combined with the fall of Fannie Mae, Freddie Mac and AIG created a crisis of confidence that led to the seizure of the interbank market. This had a trickle-down effect on trade financing in the emerging economies. Together with slackening global demand and declining commodity prices, it led to a fall in exports. Many South-East Asian countries that depended upon exports were severely affected. China's GDP growth slowed down appreciably.

As the events unfolded, it became clear that India was far too integrated into the global economy. Export growth which had been robust till August 2008, became low in September and negative from October 2008 to March 2009. The sharp decline in growth to 5.8 per cent in the second half of 2008-09 from 7.8 per cent in the first half of 2008-09, seemed to support the recoupling perspective.

Meanwhile, the Indian financial markets were affected indirectly through the linkages with the global economy. The drying up of liquidity, caused by repatriation of portfolio investments by FIIs, affected credit markets in the second half of 2008-09. This was compounded by the "risk aversion" of banks to extend credit in the face of a general downturn. There was a contraction in reserve money by more than 15 per cent between August 2008 and November 2008. A series of unconventional measures by the Reserve Bank helped to push up the rate of growth of bank credit from 25.4 per cent in August 2008 to 26.9 per cent in November 2008. However, this only partly offset the impact on Indian companies due to the freezing of financial markets in the US and EU. The Indian IT industry went into a tailspin and employees became resigned to salary cuts and job losses, a dramatic change from the "red hot" labour markets of 2006 and 2007.

Other emerging markets also started facing a slow down. Dubai, the hub of the middle east, saw a major crash in the real estate markets and severe job cuts. This jewel of the middle east had to be "bailed out," by the government of Abu Dhabi. Singapore[32], one of the major hubs of East Asia went through a severe recession.

As mentioned earlier, emerging economies also suffered in terms of foreign investment inflows due to a retreat to safety away from the emerging economies. In 2008, investors pulled out $67.2 billion from emerging market equity and bond funds, the worst since 1995. This represented more than 50% of the inflows of $130.5 billion into emerging markets between March 2003 and end of 2007.

Now as we approach the end of 2009, many Asian economies seem to be rebounding smartly, though their growth alone may not be able to pull the global economy back on track. The rebound of the Asian economies has been aided by a turnaround in manufacturing, return of normalcy to trade finance and a huge fiscal stimulus. Many Asian economies entered the downturn with healthy government finances. Hence they have been able to inject a fiscal stimulus easily. Despite this impressive growth, *The Economist*[33] sounded a word of caution: "But it would be a big mistake if Asia's recovery led its politicians to conclude that there was no need to change their exchange rate policies or adopt structured reforms to boost consumption." China for example, despite its impressive growth does not yet have a deep, well functioning financial system. The difficulties faced by Chinese leaders in stimulating domestic demand, have been partly due to the inadequacies of the country's financial sector.

Key themes from recent BIS Annual Reports

2009: Rescue, recovery, reform
The essential and complex system of finance has been critically damaged; trust has been lost. There were both macroeconomic and microeconomic causes of the collapse. The former included imbalances in international claims and a long period of low real interest rates, while the latter consisted of problems with incentives, risk measurement and regulation.

2008: The unsustainable has run its course
After a number of years of strong global growth, low inflation and stable financial markets, the situation deteriorated rapidly in the period under review. Most notable was the onset of turmoil in the US market for subprime mortgages, which rapidly affected many other financial markets and eventually called into question the adequacy of capital at a number of large US and European banks. At the same time, US growth slowed markedly, reflecting setbacks in the housing market, while global inflation rose significantly under the particular influence of higher commodity prices.

2007: Piecing the puzzle together
The favourable global economic performance seen in recent years extended into the period under review. Global growth was strong and there were even welcome signs of better balanced demand. The US economy slowed somewhat, largely due to a weaker housing sector, while domestic demand in Europe, Japan and a number of emerging market economies picked up.

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[32] Though Singapore enjoys the living standards of developed countries, in a sense, it can be called an emerging market, as the GDP growth rate is still high compared to many developed countries.
[33] August 15, 2009.

2006: Resilience to mounting strains
Global growth last year was again very rapid, in spite of higher prices for energy and other commodities. Moreover, core inflation generally stayed low even as headline inflation rose. Yet, as the year wore on, fears began to grow about prospective inflationary pressures. Concerns also began to mount about the growing imbalances in the global economy, not least the low saving and high investment levels in the United States and China, respectively, and record current account imbalances.

2005: So far, so good
Looking back over the past two decades, several global economic trends can be identified. Lower and less volatile inflation, accompanied by higher and less volatile output growth, were welcome features. Less welcome were growing external and internal imbalances, the latter leading to more frequent periods of financial stress often associated with rapid increases in credit, asset prices and fixed investment.

2004: Time to rebalance?
The global slowdown earlier this decade was met with unusually strong fiscal and monetary stimulus in the industrial countries, especially in the United States. Policy was also eased in many emerging market economies, often in association with attempts to prevent the appreciation of their currencies against the US dollar. Higher asset prices and more favourable conditions in global financial markets, contributed to global economic growth that was much stronger than expected earlier.

Ref: Bank of International Settlements website, www.bis.org

Conclusion

Political leaders have, in recent months, been repeatedly calling for changes in the current global financial architecture. The need for global collaboration among policy makers is now widely accepted. Pressure is being exerted on "mercantilist" nations like China and Germany, two large exporters to stimulate their domestic economy and increase the fiscal stimulus even as the Americans realize the need to tighten their belt. The need for "macro prudential regulation" with a greater focus on systemic risk is being articulated. A strong argument is also emerging for a more active role for countries like China and India in the management of the global economy. Increasingly, there is a call for broad basing the constitution of groups such as G-8. (USA, UK, Germany, France, Japan, Italy, Canada, Russia) The G-20 (The G8 nations, European Union, Brazil, China, Argentina, Australia, India, Indonesia, Mexico, Saudi Arabia, South Korea, South Africa, Turkey) is becoming more powerful than ever before. In the months ahead, leaders across the world will continue to deliberate on the ways in which nations across the world must cooperate to manage a global financial system that has become large, highly sophisticated and inter connected. How these deliberations will happen and whether they will lead to pragmatic and meaningful steps will determine whether the global imbalances can be corrected efficiently.

There is much to learn from past financial crises. Unfortunately, we tend not to learn from history. Which is why financial crises never seem to stop. In their recent highly rated paper[34], Carmen M. Reinhart and Kenneth S. Rogoff, have provided some important insights from the long history of financial crises. They have identified long periods of turmoil where a high percentage of all countries were in a state of default or restructuring due to serious financial crises.

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[34] "This Time is Different: A Panoramic View of Eight Centuries of Financial Crises," Working Paper, April, 2008.

The first was during the Napoleonic War. The second lasted from the 1820s through the late 1840s, when, at times, nearly half the countries in the world were in default (including all of Latin America). The third episode began in the early 1870s and lasted for two decades. The fourth episode began in the Great Depression of the 1930s and extended through the early 1950s, when again nearly half of all countries stood in default. Then a default cycle encompassed the emerging market debt crises of the 1980s and 1990s. The most recent cycle of course started in 2007 after a long period of benign economic growth and low inflation.

As the authors mention, only the two decades before World War I—the halcyon days of the gold standard—exhibited tranquility anywhere close to that of the 2003-to-2007 period that preceded the recent melt down.

Many things have changed over time. Yet the ability of governments and investors to delude themselves that things are under control, giving rise to periodic bouts of euphoria that usually end in tears, seems to have remained a constant. This phenomenon has also been popularly referred to, in recent months, as the Minsky moment.

There is little doubt that luck and policy reforms are both needed to resolve financial crises. Even Britain, at one point of time, the world's economic superpower, with all its financial muscle, could have landed in a mess had the country been less fortunate in the many wars it fought. For example, had Napoleon not invaded Russia and had France prevailed in the Napoleonic War, would Britain really have honored its debts? Similarly, Greece and Spain escaped a severe history of serial default not only by reforming institutions, but also by benefiting from the support of the European Union.

Among developing economies, Chile emerged from a serial default despite extraordinary debt pressures by running large and sustained current account surpluses. These surpluses allowed the country to significantly pay down its external debt. Other countries in Asia have also pursued a similar approach in recent years. Mexico despite its failure to engage in deep institutional reform, stands on the verge of graduation thanks to a combination of better monetary and fiscal policy, as well as the North American Free Trade Agreement.

But all these countries might well get back into trouble as the sub prime crisis testifies. The Baltic states, countries in Eastern Europe and a high income country like Iceland were all affected significantly by the recent meltdown. Even the British economy looks distinctly shaky. And there have been strident calls by some leading intellectuals to shrink that country's financial sector.

Let us end this chapter with a few thoughts about our own country, India. After a major crisis, it has become quite common to see our intellectuals, bureaucrats and politicians indulging in a boisterous round of self congratulation that the country had escaped the crisis due to their sagacity and vision. This happened after the Asian currency crisis of 1997-98. It has again happened now following the sub prime crisis. As proud Indians, it is good to feel that we have escaped lightly from the recent melt down which has brought

mighty economic powers like the US down to their knees. But to pretend that we have already graduated to an elite club may be a bit premature.

The Economist once described India's financial system as one that looked right just because it was 12 hours behind the right time. The sub prime crisis must not lead to more curbs that will stifle the innovations. Financial repression can be as harmful as financial excesses. Many poor Indians are completely shut out of the formal financial system and have to depend on moneylenders for getting exorbitantly priced loans.

India may justifiably look with a sense of complacency and self satisfaction at how things have moved in the last two years. The country has successfully held its own even as many rich countries have suffered during the sub prime meltdown. But more serious introspection would reveal that India has a lot to do in terms of structural reforms to survive and thrive in today's increasingly interconnected global financial system. The sub prime crisis should not serve as a convenient excuse for postponing long pending financial sector reforms.

Case: How Iceland became a hedge fund[35]

Introduction
The 2008–2009 Icelandic financial crisis illustrates how an interconnected global financial system can threaten the very existence of a small economy with an outsized financial sector. The crisis culminated in the collapse of all three of the country's major banks following their difficulties in refinancing their short-term debt. The trigger for this collapse was the fall of Lehman Brothers on September 15, 2008. Following the Lehman bankruptcy, the markets had started a major reassessment of the risks of the various financial instruments. As trust evaporated, lending in the short term money market and the interbank market dried up.

In late September 2008, the government stepped in and partly nationalised Glitnir, the third-largest bank. Having tried to bail out one bank, the government soon had to take care of the two others, Landsbanki and Kaupthing. Relative to the size of its economy, Iceland's banking collapse was the largest suffered by any country in economic history.

The financial crisis had serious consequences for the Icelandic economy. The country's currency fell sharply in value. Foreign exchange transactions were suspended for weeks. The market capitalisation of the Icelandic stock exchange dropped by more than 90%. The nation's gross domestic product decreased by 5.5% in real terms in the first six months of 2009. The standard of living in the country came down dramatically.

Looking back, the collapse of Iceland's banks, was not a sudden development. After a set back in 2006, when the main banks struggled to finance themselves, the banks had been trying to retreat to safety. The banks had attempted to attract foreign deposits to back their assets abroad. On the other hand, the central bank had been raising interest rates to try to cool the economy. In the end, however, thanks to the frozen credit markets, the banks were unable to roll over their debts.

Background
Iceland, the smallest of the OECD economies had a GDP of $11.8 billion in 2007. An open economy, trade made up about 80% of the GDP. Until early 2008, Iceland's economy was considered a high performer. Part of the prosperous Scandinavian region, Iceland had the fourth-highest gross domestic product per capita in the world. Unemployment was low, between 0 and 1 percent. A 2007 United Nations report identified Iceland as the world's best country in which to live on the basis of life expectancy, real per-capita income and educational levels.

Traditionally, Iceland's economy was based on marine and energy resources. The picture changed somewhat from 2000. In 2001, banks were deregulated in Iceland. The aggressive growth subsequently of Iceland's banks became a remarkable feature of the small economy. The growth was facilitated by easy access to credit and a domestic

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[35] This case draws heavily from the article, "Iceland's financial crisis," by James Jackson prepared for the US Congress.

construction boom. The commercial banks offered loans with low interest rates, long maturity and low down payments. The banks also supported refinancing of existing mortgages. Not surprisingly credit expanded and real estate prices roared. A tax reduction by the government further boosted consumer spending.

Between 2004 and 2007, the central bank had to raise interest rates to control inflation. Short term interest rates rose from 5% to 15%. At the same time, the relatively low rates of interest on housing loans sustained the housing boom. Meanwhile, the high domestic interest rates attracted a lot of foreign funds and helped the domestic currency to appreciate. The strong currency in turn added fuel to the consumer boom in Iceland. Once-frugal Icelanders embarked on regular shopping weekends in Europe. They bought fancy cars and built bigger houses paid for with low-interest loans in foreign currencies. The household debt increased sharply, reaching the equivalent of 213% of disposable income. (Around the time, Britons and Americans who were also spendthrift people, owed just 169% and 140% of disposable income respectively).

Icelandic bankers began roaming the world and aggressively seizing business. Handicapped by a small domestic market, Iceland's banks financed their international expansion with loans on the interbank lending market and, later by deposits from outside Iceland. The banks had accumulated assets of about £125 billion by the end of 2007, huge for an economy with a size of about £14.5 billion. Bulk of the assets were supported by wholesale borrowing. By the end of 2007, Iceland's three largest banks relied on short term financing for more than 75% of their funds. Almost half of the total assets and about 58% of their overall income was generated from foreign subsidiaries.

Attractive interest rates, (compared with 5.5% in the United Kingdom or 4% in the Eurozone), encouraged overseas investors to hold deposits in the Icelandic Krona. Backed by these deposits, the Icelandic money supply grew 56.5% in the twelve months to September 2008, compared with 5.0% real GDP growth. The situation was effectively an economic bubble, whose magnitude was not appreciated at that point of time.

Iceland's major banks, held foreign debt in excess of €50 billion, or about €160,000 per Icelandic resident, compared with Iceland's gross domestic product of €8.5 billion. Iceland's central bank looked puny in size when compared to the country's commercial banks. The official reserves of the CBI stood at 374.8 billion Kronur at the end of September 2008, compared with 350.3 billion Kronur of short-term international debt in the Icelandic banking sector, and at least £6.5 billion (1,250 billion Kronur) of retail deposits in the UK.

As early as March 2008, signs of the bubble were evident. The cost of private deposit insurance for deposits in Landsbanki and Kaupthing was already far higher (6–8½% of the sum deposited) than for other European banks. The Krona, was ranked by *The Economist* in early 2007 as the most overvalued currency in the world (based on the Big Mac Index), largely due to carry trading. (Carry trading involves borrowing in low interest rate currencies and investing in higher interest rate ones).

Meanwhile, Landsbanki's internet bank Icesave based in the UK was operating as a branch of the Landsbanki, rather than as a legally independent subsidiary. As such, it was completely dependent on the CBI for emergency loans of liquidity, and could not turn to the Bank of England for help. The UK Financial Services Authority (FSA) considered imposing special liquidity requirements on Icelandic deposit-taking banks in the weeks before the crisis. However, the plan was never implemented.

Meanwhile, the Guernsey (a British crown dependency in the English channel off the coast of Normandy) authorities were also planning to impose restrictions on foreign banks operating as branches and on transfers of funds between Guernsey subsidiaries and parent banks. Landsbanki operated in Guernsey through a legally independent subsidiary.

Main Events
On 29 September 2008, the government announced Glitnir would be nationalised. Glitnir had US$750 million of debt due to mature on 15 October.

On October 6, a number of private interbank credit facilities to Icelandic banks were shut down. Prime Minister Geir Haarde announced a package of new regulatory measures for consideration by the Althing, Iceland's parliament. These included the power of the FME (The Financial Supervisory Authority, Iceland) to take over the running of Icelandic banks without actually nationalising them, and preferential treatment for depositors in the event of a bank being liquidated. The government also announced it would guarantee retail deposits in Icelandic branches of Icelandic banks in full.

On October 7, the FME used the emergency legislation (passed on October 6), to take over Landsbanki and put it in receivership. The government also seized control of Glitnir. On October 8, Kaupthing was placed into receivership by the FME, following the resignation of the entire board of directors. Its UK subsidiary was placed into administration. At the same time, the Guernsey subsidiary of Landsbanki went into voluntary administration with the approval of the Guernsey Financial Services Commission. The FME also placed Glitnir under receivership.

The UK Chancellor of the Exchequer, Alistair Darling announced that he was taking steps to freeze the assets of Landsbanki. The freezing order took advantage of provisions in Sections 4 and 14 and Schedule 3 of the Anti-terrorism, Crime and Security Act 2001. Prime Minister, Gordon Brown, announced that the UK government would launch legal action against Iceland to press for compensation for the estimated 300,000 UK deposit holders. The government indicated it would foot the entire bill to compensate UK retail depositors, estimated at £4 billion. More than £4 billion in Icelandic assets in the UK were frozen by the UK government. The FSA also declared Kaupthing Singer & Friedlander, the UK subsidiary of Kaupthing Bank, in default on its obligations, sold Kaupthing Edge, its Internet bank, to ING Direct, and put Kaupthing Singer & Friedlander under administration. Geir Haarde described the UK Government actions as "unprecedented" and an "abuse of power."

Meanwhile, Sweden's central bank, made a credit facility of Swedish Krona 5 billion (€520 million) available to the Swedish subsidiary of Kaupthing, to pay "depositors and other creditors". Kaupthing's Luxembourg subsidiary obtained a suspension of payments (similar to chapter 11 protection) in the Luxembourg District Court. Kaupthing's Geneva office, was prevented from making any payments of more than 5000 Swiss francs by the Swiss Federal Banking Commission. The directors of Kaupthing's subsidiary on the Isle of Man decided to wind up the company after consultation with the authorities. The Finnish Financial Supervision Authority (*Rahoitustarkastus*) took control of the Helsinki branch to prevent money from being sent back to Iceland.

Exhibit 2.9
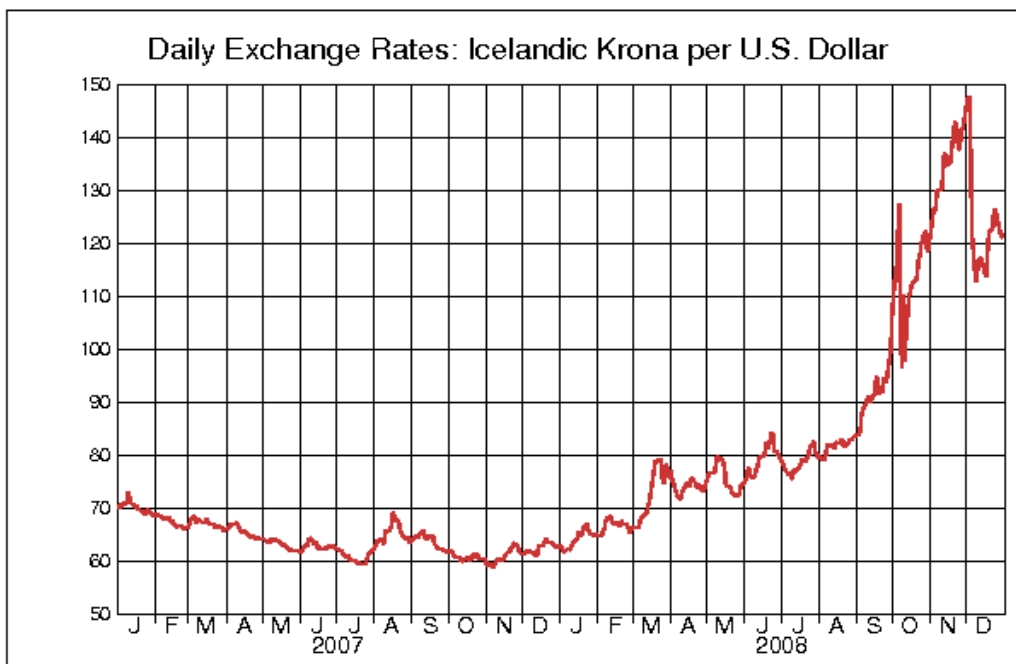
Source: Pacific Exchange Rate Service, University of British Columbia, Sauder School of Business Service provided by Prof. Werner Antweiler, University of British Columbia, Vancouver BC, Canada, fx.sauder.ubc.ca

Currency crisis

Meanwhile, Iceland's currency started to get battered. On 8th October, the CBI abandoned its attempt to peg the currency at 131 Kronur to the euro after trying to set this peg on 6th October[36]. By 9th October, the currency was quoting 340 to the euro when trading in the currency collapsed. The next day, the central bank introduced restrictions on the purchase of foreign currency within Iceland. From 9th October to 5th November, the ECB quoted a reference rate of 305 Kronur to the euro. The CBI set up a temporary system of daily currency auctions on 15th October to facilitate international trade. The first auction sold €25 million at a rate of 150 Kronur to the euro.

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[36] Draws heavily from Wikipedia.org

Trading of the Krona in the markets outside Iceland resumed on 28th October, at 240 to the euro, after a hike in interest rates by 6% to 18%. During November, the real exchange rate was roughly one-third lower than the average rate from 1980–2008, and 20% lower than the historical lows during the same period. The external rate as quoted by the ECB was lower still. On 28th November, the CBI was quoting 182.5 Kronur to the euro, while the ECB was quoting 280 Kronur to the euro.

On 28 November, Iceland finalised a new set of currency regulations, replacing the central bank's restrictions imposed early on in the crisis. Movements of capital to and from Iceland were banned without a license from central bank. Iceland's residents were asked to deposit any new foreign currency they received with an Icelandic bank.

Meanwhile, on October 24, 2008, Iceland reached an agreement with the IMF as part of a comprehensive stabilisation package. The package included a $2 billion loan. On October, 27, the Nordic prime ministers agreed to establish a high level committee to monitor the implementation of the package.

Lessons from the crisis
Various factors contributed to Iceland's fall. One of them was the monetary policy pursued by the country's central bank. High domestic interest rates encouraged domestic firms and households to borrow in foreign currency, and also attracted currency speculators. This brought large inflows of foreign currency, leading to a sharp appreciation of the domestic currency, giving the Icelanders an illusion of wealth. The speculators and borrowers profited from the interest rate difference between Iceland and abroad as well as the exchange rate appreciation. All this fuelled both economic growth and inflation, prompting the central bank to raise interest rates further. The end result was a bubble caused by the interaction between domestic interest rates and foreign currency inflows.

Before the crisis, the Icelandic banks had foreign assets worth around 10 times the Icelandic GDP. This was a clear sign that the financial sector had assumed monumental proportions. Yet in normal circumstances, this was not a cause for worry. Indeed, the Icelandic banks were better capitalized and had a lower exposure to high risk assets than many of their European counterparts. But in this crisis, the strength of a bank's balance sheet was of little consequence. What mattered was the explicit or implicit guarantee provided by the state to the banks to back up their assets and provide liquidity. The size of the state relative to the size of the banks became the crucial factor. Going by this criterion, the government was in no position to guarantee the banks.

The Icelandic authorities failed to show leadership. They did not communicate appropriately with their international counterparts, leading to an atmosphere of distrust. At the same time, Iceland failed to receive support from Britain when the Scandinavian nation badly needed the support. The UK authorities seemed to have overreacted, using antiterrorist laws to take over Icelandic assets, and causing the bankruptcy of the remaining Icelandic bank.

To conclude, the original cause of the Icelandic crisis was a combination of inappropriate monetary policy and an outsized banking system. But the extreme global financial uncertainty, the mishandling of the crisis by the Icelandic authorities and the overreaction of the UK authorities served as the tipping points. In conclusion, we must appreciate that Iceland was done in as much by its policy failures as by the interconnectedness of the global financial system.

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Chapter - 3
Risk Management Lessons from the Sub Prime Crisis

"Fannie Mae and Freddie Mac have played a very useful role in helping make housing more affordable….. through leveraging the mortgage market… I believe that we, as the Federal
Government, have probably done too little rather than too much to push them to meet the goals of affordable housing."

- *US Congress Representative Barney Frank[37]*

Introduction

It is more than two years since the sub prime crisis began to unfold. The crisis has struck at the very roots of the financial system. Only now as we approach the end of 2009, things seem to be looking up a little. Confidence seems to be returning as equity markets and leveraged loans are regaining their appeal[38]. But if ever, a financial crisis has prompted deep soul searching among bankers, intellectuals, regulators and economists, it has been the recent meltdown. The basic tenets of regulation, banking and risk management have been questioned. Indeed, the crisis, the worst since the Great Depression of the 1930s, marks a watershed event in the history of global finance.

Understanding the Sub Prime crisis

The term subprime lending refers to the practice of making loans to borrowers who do not normally qualify for such loans owing to various risk factors - low income level, little or no down payment, no credit history, and uncertain employment status. Sub prime lending in different forms, has been practised in different parts of the world. But it is in the US that the practice has been especially prevalent.

Encouraged by a period of low interest rates, following September 11, 2001, Americans moved into housing in a big way in the early 2000s. This drove up real estate prices. As prices of homes went up, they became increasingly unaffordable. But to keep the business going, many mortgage brokers decided to dilute their lending standards. The hope was that over time, things would work out fine as home prices continued to rise and there would be no defaults. Meanwhile, securitisation which helped pool mortgage loans

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[37] Hearings of the House Financial Services Committee, September 2003.

[38] During early August, 2009, European leveraged loan prices reached 89.11 percent of face value, a high last reached in July 2008. The TED spread, the spread between US treasury 3 month bills and 3 month dollar LIBOR rates fell to 29.3 basis points, from a high of 464 basis points reached in October 2008. The FTSE All World Emerging Markets Index reached 433.2 in late London trade, a level last seen, just before the collapse of Lehman. The benchmark S&P 500 Index rose above 1000 for the first time since early November 2008.

and convert them into securities enabled banks to generate liquidity and free up blocked capital. Collateralised Debt Obligations (CDOs), which we will discuss in more detail later in the chapter, became a convenient way of transferring risk and increasing liquidity. Along with CDOs, credit default swaps (CDS) were used to buy and sell protection against credit default on underlying securities. We shall examine CDS in more detail soon.

Sub prime lending was fine as long as home prices were appreciating. A borrower running into difficulty could always sell the home at a profit and square up the loan. The flood of mortgage money did indeed drive up housing prices in the US. Home appreciation which had been around 1.4% per year during 1970-2000, shot up to 7.6% between 2000 and mid 2006. From mid-2005 to mid-2006, the appreciation was 11%. However, in mid-2006, the housing market began to weaken. Home sales fell while home prices first flattened and then began to decline. Vacant homes for sales hit a multi year high and delinquencies began to rise.

Exhibit 3.1
The Sub Prime Crisis at a Glance

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┌─────────────┐          ┌──────────────┐
│    Risk     │          │ Downgrading  │
│  Transfer   │          │ of monolines │
└─────────────┘          └──────────────┘
      │                         ↑
      ↓                  ┌──────────────┐
┌─────────────┐          │ Downgrading  │
│   Capital   │          │  of CDO      │
│   freeing   │          │  tranches    │
└─────────────┘          └──────────────┘
      │                         ↑
      ↓                  ┌──────────────────┐
┌─────────────┐  ┌───────────┐  ┌──────┐  │ Collapse of Bear │
│  Subprime   │→ │  House    │→ │ Fore │→ │ Stearns and UBS  │
│  bubble     │  │  prices   │  │ clo- │  │ hedge funds      │
│  builds     │  │  fall     │  │ sures│  └──────────────────┘
└─────────────┘  └───────────┘  └──────┘
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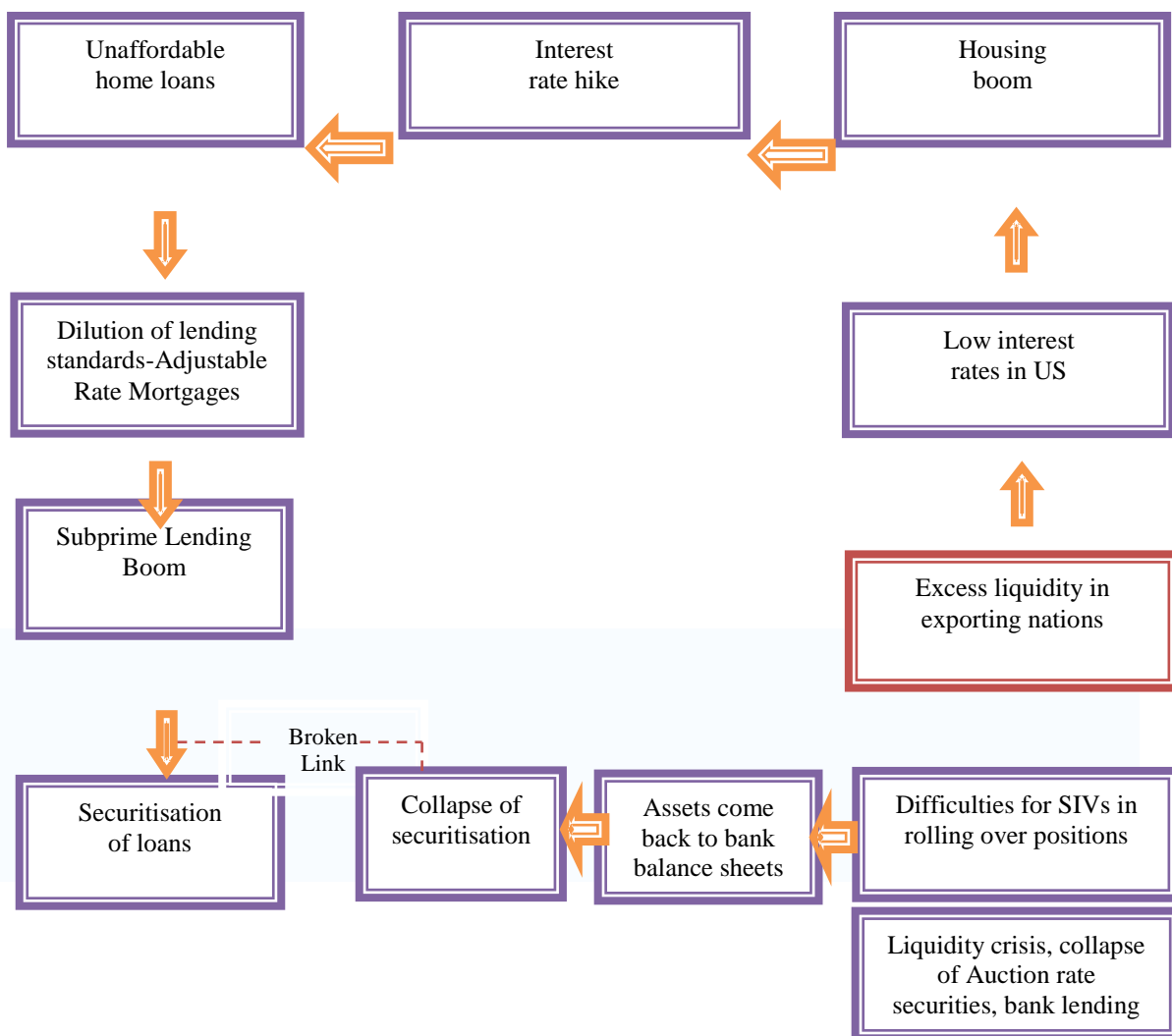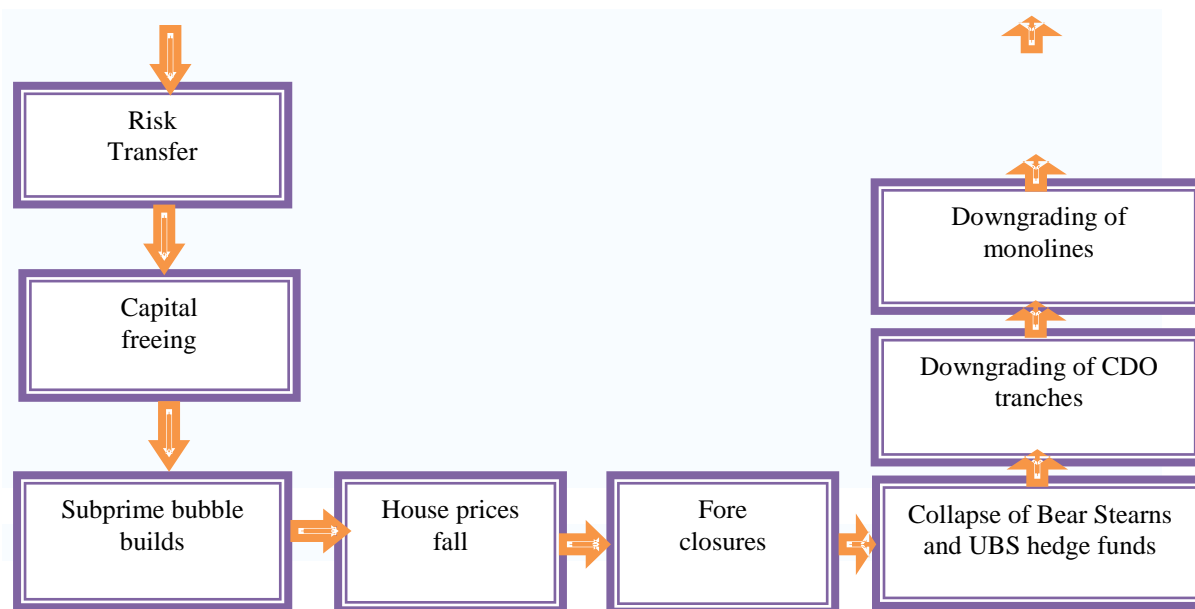
Many borrowers who had been betting on steady appreciation of their property, suddenly found it difficult to service their loans. As foreclosures started to increase, the quality of the mortgage backed securities and their various derivatives held by banks came for close examination. Many of these assets were covered by mark-to-market accounting norms. As credit rating agencies lowered their ratings for these assets, prices plunged. Banks had to reflect these developments in their profit and loss statements. From the third quarter of 2007, many of the global banks, which had invested in mortgage backed securities started to book huge losses. Some started to sell off these securities. As the trend continued to worsen, many instruments became illiquid with few takers.

To circumvent regulatory capital requirements, many investment banks had set up Structured Investment Vehicles (SIVs) to invest in various assets including sub prime securities. The banks provided an implicit guarantee and a back up line of credit to the SIVs. The money needed for making these investments was raised by selling commercial paper (CP). Essentially, short term funds were used to fund long term assets. This strategy worked when the credit environment was favourable. But when credit conditions tightened, money market funds and other investors began to lose faith. The SIVs could no longer fund or roll over their positions. Banks had no alternative but to take the assets back on their balance sheet to preserve their reputation. In February 2008, Citibank, Standard Chartered and Dresdner Bank all announced bailout plans for their SIVs. From there on, as the markets plunged, mark-to-market accounting norms led to huge write offs.

Meanwhile, the involvement of monolines created additional complications. Monolines[39] provided insurance on low risk bonds, mainly those issued by municipalities. For example, the two large monolines MBIA and AMBAC began by insuring municipal bonds and debt issued by hospitals and non profit groups. Due to their high credit rating, monolines could operate with little collateral. If they had to post collateral, the thin

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[39] The name "monolines" was coined because they originally provided insurance only on municipal bonds.

insurance spreads would have been wiped out. Taking advantage of their credit rating, the monolines operated with high leverage, with outstanding guarantees adding up at one time to about 150 times the capital. Over time, the business profile of the monolines changed as they moved into various asset backed securities and CDOs. When the crisis worsened, the monolines struggled to retain their credit rating.   And as their ratings were downgraded, the bonds they insured were also downgraded. Investors who held these bonds (Banks were among them) started to incur losses as these bonds were covered by mark-to-market accounting principles. An added complication was that monolines were counterparties to credit derivatives held by financial institutions. The valuation of these derivatives was affected as well, when the monolines suffered ratings downgrades.

As banks continued to report losses on mortgage backed securities and related derivative instruments, the situation became panicky. Information about who was holding these securities and likely to make losses was scanty. Soon distrust developed in the system. Banks stopped doing business with each other. They also found it difficult to raise money in the short term markets to keep rolling over their positions.

A key trigger[40], in the sub prime melt down was the collapse of the market for auction rate securities, a long-term instrument for which the interest rate is reset periodically at auctions. The instrument introduced in 1984 was targeted at borrowers who needed long-term funding; but functioned like a short term security. Periodic auctions gave the bonds the liquidity of a short-term asset that traded at about par. The main issuers of auction rate securities were municipalities, hospitals, museums, student loan finance authorities, and closed-end mutual funds.

When an auction failed, the securities were priced at a penalty rate—at or a spread over Libor. This meant the investors were unable to redeem their money and the issuers had to pay a higher rate to borrow. Failed auctions were rare before the credit market crisis. The banks that conducted the auctions would inject their own capital to prevent an auction failure. From the fall of 2007 onwards, these banks already burdened with huge write downs, became less willing to commit their own money to keep auctions from failing. By February 2008, fears of such failures led investors to withdraw funds from the auction rate securities market. The borrowing costs rose sharply after the auctions failed and the market became chaotic.

Any financial crisis has some defining events. In the recent sub prime crisis, the first of these was the collapse of Bear Stearns in March 2008. Then there was a period of lull till September 2008.   That month turned out to be one of the most dramatic ever in the history of financial markets. Lehman Brothers, Fannie Mae, Freddie Mac, and AIG collapsed while Merrill Lynch had to be taken over by Bank of America. A timeline at the end of this chapter chronicles the key events of the subprime crisis.

The US real estate market[41]

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[40] Anna J Schwartz, "Origins of the financial market crisis of 2008," Cato Journal, Winter 2009.
[41] This section draws heavily from the book, "Subprime Mortgage Credit Derivatives," by Laurie Goodman, Shumin Li, Douglas Lucas, Thomas Zimmerman and Frank Fabozzi, John Wiley & Sons, 2008.

Housing is a huge market in the US. Owning a home is an integral part of the American dream. Most homes are taken on mortgage. A mortgage is nothing but a loan secured by the collateral of some specified real estate property. The key variables in mortgage design are interest rate, maturity and manner of repayment. If the borrower does not make a predefined series of payments, the lender can foreclose the loan and seize the property. Where appropriate, lenders insist that the borrower obtains mortgage insurance. If mortgage insurance is taken, naturally the costs go up.

The value of residential real estate in the United States was $23 trillion in mid - 2007. Against this, there was $10.7 trillion in mortgage debt, with the remaining 53% ($12.3 trillion) representing homeowner equity[42]. Of the $10.7 trillion in residential mortgage debt, $6.3 trillion (59%) had been securitized. In 2007, agency mortgages[43] represented approximately 66% of the securitized market, with nonagency mortgages making up the remaining 34%. The non agency share contained jumbo prime (8% of the total), Alt-A (13%), and sub prime (13%).

A brief explanation of some of the technicalities is in order:

An Alt-A mortgage lies between Prime and Subprime in terms of loan quality. Basically, three types of borrowers fall into this category: those with no credit history; those who do not themselves occupy the house and those who do not disclose necessary data like the current income. These mortgages tend to be of good credit. Their key feature is limited documentation to serve as proof of income.
Subprime borrowers have a credit quality that is too low for prime mortgages. Reasons can include a flawed credit history or low income levels.
 Jumbo prime mortgages generally have a higher credit score than agency mortgages. However, their main distinguishing characteristic is size. These loans exceed a specified size limit ($417,000 in 2007).

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[42] Equity value is created either because the home is equity funded, or the home's value exceeds the mortgage.
[43] Agency mortgages are those guaranteed by either the Government National Mortgage Association (Ginnie Mae), or one of the government-sponsored enterprises (GSEs), Fannie Mae or Freddie Mac. Non agency mortgages do not meet the underwriting criteria required by the agencies. Mortgages that fail to meet the underwriting standards of the agencies are said to be non conforming mortgages.
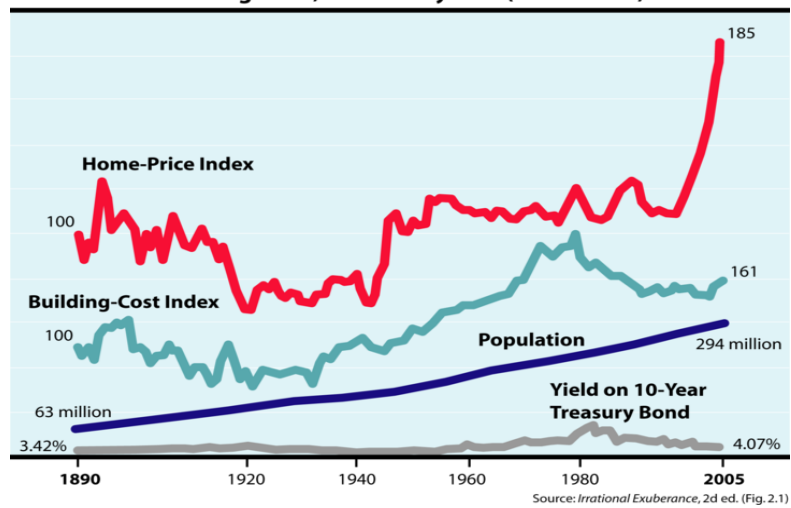
documentation. The main characteristic of subprime borrowers is their Fair Issac Corporation (FICO) score, a measure of the creditworthiness of the borrower.

Jumbo prime mortgages generally have a higher credit score than agency mortgages. However, their main distinguishing characteristic is size. These loans exceed a specified size limit ($417,000 in 2007).
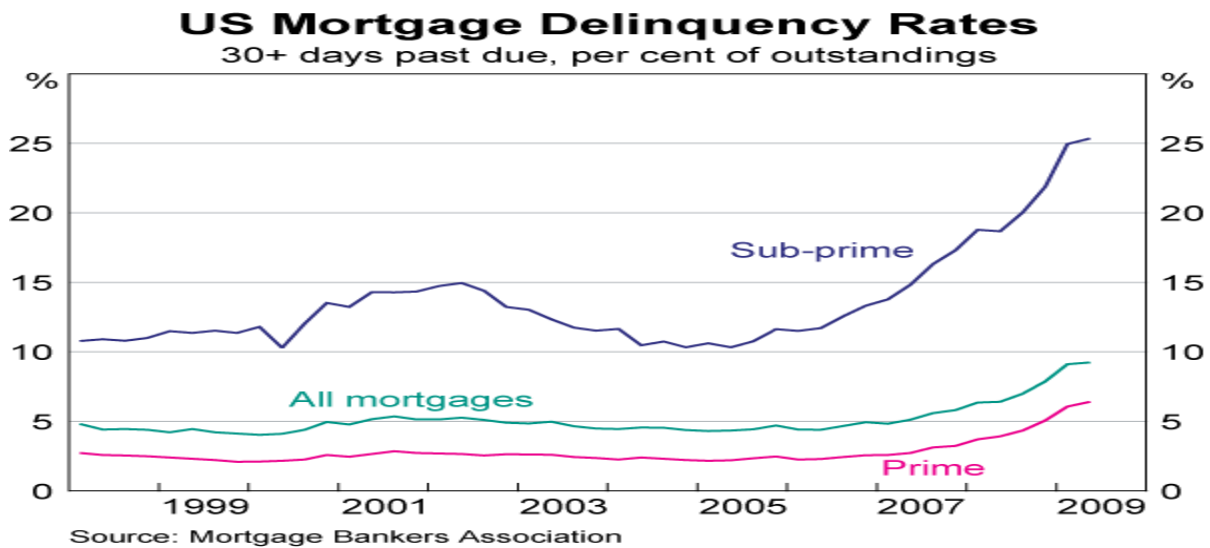
Exhibit 3.2
Falling home prices
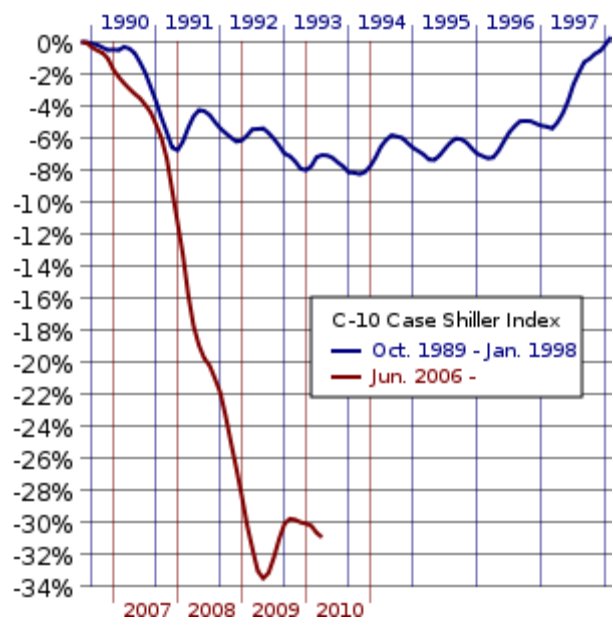
Ref: Wikipedia.org

Exhibit 3.3

Inflation-adjusted U.S. home prices, Population,
Building costs, and Bond yields (1890–2005)

Ref: Wikipedia.org

Exhibit 3.4

US Mortgage Delinquency Rates
30+ days past due, per cent of outstandings

Ref: Reserve Bank of Australia website www.**rba**.gov.au

Thanks to aggressive marketing efforts, the sub prime market boomed. Even as agency issuance declined during 2004-2006, there was a rise in subprime and Alt-A issuance. This reflected the increasing unaffordability of homes both due to property appreciation and rising interest rates. Without relaxing the lending standards, it would have been difficult to keep the mortgage lending boom going. The share of subprime mortgages to total originations was 5% ($35 billion) in 1994, 9% in 1996, 13% ($160 billion) in 1999, and 20% ($600 billion) in 2006.

By 2006, as the housing market weakened, the sub prime market had peaked. Indeed, during 2007, it became very difficult to obtain a subprime or Alt-A mortgage. Investors who had historically purchased securities backed by pools of subprime and Alt-A mortgage were no longer so willing to purchase the securities. Thus originators had no one to sell the loans to and did not have the financial muscle to warehouse these loans. As a result, many originators stopped making loans that did not qualify for agency guarantees. By mid-2007, the mortgage market was again dominated by the agencies. Most subprime originators went out of business, ceased operations or were acquired. At the same time, the agencies seemed to have bitten off more than they could chew. The fortunes of Fannie Mae and Freddie Mac continued to plunge till they had to be bailed out by the US Government in early September 2008.

Historical perspective[44]
The current meltdown is not the first crisis in the subprime market. An earlier crisis had happened in the US in 1998 and 1999, when many subprime lenders went out of business. We first start with a brief review of that crisis.

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[44] This section draws heavily from the book, "Subprime Mortgage Credit Derivatives," by Laurie Goodman, Shumin Li, Douglas Lucas, Thomas Zimmerman and Frank Fabozzi, John Wiley & Sons, 2008.

In the early 1990s, independent specialty finance companies moved into the vacuum created by the demise of the thrift industry in the late 1980s. These thrifts had previously provided loans to homeowners who had been excluded from the action. As they became more active in the housing market, these specialty finance companies took full advantage of accounting rules. They booked the entire gain from a new loan at the time of origination, rather than over the term of the loan. As a result, they could boost their profits through gain-on-sale accounting. This led to a rapid increase in their stock prices and handsome payouts for the owners.

However, the picnic was too good to last. Investors began to understand the accounting jugglery just as the 1998 liquidity crisis hit. When credit lines were pulled, the specialty finance subprime lenders were no longer able to warehouse new loans. And they did not have the capital to add newly created loans to their balance sheets. The resulting credit squeeze led to many bankruptcies or forced mergers with larger, better capitalized firms.

Financial crises do occur from time to time. While they have common features, they are also different in some respects. The subprime market of the late 1990s was markedly different from the one that crashed in 2007. The typical subprime loan in 1998 was a refinancing 30-year fixed rate loan or a 30-year, six-month floating rate loan based on LIBOR. Borrowers were middle-aged homeowners who had been in their home for about 10 years and wanted to book capital gains in order to renovate the home, fund children's college education or buy a new car. Very few subprime borrowers used these mortgages to purchase a home. Indeed, those days, the term, subprime was far less used than "home equity."

Another point to note is that the financial system was less complicated then. For example, credit default swaps had not taken off. Also, very little credit and default analysis was done in the mid-1990s. Nor was there the kind of media coverage that we see today. In fact, as the delinquency and loss rates began to rise in 1996 and 1997, there was very little comment from Wall Street because few research groups were tracking performance data at the time.

More about the current crisis

The recent crisis assumed monstrous proportions thanks to a combination of factors. These included:
- imbalances in the global financial system,
- low interest rates,
- political intervention,
- a laissez-faire attitude on the part of government officials and regulators,
- lax and predatory lending practices,
- a false belief that the housing boom would go on forever,
- a originate-to-distribute securitization process that separated origination from ultimate credit risk,
- highly optimistic rating of mortgage securities by credit rating agencies.
- new derivatives like credit default swaps that fuelled speculation in segments of the mortgage market.

Let us explore these themes in a little more detail in the following paragraphs.

Many economists and market analysts believe the roots of the current financial melt down go back at least eight years in time. The US economy had been facing the risk of a deep recession after the <u>dotcom</u> <u>bubble</u> burst in early 2000. This situation was worsened by the 9/11 terrorist attacks, which created a great deal of panic and uncertainty among Americans. In response, the US Central bank, the Federal Reserve (Fed) under the leadership of Alan Greenspan tried to stimulate the economy by reducing interest rates aggressively. In particular, Greenspan hoped housing would get the momentum back into the US economy. Between New Year's Day 2001 and mid-2003, the Fed cut the Federal Funds rate from 6.5% to 1%. The rate remained at 1% for 12 months from July 2003 to July 2004. Naturally people got an opportunity to borrow much more money than they otherwise would have been able to afford.

As mentioned earlier, owning a house is part of the American dream. And the housing market, which is huge as mentioned earlier, has a big impact on the business cycle in the US. Not surprisingly, American politicians have strongly supported the cause of home ownership. Over the years, various pieces of legislation have been introduced in the US to make mortgages affordable to more people.

- The Federal Housing Administration (FHA) was set up in 1934 to insure mortgage loans provided given by private firms. Initially, a borrower had to make a 20% down payment to qualify for the loan. Later, this requirement was reduced. By 2004, the required down payment for FHA's most popular program was 3%.
- The Home Mortgage Disclosure Act, 1975 asked lending institutions to report their loan data so that the underserved segments could be targeted for special attention.
- The Community Reinvestment Act (CRA), 1977 required institutions to provide loans to people in low and moderate income neighbourhoods. Congress amended CRA in 1989 to make banks' CRA ratings public information. In 1995, the regulators got the power to deny approval for a merger to a bank with low CRA rating.
- The Depository Institutions Deregulatory and Monetary Control Act (DIDMCA), 1980 eliminated restrictions on home loan interest rates. Financial institutions could charge borrowers a premium interest rate.
- The Alternative Mortgage Transaction Parity Act (AMTPA) allowed lenders to charge variable interest rates and use balloon payments.

Exhibit 3.5
US Corporate Bond Yields
7-10 years maturity
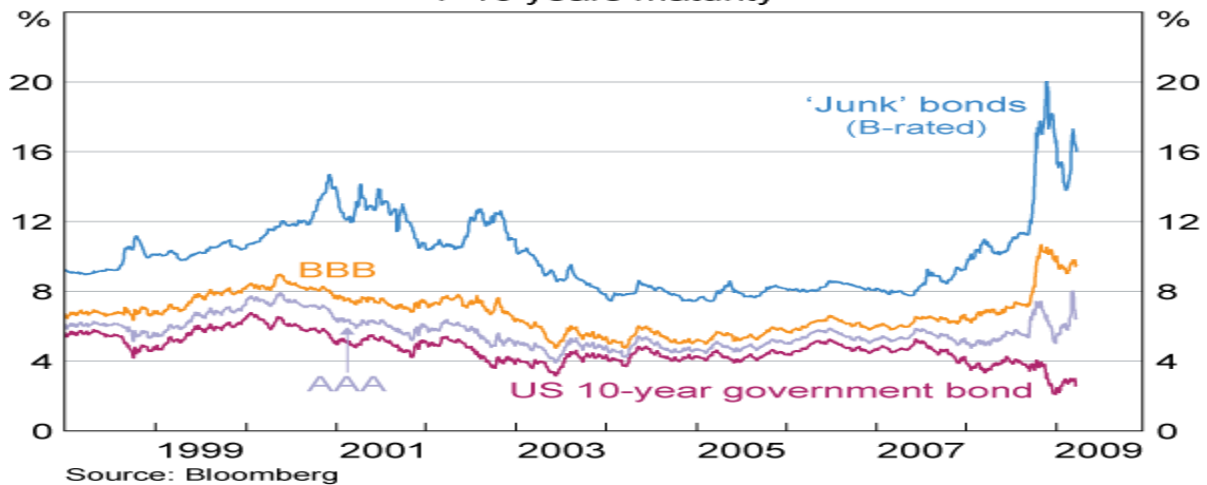
Ref: Reserve Bank of Australia website www.**rba**.gov.au

In 1992, Congress directed Fannie Mae (Fannie) and Freddie Mac (Freddie) to increase their purchases of mortgages going to low and moderate income borrowers. In 1996, Fannie and Freddie were told to allocate 42% of this financing to such borrowers. The target increased to 50% in 2000 and 52% in 2005. Fannie and Freddie were also directed to support "special affordable" loans to borrowers with low income. Fannie and Freddie could sustain this aggressive lending as the markets believed there was an implicit guarantee from the government. So the cost of funds for these agencies was only slightly more than that of Treasury securities. In September 2003, during House Financial Services Committee proceedings, suggestions were made to rein in Fannie and Freddie. But people like Barney Frank who is leading the efforts to restore the health of the American banking system today, fought hard to maintain the status quo.

President Bush personally championed the cause of housing when he articulated his vision of an "ownership society." In 2003, he signed the American Dream Down payment Act, a program offering money to lower income households to help with down payments. The Bush administration also put pressure on Fannie and Freddie to provide more mortgage loans to low income groups. By the time of the sub prime crisis, these two pillars of the American housing system had become heavy investors in the triple A rated, senior tranches of CDOs, which lay at the heart of the crisis.

At some points of time, Congress did raise some concerns about predatory lending, i.e., aggressive lending in which borrowers are not fully aware of the long term implications of the loan. In 1994, Congress passed the Home Ownership and Equity Protection Act (HOEPA) which authorised the Fed to prohibit predatory lending practices by any lender, irrespective of who regulated the lender. The Fed however used these powers only sparingly.

By mid-2004, fears about deflation had diminished while those about inflation had increased. When the Fed got into a tightening act, the benchmark interest rate went up to 5.25%. People who had borrowed when rates were 1% did not have time to adjust to the pressures of larger interest payments. With traditional profit making opportunities drying up, lenders became willing to take greater risks and entered the subprime segment in a big way. They did this by introducing adjustable rate mortgages, which came with several options:

- Low introductory interest rate that adjusted after a few years.
- Payment of only interest on the loan for a specified period of time.
- Payment of less interest than was due, the balance being added to the mortgage.
- Balloon payments in which the borrower could pay off the loan at the end of a specified period of time.

Adjustable Rate Mortgages (ARMs) had been around for the past 25 years. But in the past, they were offered to creditworthy borrowers with stable incomes and who could make bigger down payments. In 2006, 90% of the sub prime loans involved ARMs.

Traditionally, as a risk mitigation measure, lenders insisted that borrowers making small down payments must buy mortgage insurance. But insurance was costly. To allow home buyers to avoid buying mortgage insurance, generally required for large loans with low down payments, lenders counselled borrowers to take out two mortgages. This way, they circumvented the system and made it easier than ever for people to get a mortgage loan. In short, borrowers and lenders collaborated to beat the system!

As homes became more and more unaffordable, lenders became even more aggressive. Loans were offered without the need for borrowers to prove their income. "Stated income" loans went mainstream. They came to be known as liars' loans. By 2006, well over half of the subprime loans were stated income loans. Some builders even set up their own mortgage lending affiliates to ensure that credit kept flowing even if traditional lenders refused to lend.

Home equity played a big role in fuelling the boom. As real estate prices continued to rise, sub prime borrowers were able to roll over their mortgages after a specified number of years. They paid the outstanding loan with funds from a new larger loan based on the higher valuation of the property. Thus, borrowers could immediately spend the gain they booked on the property. From 1997 through 2006, consumers drew more than $9 trillion in cash out of their home equity. In the 2000s, home equity withdrawals were financing 3% of all personal consumption in the US.

Even with soaring house prices, the market could not have expanded so much without securitization. Previously, mortgages appeared directly on a bank's balance sheet and had

to be backed by equity capital. Securitization allowed banks to bundle many loans into tradable securities and thereby free up capital. Banks were able to issue more mortgage loans for a given amount of underlying capital.

For securitisation to take off, clever marketing was required. Few investors would have looked seriously at sub prime mortgage securities considered alone. To make subprime mortgages more palatable to investors, they were mixed with higher rated instruments. In the products so created, different groups of investors were entitled to different streams of cash flows based on the risk return disposition of the investors. These products came to be known as Collateralised Debt Obligations (CDOs). We shall cover CDOs in more detail a little later in the chapter.

As mentioned in Chapter 2, the imbalances in the global financial system also played a crucial role in helping securitisation take off. Many countries in the Asia Pacific and the Middle East had registered huge trade surpluses with the US and accumulated huge amounts of foreign exchange reserves. Traditionally, these countries had invested their excess dollars in US treasury bills and bonds. To generate more returns, they began to look at other US instruments including those related to mortgage, more seriously.

Complex, opaque instruments and heavy speculation transformed the market conditions dramatically. The basic principles of risk pricing were conveniently ignored. Indeed, the risk pricing mechanism broke down[45]. A study by the Fed indicated that the average difference in mortgage interest rates between subprime and prime mortgages declined from 2.8 percentage points (280 basis points) in 2001, to 1.3 percentage points in 2007. This happened even as subprime borrower and loan characteristics deteriorated overall during the 2001–2006 period. The more investors started to buy mortgage backed securities, the more the yields fell. Eventually a high rated security fetched barely more than a sub prime mortgage loan. But investors, having succumbed to the temptation, failed to back off. Rather than trying to reduce their positions, they tried to generate greater returns, using leverage.

As mentioned earlier, the payment burden for subprime mortgage borrowers increased sharply after an initial period. Borrowers were betting on rising home prices to refinance their mortgages at lower rates of interest and use the capital gains for other spending. Unfortunately, this bet did not pay off. Real estate prices started to drop in 2006 while interest rates rose. So the easy gains from refinancing mortgages evaporated.   Many of the sub prime mortgages had an adjustable interest rate. The interest rate was low for an initial period of two to five years. Then it was reset. These reset rates were significantly higher than the initial fixed "teaser rate" and proved to be beyond what most subprime borrowers could pay. This double whammy, fall in home value and higher reset rates, proved to be too much for many borrowers.

To get an idea of the magnitude of the problem, the value of U.S. subprime mortgages had risen to about $1.3 trillion as of March 2007. Of this amount, the estimated value of

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[45] This and the three paragraphs which follow draw heavily from the book, "Subprime Mortgage Credit Derivatives," by Goodman, Li, Lucas, Zimmerman and Fabozzi.

subprime adjustable-rate mortgages (ARM) resetting at higher interest rates was $400 billion for 2007 and $500 billion for 2008. Approximately 16% of subprime loans with adjustable rate mortgages (ARM) were 90-days delinquent or in foreclosure proceedings as of October 2007, about three times the rate of 2005. By January 2008, the delinquency rate had risen to 21% and by May 2008 it was 25%. Subprime ARMs only represented 6.8% of the home loans outstanding in the US. But they accounted for 43.0% of the foreclosures started during the third quarter of 2007.

The number of home loan defaults rose from an annualised 775,000 at the end of 2005 to nearly 1 million by the end of 2006. A second wave of defaults and foreclosures began in the spring of 2007. A third wave of loan defaults and disclosures happened when home equity turned negative for many borrowers. As many as 446,726 U.S. household properties were subject to some sort of foreclosure action from July to September 2007. The number increased to 527,740 during the fourth quarter of 2007. For all of 2007, nearly 1.3 million properties were subject to 2.2 million foreclosure filings, up 79% and 75% respectively compared to 2006. These developments forced a crash in the housing market. At the start of 2007, new and existing home sales were running close to 7.5 million units per year. By the end of the year, the number had fallen below 5.5 million.

Total home equity was valued (in the US) at its peak at $13 trillion[46] in 2006. This dropped to $8.8 trillion by mid-2008. Total retirement assets fell from $10.3 trillion to $8 trillion during the same period. At the same time, savings and investment assets lost $1.2 trillion and pension assets $1.3 trillion during the same period.

More about Securitisation

A more detailed account of securitisation is in order. Securitisation as a concept was introduced by Lewis S Ranieri in 1977, but has gained currency only in recent years. The securitized share of subprime mortgages (i.e., those passed to third-party investors) increased from 54% in 2001, to 75% in 2006. Of the $10.7 trillion worth of residential mortgage debt, $6.3 trillion had been securitised[47] by mid-2007. A brief account of how securitisation works, follows.

Securitisation as the name suggests converts loans into tradable securities. Illiquid loans are packaged into a special purpose vehicle and sold in parcels to investors who are happy to receive payments from the underlying mortgages over time. Effectively, securitisation aims at generating cash out of relatively illiquid instruments. Lenders can free up capital for more lending. On the other hand, investors receive returns higher than they would have got in case of equivalent traditional investments. In the early 2000s, as the housing market boomed, securitisation seemed to create a win-win situation for lenders and investors.

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[46] Roger C Altman, "The great crash, 2008 – A geopolitical set back for the west," *Foreign Affairs,* Jan – Feb 2009.

[47] The securitised portion consisted of agency and non agency mortgages. Agency mortgages were generated by Ginnie Mac, Fannie Mac or Freddie Mac. Non agency mortgages did not meet the underwriting criteria required by the agencies.

Exhibit 3.6
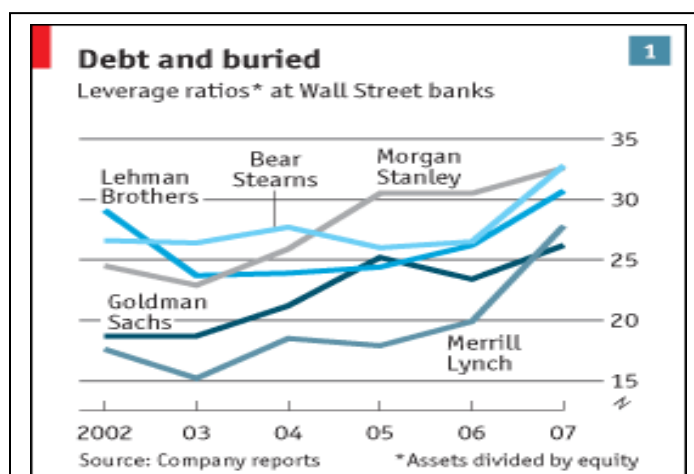
Ref: The Economist, May 17, 2008.

As the market boomed, financial engineering and increased trading went hand in hand. Many investment banks bought the mortgages from lenders and <u>securitized</u> these mortgages into bonds, which were sold to investors in various forms. This "plain vanilla" securitisation soon gave way to more sophisticated structured products. Assets of different risk characteristics were combined. The cash flows expected from these assets were <u>tranched</u> and traded in the extremely large and very liquid <u>secondary mortgage market</u>. This is how Collaterised Debt Obligations (CDOs) were born.

Exhibit 3.7

Why securitisation failed to spread risk
▪ A large part of the credit risk remained in the banking system as banks were among the most active buyers of structured products.
▪ Risks also remained in the banking system as sponsoring banks provided liquidity guarantees to structured investment vehicles.
▪ Risk was not properly measured and priced by the credit rating agencies who were excessively optimistic about the prospects for the structured products.
▪ AAA tranches were designed in such a way that they just managed to cross the threshold level needed to get the highest rating. A slight change in the circumstances was all that was required to increase the probability of default and trigger off a ratings downgrade with cascading effects.
▪ There was a moral hazard problem as the loan originating bank had less incentive to take particular care while approving loans.
▪ Unlike traditional corporate bonds, whose fortunes are linked mainly to the firm's performance, the performance of CDO tranches was affected by the performance of the economy as a whole. In other words, risks that were largely diversifiable, were substituted by those that were highly systematic. CDOs had a much less chance of surviving a severe economic downturn, compared to traditional corporate securities of equal rating.

Ref: (1) Markus K Brunnermeier, "Deciphering the liquidity and credit crunch 2007-08," Journal of Economic Perspectives, Winter 2009.
(2) Joshua Coval, Jakub Jurek, Erik Stafford, "The Economics of Structured Finance," Journal of Economic Perspectives, Winter 2009.

The originate-to-distribute model of securitisation ensured that the identity of the original instruments was completely lost. Indeed, the instruments were transformed beyond

recognition. Simple instruments became "exotic" ones. From the point of origination to the point at which it became part of a mortgage-backed security, various intermediaries were involved. A brief account of the roles played by these intermediaries, follows.

Mortgage brokers had big financial incentives for selling complex, adjustable rate mortgages (ARMs), since they earned higher commissions[48]. In 2004, mortgage brokers originated 68% of all residential loans in the U.S., with subprime and Alt-A loans accounting for 42.7% of the total production volume of brokerages.

The *mortgage originator* could be a bank, mortgage banker or mortgage broker. Banks and mortgage bankers used their own funds to originate mortgages unlike mortgage brokers, who acted as independent agents for banks or mortgage bankers. While banks used their traditional sources of funding to make loans, mortgage bankers typically used a line of credit to fund loans.

Most banks and nearly all mortgage bankers, quickly offloaded newly originated mortgages in the secondary market. However, depending on their size and sophistication, originators might accumulate mortgages for a certain period of time before selling the whole package. There was risk involved for originators who held on to a mortgage after an interest rate had been quoted and locked in by a borrower. In general, mortgage originators made money through the fees that were charged to originate a mortgage and the difference between the interest rate given to a borrower and the premium the investors in the secondary market were prepared to pay.

Aggregators were large mortgage originators with ties to Wall Street firms and government-sponsored enterprises (GSEs), like Fannie Mae and Freddie Mac. Aggregators purchased newly originated mortgages from smaller originators, and along with their own originations, formed pools of mortgages. They either securitized these mortgages into private label mortgage backed securities (MBS) (by working with Wall Street firms) or agency MBSs (by working with government backed agencies like Fannie Mae and Freddie Mac.). Aggregators hedged the mortgages in their pipelines until the securities were sold to a dealer. Aggregators made profits by the difference in the price that they paid for mortgages and the price at which they could sell the MBSs created from those mortgages.

An MBS was typically sold to a securities dealer. Dealers frequently used MBS to structure other products with somewhat definite prepayment characteristics and enhanced credit ratings compared to the underlying MBS or whole loans. Dealers arbitraged through the spread in the price at which they bought and sold MBS.

Investors included foreign governments, pension funds, insurance companies, banks, GSEs and hedge funds. In the build up to the sub prime crisis, some of these investors preferred to invest in high-credit rated mortgage products while others such as hedge funds typically invested in low-credit rated mortgage products and structured mortgage products with greater interest rate risk. Typically, banks invested in senior instruments.

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[48] According to a study by Wholesale Access Mortgage Research & Consulting Inc.

Thanks to the high credit rating of these instruments, they had to keep little capital in reserve. Insurance companies and various asset managers who were searching for higher returns invested in the mezzanine tranches. At the same time, they were not bound by the same regulatory constraints as banks. The hedge funds were prepared to move into equity tranches. This meant more risk but there was no option as these funds, due to the very nature of their business model, had promised their clients very high returns.

What happened essentially was that a huge *shadow banking system* was created. Banks did not want to keep mortgages and loans on their balance sheet as they needed more capital backing. Instead, they held MBS with low risk weights as per the Basle framework. The funding for the loans increasingly came from non banking institutions. These included investment banks, hedge funds, money market funds, finance companies, asset backed conduits and SIVs.

According to Mark Zandy of Economy.com, the shadow banking system provided credit to the tune of $6 trillion by the second quarter of 2007. The shadow banking system was subject to minimal regulatory oversight and did not have to make significant public disclosures. The use of leverage amplified the problem. At the peak of the frenzy in 2005-06, some hedge funds were leveraging their investments as many as 50 times.

More about CDOs and CDSs

One of the fascinating aspects of the sub prime crisis has been the degree of opaqueness created in the financial system by securitisation. The vehicle which has made this possible is the Collateralised Debt Obligation (CDO). CDOs allow asset backed securities to be mixed with subprime mortgage loans and placed into different risk classes, or underlined tranches, each with its own repayment schedule. Upper tranches receive 'AAA' ratings as they are promised the first cash flows that come into the security. Lower tranches have lower priority but carry higher coupon rates to compensate for the increased default risk. Finally at the bottom, lies the "equity" tranche. Its cash flows may be wiped out if the default rate on the entire asset backed securities creeps above 5 to 7%.

A simple illustration will explain how a CDO operates. Say a bank has granted 1000 subprime mortgage loans with an overall principal value of $ 300 million.

Based on the historical delinquency rates of 4% and average losses for defaulted sub prime mortgages of 25%, the expected loss for the pool would be 4% of 25%, i.e., 1%, or USD 3mn. This loss rate would be too high for the instrument to achieve a AAA credit rating.

So the bank redistributes the cash flows of the underlying mortgages to four different tranches. Tranche 1, the "AAA"-rated tranche, has a senior claim on all interest and principal payments of the mortgage pool. No other tranche may receive any cash-flows till all payments on the AAA tranche are met. Its size equals say 80% of the overall volume of the mortgage pool, or 0.8 x 300 million, i.e., $240 million.

Tranche 2, the "A"-rated tranche, is subordinated to the AAA tranche, but remains senior to all remaining tranches. Its size is 12% of the over-all volume, or 0.12 x 300 million i.e., 36 million.

Tranche 3, the "BB"-rated or High Yield tranche represents another 5% of the overall volume, i.e., $15 million and is subordinated to both higher-rated tranches.

The "Equity tranche" equals 3% of the pool volume, ie., $9 million and receives anything that is left over, after all other tranches are fully serviced.

If the losses remain within $3 million, the equity tranche takes all losses while all other tranches receive the full amount of interest and principal payments. Even with a cyclical rise in default rates, the AAA tranche would be well protected from losses.

Let us assume that if delinquency rates rise to 25%, losses on defaulted subprime mortgages will rise to 50%. This may result in a loss rate of 0.25 x 0.5 = 12.5% i.e., (.125) (300) = $37.5 million. This would erase the Equity tranche (3%, 9 million) and the BB tranche (5%, 15 million) entirely. The remaining losses ($13.5 million) would be absorbed by the A tranche which would lose 37.5% of principal (13.5/36). The AAA tranche would not carry losses, but its buffer for further losses would largely disappear. It would be living at the edge, so to say!

Through the process of tranching, the subprime mortgage lenders found a way to sell their risky debt. Nearly 80% of these bundled securities were rated <u>investment grade</u> ('A' rated or higher), by the rating agencies, who earned lucrative fees for their work in rating the ABSs.

Having found a way to <u>originate</u> and distribute risky mortgages, banks moved into subprime lending very aggressively. Basic requirements like proof-of-income and <u>down payment</u> were waived off by some mortgage lenders. By using <u>teaser rates</u> within <u>adjustable-rate mortgages</u> (ARM), borrowers were enticed into an initially affordable mortgage in which payments would skyrocket in a few years. The CDO market ballooned to more than $600 billion in issuance during 2006 alone - more than 10 times the amount issued just a decade earlier.

Exhibit 3.8
Growth in outstanding credit default swaps
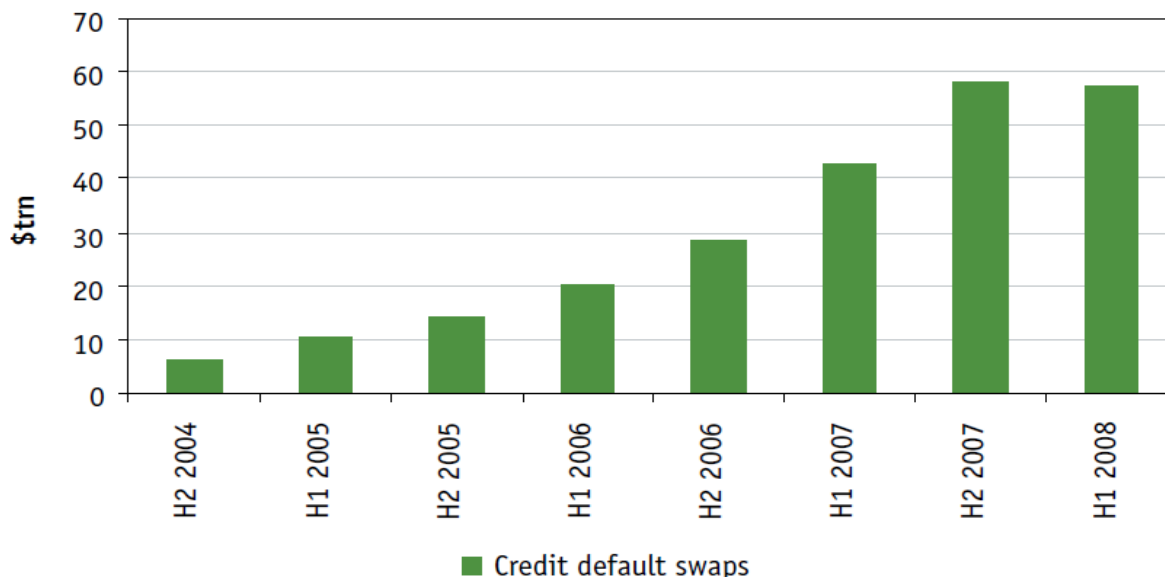
Source: BIS Quarterly Review, December 2008

Ref: The Turner Review - A regulatory response to the global banking crisis, published by: UK Financial Services Authority, www.fsa.gov.uk/pubs/other/turner_review; March 2009.

The need to satisfy risk management and regulatory capital requirements fuelled another financial innovation, the credit default swap (CDS). CDS was first introduced by J P Morgan in the early 1990s to hedge credit risk. CDS effectively acts as an insurance. The protection buyer pays a premium or spread at periodic intervals to the protection seller. The protection seller pays the buyer a predefined amount in case of a default or a lowering of credit rating. CDS effectively replaces the credit risk of the counterparty by the risk of the protection seller.

Unlike insurance, CDS is an unregulated market. Moreover, unlike insurance where the insurance buyer owns the asset, CDS can be bought even without asset ownership. Mortgage backed securities and CDOs make up the bulk of the CDS market. Sellers of credit protection do not need to put aside capital as per regulatory guidelines. While many banks insist on protection sellers putting aside some money, there are no industry standards.

By mid-2008, the CDS market had exploded, reaching about $60 trillion at its peak. Banks, hedge funds, insurance companies, mutual funds and pension funds were major players in the market. Many complicated deals were structured. A hedge fund might sell protection to a bank which might sell the same protection to another bank and so on with some transactions completing the full circle. Synthetic CDOs invested the money they raised in risk free instruments and simultaneously sold CDS on securities.

As the US housing market started to slow down, new homes sales stalled, sale prices flattened and default rates began to rise sharply. CDOs no longer looked so attractive to

investors in search of high yield. Many of the CDOs had been re-packaged many times. So it became difficult to tell how much subprime exposure was actually in them. Many CDOs became unmarketable. Doubts started to increase about the ability of the CDS protection sellers to discharge their obligations. Most mortgage lenders were forced to shut down their operations.

Changing risk profile

As a result of securitization, the risk profile of mortgage backed assets has changed drastically in recent years.

Credit risk: Traditionally, credit risk has been assumed by the bank originating the loan. However, due to securitization, credit risk can be transferred to third-party investors. In exchange for assuming credit risk, third-party investors receive a claim on the mortgage assets and related cash flows.

Market risk: The valuation of MBS (Mortgage Backed Securities) and CDO (Collateralised Debt Obligations) is complex. The valuation is linked to the collectibility of subprime mortgage payments and the existence of a viable market for these assets. During the crisis, rising mortgage delinquency rates reduced the demand for such assets. Banks and institutional investors recognized substantial losses as they revalued their MBS downward. Several companies that borrowed money using MBS or CDO assets as collateral, faced margin calls, as lenders executed their contractual rights to get their money back.

Liquidity risk: Many companies relied on access to short-term funding markets such as the commercial paper and repo markets. However, because of concerns regarding the value of the mortgage asset collateral linked to subprime loans, the ability of many companies to issue such paper was significantly affected. In addition, the interest rate charged by investors to provide loans for commercial paper increased substantially above historical levels.

Counterparty risk: Major investment banks and other financial institutions took significant positions in credit derivative transactions. Due to the effects of credit, market and liquidity risks, the financial health of investment banks declined. Rising counterparty risk created further uncertainty in financial markets.

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*Source***:** Laurie Goodman, Shumin Li, Douglas Lucas, Thomas Zimmerman and Frank Fabozzi, "Subprime Mortgage Credit Derivatives," John Wiley & Sons, 2008.

In the face of this growing uncertainty, investors became much more <u>risk averse</u>, and looked to unwind positions in potentially risky MBSs. Three-month Treasury bills became popular and yields fell sharply in a matter of days. (As bond prices increase, yields tend to fall). The <u>spread</u> between similar-term corporate bonds and T-bills, widened to unprecedented levels.

Exhibit 3.9

TED Spread & Components - 2008

The "TED Spread" is a measure of credit risk for inter-bank lending. It is the difference between: 1) the three-month U.S. treasury bill rate; and 2) the three-month LIBOR rate, which represents the rate at which banks typically lend to each other. A higher spread indicates banks perceive each other as riskier counterparties.

Percent

LIBOR (3 mo.)

TED Spread

T-bill (3 mo.)
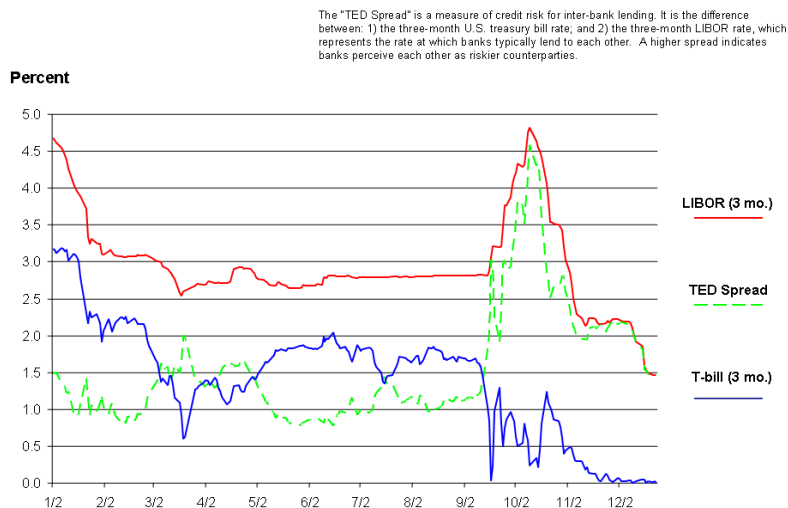
Ref: Wikipedia.org

The Liquidity Crunch

As the sub prime crisis unfolded, linkages among different markets became evident. The uncertainty in the interbank market spilled over to the corporate market, especially for lower rated loans and bonds. Banks had been using junk bonds to finance leveraged buyouts. They had hoped to off-load them to investors quickly. But in the troubled environment, the junk bonds remained on the balance sheet.

Monolines briefly mentioned earlier, had been providing insurance on municipal bonds. This was widely considered a pretty safe business as state and local governments rarely defaulted. But many monolines expanded beyond this business. They entered the CDS market in a big way. The rating agencies threatened to downgrade the ratings of the bond insurer. And as the bond insurers were downgraded, so too were the bond issuers. Even municipalities with stable finances found interest rates on their bonds going up.

As the mortgage market correction gained momentum, investors began to focus more closely on credit quality and valuation challenges in illiquid markets. The first signs of the impending liquidity squeeze came in the asset-backed commercial paper (ABCP) market, when issuers began to encounter difficulties rolling over outstanding volumes. When nervousness about funding needs and the liabilities of banks intensified, liquidity demand surged, causing a major disruption in the interbank money markets.

Markus Brunnermeier[49], has explained how liquidity problems amplified the sub prime crisis in various ways. When asset prices dropped, financial institutions' capital eroded and, at the same time, lending standards and margins tightened. Both effects caused fire-

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[49] "Deciphering the Liquidity and Credit crunch 2007-2008," Journal of Economic Perspectives, Winter 2009.

sales, pushing down prices and tightening funding even further. Banks also became concerned about their future access to capital markets and started hoarding funds.

The nature of funding aggravated these problems. Most investors preferred assets with short maturities, such as short-term money market funds. It allowed them to withdraw funds at short notice to accommodate their own funding needs. It might also have served as a commitment device to discipline banks with the threat of possible withdrawals. On the other hand, most mortgages had maturities measured in decades.

In the traditional banking model, commercial banks financed these loans with deposits that could be withdrawn at short notice. In the build up to sub prime, the same maturity mismatch was transferred to a "shadow" banking system consisting of off-balance-sheet investment vehicles and conduits. These structured investment vehicles raised funds by selling short-term asset-backed commercial paper with an average maturity of 90 days and medium-term notes with an average maturity of just over one year, primarily to money market funds.

The strategy of off-balance-sheet vehicles—investing in long-term assets and borrowing with short-term paper—exposed the banks to *funding liquidity risk*. To ensure funding liquidity for the vehicle, the sponsoring bank had granted a credit line to the vehicle, called a "liquidity backstop." As a result, the banking system still carried the liquidity risk. When investors suddenly stopped buying asset-backed commercial paper, preventing these vehicles from rolling over their short-term debt, the assets came back to the balance sheets of the banks.

Another important trend was an increase in the maturity mismatch on the balance sheet of investment banks, due to a growth in balance sheet financing with short-term repurchase agreements, or "repos." Much of the growth in repo financing (as a fraction of investment banks' total assets) was due to an increase in overnight repos. The fraction of total investment bank assets financed by overnight repos (as opposed to term repos with a maturity of upto three months) roughly doubled from 2000 to 2007. The excessive dependence on overnight repos caused serious liquidity problems as the crisis aggravated.

Sub prime Terminology

Loan-to-Value Ratio
The loan-to-value (LTV) ratio refers to the loan amount divided by the value of a home. Higher the ratio, the greater the risk involved for the lender.
Credit Score
A credit score is a measure of the likelihood that a borrower will repay a debt.
FICO Scores
 FICO scores are tabulated by independent credit bureaus, using a model developed by Fair Isaac Corporation (FICO). These scores range from 350 to 900, with higher scores denoting lower risk.
SISA/NISA/No ratio
Documentation is needed to verify the borrower's financial circumstances and assess the repayment capability. Full documentation generally involves the verification of income and assets. With limited documentation, either income or assets are not verified. Limited documentation can take many forms, including SISA (stated income, stated assets), NISA (no income, income not provided, stated assets), No Ratio (income not provided, assets verified).

Alt A
Limited documentation is the key feature of Alt-A products. In fact, the Alt-A market originally targeted borrowers who owned their own business and lacked traditional documentation such as employment and income verification. Then, in the late 1990s, the agencies began to accept limited documentation for borrowers with higher FICO scores and lower LTVs.

Agency Loans
All agency (Fannie Mae, Freddie Mac, Ginne Mae) loans for single family homes must be less than a specified limit ($417,000 in 2007). The loan limit is reset annually. Even though there is a limit, the average loan size is much smaller. (In the third quarter of 2007, it was approximately $225,000 for new origination).

Jumbo Loans
Loans meeting the credit criteria of Fannie Mac & Freddie Mac except size are referred to as *jumbo* loans.

Conforming / Non confirming loans
Alt-A loans can be either *conforming* or *nonconforming*. Their average size of $294,000 falls midway between that of agencies and jumbos. Subprime loans are typically similar in size to agency loans. However, there is a substantial minority of loans that are nonconforming in terms of size.

Debt-to-Income Ratio (DTI)
While the FICO score is used as an indicator of individuals' willingness to repay their loan, DTI is used as a measure of the ability to repay. Two DTI ratios are commonly used in mortgage underwriting: *front-end* DTI and *back-end* DTI. The front-end ratio divides a homeowner's housing payments (including principal, interest, real estate taxes, and home insurance payments) by gross income. The back-end ratio divides total monthly debt payment (including housing-related payments plus all credit card and auto debt, as well as child support payments) by gross income. In practice, FICO and DTI tend to be highly correlated.

Adjustable Rate Mortgages
As the name suggests, the interest rate in case of such mortgages varies over the life of the mortgage. The standard adjustable rate mortgage (ARM) is fixed for a period of time, and floats thereafter. In agency, Alt-A, and jumbo lending, the standard ARM is fixed for 3, 5, 7 or 10 years, and resets annually thereafter. Five years is the most common time to reset, with both 7- and 10-year terms more popular than the three-year term.

Borrowers taking out ARMs are generally looking to lower their monthly payments. ARM borrowers are generally characterised by higher defaults. They also have higher loss severity.

Interest-only Mortgages
Here the borrower pays only interest and not principal for a period of time. Borrowers taking out interest-only mortgages tend to have higher default rates than those who use conventional 30-year mortgages.

Prime mortgages
Prime mortgages are granted to borrowers with clean credit history and sufficient current income to meet payments.

Subprime Mortgages
Mortgages of poor credit quality, typically with a flawed credit history or low income levels in relation to the mortgage payments involved. They have very low credit score.

Conduit
A conduit is a medium or a legal vehicle formed to hold receivables transferred by the originator on behalf of the investors. It is a Special Purpose Vehicle (SPV) which holds the receivables transferred by different originators, financed by the issue of commercial paper. In case of a liquidity crunch, investors in such vehicles can encounter difficulties in accessing the money market to refinance the receivables. Conduits don't need to be consolidated in financial reporting.

Level 1,2, 3 valuations
A three level hierarchy exists for measuring "fair values" of assets and liabilities.
- Level 1 means the values come from quoted prices in active markets.
- Level 2 valuation techniques are based on "observable inputs", such as recent transaction prices for similar items.
- Level 3 is based on valuation techniques using "unobservable inputs". Such inputs incorporate all factors which market participants would consider when pricing the asset (or liability) in a current transaction at the balance sheet date.

Mortgage pass through securities
Such securities are created by pooling mortgages and selling shares or participation certificates in the pool. The cash flows of such securities depend on the cash flows of the underlying pool of mortgages. When cash flows of mortgage related products are redistributed to different bond classes, the resulting securities are called collateralised mortgage obligations. The collateral is nothing but the mortgages underlying the cash flows. Collateralised debt obligation is a more general term with the underlying assets including various kinds of debt instruments.

Stripped mortgage backed securities
In some mortgage backed securities, there are only two bond classes. One bond class receives all of the interest and the other all of the principal. The one which receives only the interest is called interest only mortgage strip. The one receiving only the principal is called principal only mortgage strip.

Source: Laurie Goodman, Shumin Li, Douglas Lucas, Thomas Zimmerman and Frank Fabozzi, "Subprime Mortgage Credit Derivatives," John Wiley & Sons, 2008.

How the Investment banks were trapped

In mid-2007, SIVs held $1.4 trillion of sub prime MBSs and CDOs. Banks found SIVs attractive for more than one reason. Not only could sizable profits be generated for creating and managing SIVs, but also due to their off balance sheet nature, little capital was needed to back them.

SIVs issued commercial paper to finance much longer term investments. This was fine as long as money market funds were willing takers. But when the performance of the SIVs deteriorated, the money market funds withdrew. So, the SIVs turned to their parent companies for funding. In late 2007, when nearly all the SIVs looked like failing simultaneously, the big banks brought the SIV investments back to their balance sheets.

Conduits were similar to SIVs. They held the loans until they could be pooled into securities. Conduits were also funded with short term paper. Like the SIVs, the conduits also ran into trouble when the money market funds withdrew.

In hindsight, it is clear that one distorting force leading to the popularity of SIVs was *regulatory and ratings arbitrage.* The Basel norms required that banks hold capital of at least 8 percent of the loans on their balance sheets. This capital requirement was much lower for contractual credit lines. Moreover, there was no capital charge at all for "reputational" credit lines—noncontractual liquidity backstops that sponsoring banks provided to SIVs to maintain their reputation. Thus, moving a pool of loans into off-balance-sheet vehicles, and then granting a credit line to that pool to ensure a AAA-rating, allowed banks to reduce the amount of capital they needed to hold to conform

with Basel regulations. While all this happened, the risk for the bank remained essentially unchanged.

Raghuram Rajan[50] has raised a very interesting point. Why did the originators of these complex securities—the financial institutions that should have understood the deterioration of the underlying quality of mortgages—hold on to so many of the mortgage-backed securities (MBS) in their own portfolios? Clearly, some people in the bank thought these securities were worthwhile investments, despite their risk. Investment in mortgage securities seemed to be part of a culture of excessive risk-taking that had overtaken many banks. A key factor contributing to this culture is that, over short periods of time, it is very hard, especially in the case of new products, to tell whether a financial manager is generating true alpha (excess returns) or whether the current returns are simply compensation for a risk that has not yet shown itself but will eventually materialize. In short, are the returns being measured after adjusting for the full cost, including the risk involved? A simple example illustrates this point. Consider credit insurance. If traders are given bonuses by treating the entire insurance premium as income, without setting apart a significant fraction as a reserve for an eventual payout, they have a strong incentive to get more of such business and earn more bonuses. Thus, the traders in AIG wrote credit default swaps, pocketed the premiums as bonuses, but did not bother to set aside reserves in case the bonds covered by the swaps actually defaulted. And the traders who bought AAA-rated mortgage backed securities (MBS) were essentially getting the additional spread on these instruments relative to corporate AAA securities (the spread being the insurance premium) while ignoring the additional default risk entailed in these untested securities.

Exhibit 3.10
Where Did all the AAAs Go?

(In percent, as of June 30, 2009)
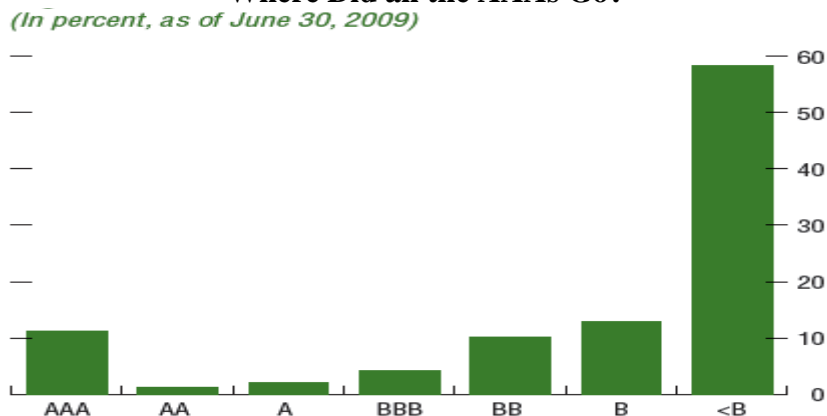
Source: Standard & Poor's.
Note: S&P rating distribution of 2005–07 issued U.S. AAA-rated asset-backed security collateralized debt obligations.

Ref: IMF Global Financial Stability Report, October 2009, www. imf.org

Many investment banks fell unwittingly into the CDO trap, by moving heavily into super-senior debt, the tranche with the highest priority for receiving cash flows if the CDO defaulted. Rating agencies gave super-senior CDO debt a triple-A rating, irrespective of what constituted the CDO. Thanks to the triple-A tag, banks were only required to hold

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[50] Federal Reserve Bank of St. Louis *Review* September/October, Part 1 2009. Pp. 397-402.

minimal capital against super senior debt. This debt typically offered a spread of about 10 basis points over risk-free bonds. Some banks kept tens of billions of dollars of super-senior debt on their balance sheet and looked at the spread as an easy and continuing source of profit.

Looking back, it is clear that the triple A rating given to the super senior tranche was completely illusory. Joseph R Mason[51], has dealt in detail with the rating discrepancies Corporate bonds rated Baa, the lowest Moody's investment rating rating, had an average 2.2 per cent default rate over five-year periods from 1983 to 2005. From 1993 to 2005, CDOs with the same Baa rating suffered five-year default rates of 24 per cent. In other words, Baa CDO securities were 10 times as risky as Baa corporate bonds. Similarly, over time horizons of both five years and seven years, S&P attached a higher default probability to a CDO rated AA than to an ABS rated A. Over a three year time horizon, a CDO rated AA had a higher probability of default than an ABS rated A-.

Such ratings created some intriguing possibilities. A seven-year ABS rated AA+ had an idealized default probability of 0.168%. If the security (all by itself) was repackaged and called a CDO, it might get a rating of AAA because the idealized default rate for the AAA rated CDOs was 0.285% over seven years. As Mason put it, "Municipal bond insurance for an Al state general obligation bond therefore merely translates the Al municipal rating to the Aaa corporate (global) rating of the monoline guarantor without any reduction in risk."

As Anna J Schwartz has mentioned[52], "The design of mortgage-backed securities collateralized by a pool of mortgages assumed that the pool would give the securities value. The pool, however, was an assortment of mortgages of varying quality." The designers left it to the rating agencies to determine the price of the security. But the rating agencies had no formula for this task. They assigned ratings to complex securities as if they were ordinary corporate bonds. And these ratings overstated the value of the securities and were fundamentally arbitrary. Rather than admitting the inadequacy of their rating models and adopting a conservative rating approach, the rating agencies enthusiastically took part in the party that was going out of control.

As Joshua Coval, Jakub Jurek and Eric Stafford[53] have mentioned, structured finance products received high ratings far more liberally than justified. In 2007, roughly 60% of all global structured products were AAA rated in contrast to less than 1% of corporate bond issues. The AAA ratings combined with high yields resulted in tremendous demand for structured products like CDOs. In 2006, Moody's earned 44% of its revenues from rating structured products, compared to 32% in case of structured products.

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[51] "The (continuing) Information problems in structured Finance" The Journal of Structured Finance, Spring 2008.
[52] "Origins of the financial market crisis of 2008" Cato Journal, Winter 2009.
[53] "The Economics of Structured Finance," Journal of Economic Perspectives, Winter 2009.

According to Brunnermeier[54], "rating at the edge" might also have contributed to favorable ratings of structured products versus corporate bonds. While a AAA-rated bond represented a band of risk ranging from a near-zero default risk to a risk that just made it into the AAA-rated group, banks worked closely with the rating agencies to ensure that AAA tranches were always sliced in such a way that they *just* crossed the dividing line to reach the AAA rating.

Fund managers, "searching for yield," were attracted to buying structured products because they promised high expected returns with a small probability of catastrophic loss. In addition, some fund managers may have favored the relatively illiquid junior tranches precisely because they traded so infrequently and were therefore hard to value. These managers could make their monthly returns appear attractively smooth over time because they had some flexibility with regard to when they could revalue their portfolios.

The blunders made by the rating agencies became evident when 27 of the 30 tranches of asset backed CDOs underwriten by Merrill Lynch in 2007 were downgraded from AAA to junk. Overall, in 2007, Moody's downgraded 31% of all tranches for asset backed CDOs it had rated and 14% of those initially rated AAA. By mid 2008, the market for structured finance products had well and truly collapsed.

As information flowed about the poor quality of the underlying assets, the markets became increasingly weary about CDOs and their tranches. The prices of some tranches of debt fell by 30 per cent in a few months. Instead of booking profits, banks were faced with the possibility of write downs. Yet few anticipated the quantum of the write downs. Only as banks like UBS, Citigroup and Morgan Stanley started to announce big losses during the second half of 2007, the magnitude of the crisis became more evident.

Exhibit 3.11
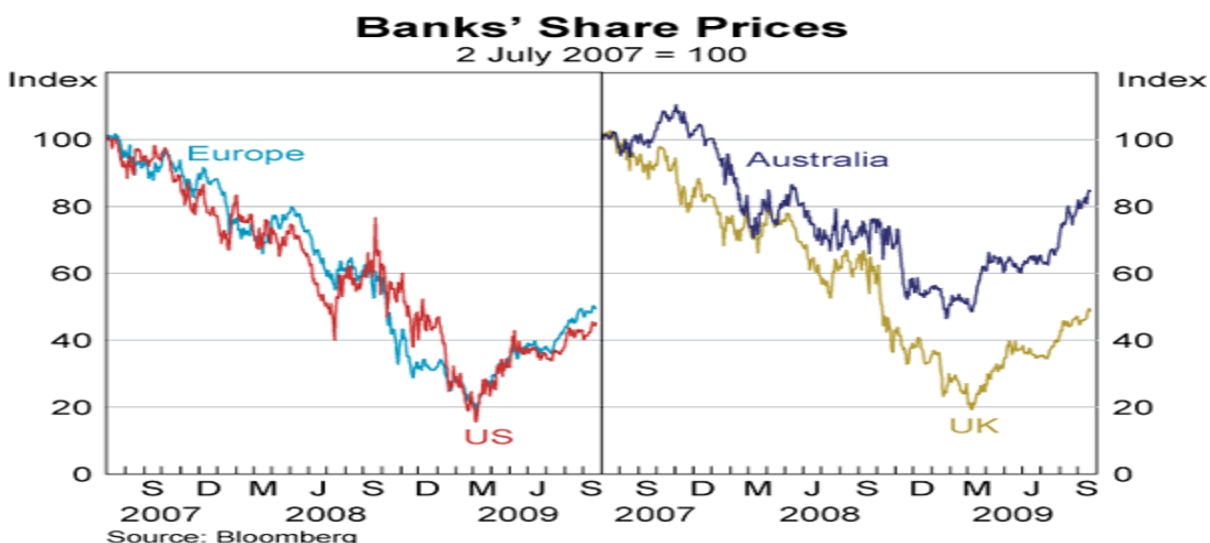
Ref: Reserve Bank of Australia website www.**rba**.gov.au

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[54] Deciphering the Liquidity and Credit Cruch 2007-2008, Journal of Economic Perspectives, Winter 2009.

The crisis deepens

Events took a sharp turn in mid March 2008 when investor concerns about Bear Stearns (Bear), an icon on Wall Street suddenly increased. Bear Stearns had bet big on the residential mortgage market. It had issued mortgage securities and also acquired mortgage lending firms that originated the loans underlying these securities. Being a broker dealer, Bear depended on other institutions for liquidity. As uncertainty increased in the market, doubts grew about Bear's ability to meet its obligations. When Bear's shares were hammered down by speculative trading, panic in the financial markets grew.

In early 2007, the typical price of a credit default swap, (cost of credit protection) tied to the debt of an investment bank like Bear had been about 25 basis points. By March 14, the cost of buying protection on Bear's debt had increased to 850 basis points[55]. The widening spread predicted a high probability of default. Doubts about the very existence of Bear mounted. Over a weekend of hectic negotiations, the Fed worked closely with JP Morgan Chase, which agreed to take over Bear with the Fed guaranteeing the outstanding liabilities of Bear Stearns. The Fed pledged $29 billion to cover Bear's loan obligations.

Many thought that the collapse of Bear signalled an end to the banking crisis. But it only proved to be a lull in the storm. It was in August that the action again started to pick up. Fannie and Freddie announced their fourth consecutive quarterly loss. On September 7, the US Treasury was forced to bail out the two agencies. Meanwhile, the fortunes of Lehman Brothers, another investment banking icon on Wall Street, had fluctuated wildly in the past few months. Lehman came close to bankruptcy, a couple of times but was saved at the last moment by some desperate measures. On September 15, Lehman threw in the towel and filed for bankruptcy. A big surprise followed the next day when the US Treasury announced a $85 billion bailout of AIG, the respected, global insurance company. AIG had taken huge positions in CDS without realising that credit default insurance was a completely different business compared to its traditional insurance activities. Meanwhile, Merril Lynch, realising it would be difficult to survive as an independent entity, decided to merge with Bank of America. Many of the deeper problems plaguing Merril would become evident only later. At the same time, Goldman Sachs and Morgan Stanley accepted a proposal from the US Treasury to convert themselves from pure play investment banks into bank holding companies. In short, the complexion of Wall Street changed completely in a week.

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[55] "Bloomberg Markets", July 2008.

Exhibit 3.12
Financial Sector Credit Default Swap Spreads

(In basis points)
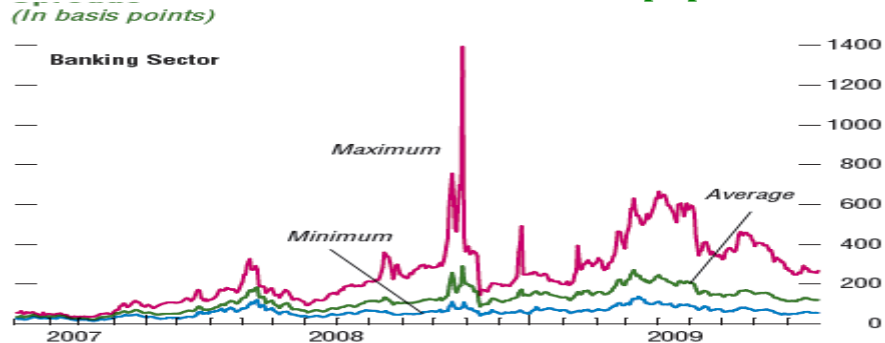
Ref: IMF Global Financial Stability Report, October 2009, www. Imf.org

In the last quarter of 2008, the Fed slashed the benchmark Federal Funds rate to zero. At the same time, the US Treasury continued its efforts to pump in capital into many of the leading banks. A major fiscal stimulus – government spending and tax cuts - was initiated by the Bush administration to mitigate the crisis. The fiscal measures were further strengthened by the new administration led by Barack Obama. A package announced by Treasury Secretary, Tim Giethner on March 23, 2009 was well received by the markets. But the growing indebtedness of the US and the bourgeoning budget deficit have undoubtedly damaged the credibility of the dollar. In a remarkable reversal of events, the Chinese who are major investors in US T Bills have started delivering sermons to the US administration on how to manage their economy. And US officials like Tim Giethner and Hilary Clinton have been making trips to the Middle Kingdom to offer assurances to the Chinese on the long term strength of the American economy!

Conclusion

Charles Calomiris[56] has summed up the policy failures that lay behind for the melt down of 2007-08. Lax Fed interest rate policy, especially from 2002 through 2005, promoted easy credit and kept interest rates very low for a protracted period. Numerous government policies and initiatives specifically promoted subprime risk-taking by financial institutions. Those policies included political pressures from Congress on Fannie Mae and Freddie Mac to promote "affordable housing" by investing in high-risk subprime mortgages, lending subsidies policies via the Federal Home Loan Bank System and FHA[57] subsidization of high mortgage leverage and risk. Besides, GSE mortgage foreclosure mitigation protocols were developed in the late 1990s and early 2000s to reduce the costs to borrowers of failing to meet debt service requirements on mortgages.

At the same time, government regulations on share ownership in banks has made effective corporate governance within large financial institutions virtually impossible. Pensions, mutual funds, insurance companies, and banks are restricted from holding anything but tiny stakes in any particular company. So these professional investors can do little in terms of promoting any change within badly managed firms.

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[56] Financial Innovation, Regulation and Reform, Cato Journal, Winter 2009.
[57] Federal Housing Administration

Hostile takeovers often provide an alternative means of discipline for poorly managed firms. But they are not a feasible source of discipline for financial companies as they are people centric. Firms will not risk an exodus of key talent by making hostile bids. It is also difficult for a hedge fund or private equity investor to become a major block holder in a financial firm and try to change it from within. The Bank Holding Company Act in the US prevents any entity with a controlling interest in a nonfinancial company from acquiring a controlling interest in a bank holding company.

Meanwhile deregulation triggered off various financial innovations of questionable value. Indeed, many innovations that claimed to slice and dice risk to cater to the requirements of different investor segments miserably failed. For example, securitisation was encouraged on the grounds that it would lead to risk diversification. But that did not happen because of perverse incentives and the moral hazard problem. A bank which holds a loan has a strong incentive to monitor borrowers and work with them in case of a default. Such a bank will also be careful right from the stage of making the loan. But thanks to securitisation, ownership and responsibility evaporated. As Mark Zandy[58] has mentioned, "At every stage along the long securitisation chain, there was a belief that someone else would catch the mistakes and preserve the integrity of the process. The mortgage lender counted on the Wall Street Investment banker, who counted on the CDO manager, who counted on the ratings analyst or perhaps the regulator."

Auction Rate Security was another financial innovation that failed miserably. By appearing long-term to the borrower but short-term to the lender, it created an illusion. As Schwartz mentions[59], "A funding instrument that is long-term for one party must be long-term for the counterparty." In other words, financial instruments must create real, not illusory value to be useful to society.

That brings us next to the rating agencies, whose role has come for a lot of critical examination. As Mason mentions, ratings agencies claim that the "issuer pays" model has been adequately insulated from inherent conflicts of interest. But there are few takers for this argument. Large institutional investors are tired of buying ratings that are prepared for issuers and have been shown to be significantly biased. It will take some time before the "issuer pays" model is replaced by an "investor pays" model.

At the same time, the problem is much deeper than issuers trying to get favourable ratings by misrepresenting reality. The "opinions" of rating agencies carry substantial regulatory weight. Indeed, as Mason points out, "The regulatory use of ratings has changed the constituency demanding a rating from free-market investors interested in a conservative opinion to regulated investors looking for an inflated one."

Meanwhile, rating agencies have become a cosy club. These agencies are also relatively immune to the loss of business. Issuers *must* have ratings, even if investors do not find them accurate. And there are not too many raters around.

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[58] Financial Shock

[59] "Origins of the financial market crisis of 2008," Cato Journal, Winter 2009.

Could the meltdown have been better anticipated? The sub prime crisis is not the first financial bubble in history. There have been various bubbles in the past relating to tulip bulbs, canals, cotton, technology stocks, commodities, specific types of debt, etc. Though they look different at a glance, all financial crises have common characteristics. An extraordinary increase in liquidity expands the credit activity and ultimately creates a bubble in a specific asset or asset class. For example, during the Japanese real estate bubble, the 3.4 square kilometers of Tokyo Imperial Palace and Gardens were valued at more than all of the real estate in California! Then as the bubble increases in size beyond a point, a few people, usually those responsible for starting the bubble begin to sell. This seeds doubts in the market. Soon these doubts start to increase. When the bubble bursts, there is panic, a crisis of confidence develops, consumers stop spending and recessionary trends strengthen. And it takes a long time for confidence to return to the markets.

Compared to past crises, however, the extent and magnitude of the current crisis is truly unprecedented. Japan's stock and real estate market bubbles were almost exclusively contained to that country. The tech market bubble of 2000 was restricted to one sector of the US economy. The sub prime crisis that started in the US, spread across the international financial system. Through the money markets, the crisis spread to the real sector. Many corporates began to find it difficult to meet their working capital requirements.

Financial crises seldom go away on their own. It usually takes strong political leadership, will and loud and clear communication to deal with a financial crisis. Early and decisive government action, to recapitalise banks and deal with troubled debts, can minimise the cost to the taxpayer and the damage to the economy. For example, Sweden quickly took over its failed banks after a property bust in the early 1990s and recovered relatively fast. In contrast, thanks to the slow pace of government intervention, Japan took a decade to recover from a financial bust. The crisis ultimately cost its taxpayers a sum equivalent to 24% of GDP.

In the current crisis, the US Fed and Treasury have certainly moved very fast as indeed have other central banks and governments in many other developed countries. Barrack Obama's, administration has launched various initiatives to restore confidence. A recovery has begun though we cannot be sure whether it will be sustained. Whatever be the nature of recovery, it is clear that it will take quite some time before the "animal spirits" return. It will be a long time indeed before the sub prime crisis becomes completely forgotten!

Annexure
Sub Prime Timeline

2001: The US Federal Reserve (The Fed) lowers the benchmark Federal funds rate 11 times, from 6.5% (May 2000) to 1.75% (December 2001).

2002: Annual home prices appreciate by 10% or more in California, Florida, and most Northeastern states.

2003: The Federal Funds (Funds) rate touches 1%.

2004: Arizona, California, Florida, Hawaii, and Nevada record annual housing price growth in excess of   25%   per year.

2005: The booming housing market halts abruptly in many parts of the U.S. in the late summer of 2005.

2006: Prices are flat, home sales fall, resulting in inventory buildup.

2007: Home sales continue to fall. The subprime mortgage industry collapses. Banks find themselves in big trouble.

- **February–March**: More than 25 subprime lenders declare bankruptcy, announcing significant losses, or putting themselves up for sale.

- **March 5:** HSBC indicates high delinquency rates in its portfolio of sub prime mortgages.

- **April 2**: New Century Financial, the largest U.S. subprime lender, files for Chapter 11 bankruptcy protection.

- **June 22**: Two Bear Stearns hedge funds that had invested in mortgage backed securities run into problems.

- **June 28**: The Fed leaves the Funds rate unchanged at 5.25%.

- **July 11**: S&P places 612 securities backed by sub prime residential mortgages on credit watch.

- **July 31**: Bear Stearns liquidates its two troubled hedge funds.

- **August 6**: American Home Mortgage files for Chapter 11 bankruptcy.

- **August 7**: The Fed leaves the Funds rate unchanged at 5.25%.

- **August 9**: BNP Paribas suspends operations on three investment funds. The European Central Bank (ECB) pumps $95 billion into the banking system.

- **August 16**: Countrywide Financial Corporation, the biggest U.S. mortgage lender, narrowly avoids bankruptcy by taking out an emergency loan of $11 billion from a group of banks.

- **August 17**: The Fed lowers the primary credit rate by 50 basis points to 5.75% from 6.25%. Sachsen LB is bailed out by the German savings bank association.

- **August 31**: President Bush announces a limited bailout of U.S. home owners unable to pay the rising interest costs on their debts.

- **September 10**: Victoria Mortgage of the UK goes bankrupt.

- **September 14**: A run on the bank starts at the Northern Rock, England's fifth largest mortgage lender. Bank of England starts providing liquidity support.

- **September 18**: The Fed lowers the target Federal Funds rate to 4.75%.

- **October**: Global banks, Citi, Merrill, UBS announce major losses.

- **October 15–17**: A consortium of U.S. banks backed by the U.S. government announces a Master Liquidity Enhancement Conduit to purchase mortgage backed securities from a special purpose vehicle following a sharp decline in mark-to-market value.

- **October 31**: The Fed lowers the Funds rate from 4.75% to 4.5%.

- **November 1**: The Fed injects $41 billion into the money supply for banks to borrow at a low rate.

- **November 8**: Moody's announces it will re-estimate the capital adequacy ratios of US Monoline insurers.

- **December 6**: President Bush announces a plan to freeze the mortgages of a limited number of mortgage debtors holding adjustable rate mortgages. He also asks Congress to temporarily reform the tax code to help home owners refinance during this time of housing market stress and pass legislation to reform Government Sponsored Enterprises (GSEs) like Freddie Mac and Fannie Mae.

- **December 10**: UBS announces measures to raise capital following big write downs.

- **December 11:** The Fed reduces the Funds from 4.5% to 4.25%.

- **December 12**: Central Banks of the UK, the US, Europe, Switzerland and Canada together announce measures to improve liquidity in short term markets. The Fed sets up a Term Auction Facility under which fixed amounts of term funds will be auctioned to commercial banks against a wide variety of collateral.

- **December 21:** Citi, J P Morgan and Bank of America abandon plans for the Master Liquidity Enhancement Conduit.

2008

- **January 11:** Bank of America confirms purchase of Countrywide.

- **January 18:** Fitch downgrades AMBAC, the monoline insurer.

- **January 22:** The Fed acknowledges the need for urgent action by slashing the target Federal Funds rate by 75 basis points to 3.5%.

- **January 24:** Societe Generale, the French bank reports trading losses due to fraudulent trading.

- **January 30:** The Fed cuts target Federal Funds rate again from 3.5% to 3%. In less than 10 days, the Fed has cut rates by 125 basis points.

- **February 13:** President Bush signs the Economic Stimulus Act of 2008 into law.

- **February 17**: The UK government announces the temporary nationalization of Northern Rock.

- **March 11**: The Fed sets up a Term Securities Lending Facility to lend upto $200 billion of Treasury securities for 28 day terms against a range of securities.

- **March 14**: Bear Stearns gets Fed funding as its shares plummet.

- **March 16**: Bear Stearns is acquired by JP Morgan Chase in a distress sale. The deal is backed by the Fed which provides guarantees to cover possible Bear Stearn losses. The Fed announces the establishment of a Primary Dealer Credit Facility.

- **March 18**: The Fed cuts interest rates again, reducing the target Federal Funds rate by 75 basis points to 2.25%.

- **April 30**: The Fed cuts the Funds rate by 25 basis points to 2%.

- **June 5**: S&P downgrades monoline bond insurers AMBAC and MBIA from AAA to AA.

- **June 25**: The Fed leaves the Funds rate unchanged at 2%.

- **July 11**: IndyMac Bank, the largest savings and loan association in the Los Angeles area and the seventh largest mortgage originator in the United States is closed.

- **July 15**: The SEC issues an emergency order temporarily prohibiting naked short selling in the securities of Fannie Mae, Freddie Mac and primary dealers.

- **July 13**: As pressure mounts on Freddie Mac & Fannie Mae, the government launches a rescue plan.

- **July 30**: The Housing and Economic Recovery Act of 2008 comes into effect. The Act authorises the Treasury to purchase Fannie Mae & Freddie Mac obligations. Regulatory supervision of the GSEs is now transferred to a new Federal Housing Finance Agency.

- **August 5**: Fed keeps the Funds rate unchanged.

- **August 6**-**8**: Fannie Mae and Freddie Mac report fourth consecutive quarterly losses and cut dividends.

- **September 7:** The US Government places Fannie Mae and Freddie Mac in government conservatorship.

- **September 15:** Lehman Brothers files for bankruptcy. Bank of America announces it will purchase Merrill Lynch for $50 billion.

- **September 16:** The US Treasury backs a desperate $85 billion loan by the Fed to avert the collapse of AIG. Fed keeps the Funds rate unchanged. The net asset value of shares in the Reserve Primary Money Fund, a money market fund, falls below $1 due to losses on Lehman commercial paper and medium term notes.

- **September 18**: The merger of Lloyds TSB, HBOS is announced. The UK Financial Services Authority bans short selling of financial shares.

- **September 19:** The US Treasury announces a temporary guarantee for US money market mutual funds. SEC bans short selling of financial stocks.

- **September 20:** The US Treasury announces plans to purchase upto $700 billion of troubled assets under the Troubled Asset Relief Program (TARP).

- **September 21:** Goldman Sachs and Morgan Stanley receive Fed approval to become bank holding companies.

- **September 23:** Berkshire Hathaway decides to invest $5 billion in Goldman Sachs.

- **September 25:** Washington Mutual is closed down. JP Morgan Chase announces the purchase of Washington Mutual's banking operations.

- **September 29:** The governments of Belgium, Netherlands and Luxembourg announce the bailout of Fortis.

- **September 30:** Dexia receives capital injection from shareholders and governments of Belgium, France and Luxembourg. Irish Government announces a guarantee for depositors in banks.

- **October 3:** The Emergency Economic Stabilization Act of 2008 (EESA) is signed into law. Through EESA, the US Treasury gets the authority to take various actions to stabilize and provide liquidity to the US financial markets. The US Treasury can now buy troubled assets from financial institutions under the Troubled Asset Relief Program (TARP). Under the capital purchase program (CPP), the Treasury can also directly purchase the equity of financial institutions. The US House of Representatives approves a plan by the Treasury to buy "toxic assets" from banks as part of a $700 bn package. Wells Fargo and Wachovia agree to merge. UK FSA raises the limit of deposit guarantee to £ 50,000.

- **October 7:** The deposit insurance coverage in the US increased to $ 250,000 per depositor.

- **October 8:** After more than 5 months , the Fed cuts the Funds rate by 50 basis points to 1.5%.

- **October 14:** US Treasury Secretary, Hank Paulson changes course and announces plans to buy equity in banks. Under the authority of the EESA, the Treasury announces that $250 billion of capital will be made available to American financial institutions.

- **October 28:** The US Treasury purchases a total of $125 billion in preferred stock in nine US banks under the CPP.

- **October 29:** The Funds rate is further reduced by 50 basis points to 1%.

- **November 12:** Paulson drops plans to buy toxic assets.

- **November 14:** US Treasury purchases $ 33.5 billion in preferred stock in 21 US banks.

- **November 16:** G 20 leaders promise united action on the global crisis. But there is little to suggest an unified approach to the crisis.

- **November 23:** The US authorities announce support to Citi in the form of guarantees, liquidity access and collateral.

- **November 25:** The Term Assets Backed Securities Lending Facility (TALF) is created.

- **December 16:** Signalling that fears of deflation could not be ruled out, the Fed establishes a target of 0 - .25% for the effective Fed funds Rate. With this, the Fed no longer has any scope to cut interest rates.

2009

- **January 8:** Bank of England reduces Bank Rate by 0.5 percentage points to 1.5%.

- **January 16:** US authorities announce support to Bank of America in the form of guarantees, liqudity access and capital.

- **February 5:** Bank of England reduces Bank Rate by 0.5 percentage points to 1.0%.

- **February 10:** US Treasury announces a Financial Stability Plan. This includes'stress tests' to assesses the need for capital injections, the creation of a Public-Private Investment Fund to acquire troubled loans and other assets from financial institutions, expansion of the TALF, and new initiatives to stem residential mortgage foreclosures and to support small business lending.

- **February 17:** President Obama signs into law the 'American Recovery and Reinvestment Act of 2009'. The Act includes a variety of spending measures and tax cuts intended to promote economic recovery.

- **February 26:** Royal Bank of Scotland (RBS) announces an attributable loss of £24.1 billion.

- **February 27:** The US Treasury announces its willingness to convert up to US$25 billion of Citigroup preferred stock issued under the CPP into common equity.

- **March 2:** The US authorities announce a restructuring of their assistance to AIG, providing as much as $30 billion of additional capital.

- **March 3:** The US authorities announce the launch of the TALF. Under the program, the New York Fed announces it will lend up to US$200 billion to eligible owners of certain AAA-rated asset-backed securities.

- **March 5:** The Bank of England reduces Bank Rate by 0.5 percentage points to 0.5% and announces £75 billion asset purchase programme.

- **March 18:** The Fed maintains the target range for the Funds rate at 0% to 0.25% and announces an expansion of over US$1 trillion in its planned asset purchases for the year.

- **March 19:** The US Treasury announces $5 billion support for the automotive industry.

- **April 2:** G20 Summit communiqué announces a trebling of the IMF's available resources to US$750 billion.

- **April 22:** IMF issues warning that the global economy will decline by 1.3% in 2009, the weakest performance since World War II.

- **May 6:** IMF approves a US$20.6 billion credit line for Poland.

- **May 7:** The Fed releases the results of the stress test of the 19 largest US bank holding companies. The assessment finds that losses at the 19 firms during 2009 and 2010 could be $600 billion and ten firms would need to add, in aggregate, $185 billion to their capital to maintain adequate buffers if the economy were to enter the more adverse scenario considered in the programme.

- **May 7:** The Bank of England maintains the Bank Rate at 0.5% and increases the size of the asset purchase programme by £50 billion to £125 billion.

- **May 7:** The ECB announces it will lower its policy interest rate to 1.0%, after reducing it by 50 basis points in March and 25 basis points in April. It indicates plans to purchase around €60 billion of covered bonds.

- **May 7:** The European Investment Bank becomes an eligible counterparty in the Eurosystem's monetary policy operations.

- **June 1:** General Motors and three domestic subsidiaries announce that they have filed for relief under Chapter 11 of the US Bankruptcy Code.

- **June 9:** The US Treasury announces that ten of the largest US financial institutions participating in the CPP have met the requirements for repayment.

- **June 17:** President Obama announces a comprehensive plan for regulatory reform that will give the Fed new responsibilities for consolidated supervision of systemically important banks. The proposal calls for the creation of a Financial Services Oversight Council. New authority is proposed for the Fed to supervise all firms that pose a threat to financial stability.

- **July 21:** Ben Bernanke testifies to the Congress that extreme risk aversion is receding.

- **August 17:** The Fed and Treasury announce the extension of TALF.

- **August 25:** Ben Bernanke is appointed as the Fed Chairman for a second term subject to Congress approval.

- **September 14:** The US Treasury releases a report that focuses on winding down those programs that were introduced to cope with systemic failure.

Case Illustration: The Collapse of Lehman Brothers

Introduction

On September 15, 2008, Lehman Brothers, the well known investment bank, filed for Chapter 11 bankruptcy protection. The collapse of Lehman marked the largest bankruptcy in U.S. history and the largest failure of an investment bank since the failure of Drexel Burnham Lambert 18 years earlier. It marked a turning point in the sub prime meltdown.

The Lehman collapse had major repercussions for the financial markets as the events of the next three months would testify. The Dow Jones closed down just over 500 points on September 15, 2008, the largest drop in a single day since September 11, 2001. The collapse of Lehman even had implications for the US presidential elections. An evenly matched presidential race till that point of time, changed into a clear lead for Barack Obama as the markets looked for a leader who could bring calm to a highly turbulent business environment.

After Lehman collapsed, other banks tried to step into the vacuum. On September 16, the British bank Barclays announced it would purchase Lehman's North American investment-banking and trading divisions along with its New York headquarters building. A few days later, Nomura Holdings announced that it would acquire Lehman's franchise in the Asia Pacific region, including Japan, Hong Kong and Australia as well as the investment banking and equities businesses in Europe and the Middle East. Lehman Brothers' Investment Management business, including Neuberger Berman, was sold to its management on December 3, 2008. Thus came to an end one of the most respected banks on Wall Street.

Background[60]

German immigrants to the US set up Lehman Brothers in 1850. After starting off in the cotton business, the firm later entered the emerging market for railroad bonds and then the financial-advisory business. Lehman became a member of the Coffee Exchange as early as 1883 and finally the New York Stock Exchange in 1887. In 1899, it underwrote its first initial public offering (IPO), that of the International Steam Pump Company.

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[60] This background note draws heavily from the information provided on Wikipedia.

In 1906, under Philip Lehman, the firm partnered with Goldman Sachs to bring the General Cigar Co. to market, followed closely by Sears, Roebuck and Company. During the following two decades, almost 100 new issues were underwritten by Lehman, many in association with Goldman. When the US government introduced a clear distinction between commercial banking and securities trading in the 1930s, Lehman chose to be an investment banker.

In the 1930s, Lehman helped fund the Radio Corporation of America (RCA). The firm also helped finance the rapidly growing oil industry, including Halliburton. In the 1950s, Lehman underwrote the IPO of Digital Equipment Corporation.

Robert Lehman who had taken charge of the firm in 1925, after his father Philip Lehman's retirement, died in 1969. This marked the transition from family to professional management. Initially, Robert's death left a void in the company. Coupled with a difficult economic environment, Lehman struggled to survive. In 1973, a new CEO Pete Peterson, was brought in to save the firm.

Under Peterson's leadership, Lehman merged with Kuhn, Loeb & Co., in 1977 to become the country's fourth-largest investment bank, behind Salomon Brothers, Goldman Sachs and First Boston. Peterson led the firm from significant operating losses to five consecutive years of record profits with one of the best returns on equity in the investment-banking industry.

However, major differences of opinion between the firm's investment bankers and traders (who were generating most of the firm's profits) prompted Peterson to appoint Lewis Glucksman, the firm's President, COO and former trader, as his co-CEO in May 1983. Soon there was a power struggle that ousted Peterson and left Glucksman as the sole CEO.

As internal rivalries mounted and the performance started to decline, Glucksman was pressured into selling the firm to Shearson, an American Express-backed electronic transaction company, in 1984, for $360 million. On May 11, the combined firms became Shearson Lehman/American Express. In 1988, Shearson Lehman/American Express and E.F. Hutton & Co. merged as Shearson Lehman Hutton Inc.

Recent History (1994–2008)

In 1993, under newly appointed CEO, Harvey Golub, American Express began to divest itself of its banking and brokerage operations. In 1994, Lehman Brothers Holdings, Inc. was spun off through an IPO. The firm embarked on a new phase of growth under the leadership of CEO Richard S Fuld Jr.

Lehman which occupied three floors of one of the twin towers displayed its resilience during the terrorist attacks of September 11, 2001. Lehman rebuilt its presence in Jersey City, New Jersey, where an impromptu trading floor was built and brought online less than forty-eight hours after the attacks. The investment-banking division converted the first-floor lounges, restaurants, and all 665 guestrooms of the Sheraton Manhattan Hotel into office space. In October 2001, Lehman purchased a 32-story, 1,050,000-square-foot (98,000 m^2) office building for $700 million.

In 2003, Lehman faced a setback when it found itself in a list of ten firms fined for undue influence over research analysts by their respective investment-banking divisions. It seemed the firms had promised favorable research coverage, in exchange for underwriting opportunities. The settlement, resulted in fines amounting to $1.4 billion, including $80 million against Lehman. It proposed a complete separation of investment banking departments from research departments, no analyst compensation, directly or indirectly, from investment-banking revenues, and the provision of free, independent, third-party, research to the firms' clients.

Despite these setbacks, Lehman performed quite well under Fuld. In 2001, the firm acquired the private-client services, or (PCS), business of Cowen & Co. In 2003, Lehman aggressively re-entered the asset-management business, which it had exited in 1989. Beginning with $2 billion in assets under management, the firm acquired the Crossroads Group, the fixed-income division of Lincoln Capital Management and Neuberger Berman These businesses, together with the PCS business and Lehman's private-equity business, comprised the Investment Management Division, which generated approximately $3.1 billion in net revenue and almost $800 million in pre-tax income in 2007. Prior to going bankrupt, Lehman had in excess of $275 billion in assets under management. Altogether, since going public in 1994, the firm had increased net revenues from $2.73 billion to $19.2 billion and had increased employee headcount from 8,500 to almost 28,600.

Fuld established a reputation as a smart operator capable of leveraging his bank's small capital base to take big risks and earn higher returns than larger rivals. Lehman grew riding its luck on huge positions in mortgage backed securities and leveraged loans. Fuld was rewarded a $186 million ten year stock award bonus in 2006.

Subprime mortgage crisis

Prior to its collapse, Lehman with a core equity of $18 billion had taken positions totaling about $780 billion in mortgages, stocks, bonds, oil, gold derivatives and other investments. This high leverage demonstrated Lehman's confidence in its risk taking abilities. At the peak of the bubble, on May 29, 2007, Lehman spent $15bn to take a stake in Archstone Smith Trust, a property investment company that owned apartments in posh areas of various American cities.

In June, Lehman announced a $2.8bn loss. But the bank immediately raised $6bn in new capital. The bank also continued to look for international sources of capital. After the earnings announcement, Fuld also made a top management reshuffle. He launched a vocal attack on what he called a campaign by a group of short sellers to bring down Lehman. This prompted the SEC to impose restrictions on short selling of financial stocks. In late June and early July, Fuld thought in terms of a management buyout and approached private equity groups. But these moves did not lead anywhere. Meanwhile, the firm's exposure to sub prime assets and high leverage was rapidly leading it to the edge of a precipice.

In August 2007, Lehman closed its subprime lender, BNC Mortgage, and took an after-tax charge of $25 million and a $27 million reduction in goodwill. The problems only aggravated in 2008. Lehman faced an unprecedented loss, since it had held on to large positions in subprime and other lower-rated mortgage tranches when securitizing the underlying mortgages. In the second quarter, Lehman reported losses of $2.8 billion and was forced to sell off $6 billion in assets. In the first half of 2008, Lehman stock lost 73% of its value as the credit market continued to tighten.

On August 22, 2008, shares in Lehman moved up briefly on reports that the state-controlled Korea Development Bank (KDB) was considering buying the bank. But the gains quickly disappeared on reports that KDB was facing difficulties in getting the approval of Korean regulators and in attracting partners for the deal. On September 9, Lehman's shares plunged 45% to $7.79, after it was reported that KDB had put talks on

hold. The S&P 500 slid 3.4% on September 9. The Dow Jones lost 300 points the same day.

The next day, Lehman announced a loss of $3.9 billion and indicated it would to sell off a majority stake in the investment-management business, which included Neuberger Berman. Standard & poor announced it might downgrade the bank's single A credit rating. The stock slid seven percent that day. The stock price dropped another 42 percent on September 11. The cost of credit insurance for Lehman rose to 805 basis points. On September 12, top executives of leading Wall Street banks met to discuss ways to deal with the crisis. The US authorities sent out signals that they were reluctant to bail out Lehman with tax payers' money.

Bankruptcy

On Saturday September 13, Tim Geithner, the president of the Federal Reserve Bank of New York called a meeting to discuss the future of Lehman. Lehman reported that it had been in talks with Bank of America and Barclays for the company's possible sale. However, both Barclays and Bank of America ultimately declined to purchase the entire company.

The British government appeared luke warm about a British bank assuming the large liabilities of a major American investment bank. Bank of America pulled out after the US government refused to assume some of Lehman's liabilities. Moreover, the bank had already tied up with Merrill and did not have the appetite for one more big deal.

Exhibit 3.13

The long goodbye
Lehman Brothers share price ($)
Source: Thomson Datastream

Lehman's huge derivatives positions were a major concern for the markets. The International Swaps and Derivatives Association (ISDA) arranged an exceptional trading session on Sunday, September 14, 2008, to allow market participants to offset positions in various derivatives.

In New York, shortly before 1 a.m. the next morning, Lehman announced it would file for Chapter 11 bankruptcy protection. It further announced that its subsidiaries would

continue to operate as normal. A group of Wall Street firms agreed to provide capital and financial assistance for the bank's orderly liquidation. The Federal Reserve, in turn, agreed to a swap of lower-quality assets in exchange for loans and other assistance from the government.

On September 16, 2008, Barclays announced it would acquire a "stripped clean" portion of Lehman for $1.75 billion, including most of Lehman's North America operations. On September 20, the transaction was approved.

Nomura, Japan's top brokerage firm, agreed to buy the Asian division of Lehman for $225 million and parts of the European division for a nominal fee of $2. It would not take on any trading assets or liabilities in the European units. Nomura decided to acquire only Lehman's employees in the region, and not its stocks, bonds or other assets.

Conclusion

Despite having $42bn of capital on its balance sheet, the previous working day, Lehman went bankrupt. This was clearly due to the excessive leverage employed by the bank. As asset prices collapsed and Lehman's own share price fell sharply, Lehman found it difficult to raise funds on the interbank market. Had the bank been proactive, it would have sold off assets much earlier to shore up its asset base.

Did the US government make a big blunder, by not bailing out Lehman? After all, following the bankruptcy there were major upheavals in the financial markets. By October, it was evident that the credit markets had seized up. Companies found it difficult to raise working capital. Trade finance became scarce. Investment decisions were postponed, industrial production shrank and world trade collapsed. By the end of 2008, the world economy was shrinking for the first time since World War II. G7 economies contracted at an annualised rate of 8.4% in the first quarter of 2009.

Former US Treasury secretary, Hank Paulson and Tim Giethner, later justified their actions stating that the regulators did not have sufficient authority to do a quick bailout. The Fed had tried to broker a deal, but no buyer could be found for Lehman. Barclays which showed interest did not get approval from UK regulators. Bank of America, a potential bidder had already paired up with Merrill and did not have the capacity for one more large acquisition.

The collapse of Lehman had some unintended consequences. As Niall Ferguson mentioned[61], Paulson might have taken the right decision without being fully aware: "By showing Americans and particularly their legislators in Congress, just what could happen if even the fourth largest investment bank failed, he created what had hitherto been lacking: the political will for a wholesale bailout of the financial system" If Lehman had been bailed out, there would have been a hue and cry in congress. The TARP bailout would never have been possible. In that case, Citigroup, a bank three times bigger than Lehman might have collapsed.

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[61] *Financial Times,* September 15, 2009.

An editorial in the *Financial* Times was more emphatic[62], that the US authorities had been right to allow Lehman Brothers to fail. "They could not know how awful it would prove to be and when it comes to saving failing companies, governments should err on the side of inaction. Capitalism relies on the discipline provided by the lure of wealth and the fear of bankruptcy."

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[62] *Financial Times,* September 14, 2009.

Case Illustration: The Collapse of Bear Stearns

Introduction

Bear Stearns (Bear) was one of the largest global investment banks and securities trading and brokerage firms in the world, prior to its sudden collapse and distress sale to JP Morgan Chase in March 2008. Bear, a major player in the securitization and asset-backed securities markets, found itself facing huge losses as the sub prime crisis worsened. In March 2008, the Federal Reserve Bank of New York provided an emergency loan to try to avert a sudden collapse of the bank. The bank could not be saved, however, and was sold to JPMorgan Chase at $10 per share, a price far below the 52-week high of $133.20 that the share hit a few months before the crisis.

Background Note[63]

Bear Stearns was founded as an equity trading house on May 1, 1923 by Joseph Bear, Robert Stearns, and Harold Mayer with a capital base of $500,000. By 1933, Bear had opened its first branch office in Chicago. In 1955, the firm opened its first international office in Amsterdam. In 1985, Bear Stearns became a publicly traded company. The bank's business expanded to cover corporate finance, mergers and acquisitions, institutional equities, fixed income sales, trading and research, private client services, derivatives, foreign exchange and futures sales and trading, asset management and custody services.

Bear established a solid reputation in investment banking circles. In 2005-2007, Bear was recognized as the "Most Admired" securities house by Fortune. The April 2005 issue of Institutional Investor magazine mentioned that Bear was the seventh-largest securities firm in terms of total capital.

The sub prime crisis changed the fortunes of Bear dramatically. On June 22, 2007, Bear pledged a collateralized loan of up to $3.2 billion to "bail out" one of its funds, the High-Grade Structured Credit Fund, while negotiating with other banks to loan money against collateral to another fund, the High-Grade Structured Credit Enhanced Leveraged Fund. During the week of July 16, 2007, Bear disclosed that the two subprime hedge funds had lost nearly all of their value amid a rapid decline in the market for subprime mortgages.

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[63] This background note draws heavily from the information provided on Wikipedia and Investopedia.

The funds had built up highly leveraged positions in CDOs, and used credit default swaps as an insurance against movements in the credit market. Unfortunately, the hedge fund managers did not anticipate the extent of the fall in CDO prices due to the delinquent sub prime loans. So there was insufficient credit protection against the losses. Meanwhile, creditors who were financing the funds had taken sub prime mortgage bonds as collateral. As the collateral fell in value, creditors asked Bear to post more collateral. Because the funds did not have enough cash, they had to sell bonds driving down bond prices further. As this happened, losses increased, leading to more bond sales and so on. In little time, the capital of the funds was wiped out.

The collapse of the hedge funds led to a top management shakeout. Co-President Warren Spector was asked to resign on August 5, 2007. Matthew Tannin and Ralph R. Cioffi, both former managers of hedge funds at Bear Stearns were arrested on June 19, 2008, on criminal charges and for misleading investors about the risks involved in the subprime market. They were also named in civil lawsuits brought in 2007 by investors, including Barclays, who claimed they had been misled. Barclays claimed that Bear knew that certain assets in the High-Grade Structured Credit Enhanced Leverage Master Fund were worth much less than their professed values. The suit alleged that Bear's managers devised "a plan to make more money for themselves and further to use the Enhanced Fund as a repository for risky, poor-quality investments." Bear had apparently told Barclays that the enhanced fund was up almost 6% through June 2007 — when "in reality, the portfolio's asset values were plummeting."

As of November 30, 2007, Bear had notional contract amounts of approximately $13.40 trillion in derivative financial instruments. In addition, the investment bank was carrying more than $28 billion in 'Level 3[64]' assets on its books at the end of fiscal 2007 versus a net equity position of only $11.1 billion. This $11.1 billion supported $395 billion in assets, implying a leverage ratio of 35.5 to 1. This highly leveraged balance sheet, consisting of many illiquid and potentially worthless assets, led to the rapid dilution of investor and lender confidence. On December, 20, Bear reported the first quarterly loss in its 84 year history. The loss included a $1.9 billion write-down on mortgage holdings. This presumably prompted Jimmy Cayne to step-down and make way for Alan Schwartz as CEO on January 7, Cayne remained non executive Chairman.

Fed bailout and sale to JPMorgan Chase

On March 7, 2008, press reports indicated that Carlyle Capital Corporation (CCC) was in big trouble. This hedge fund with major exposure to mortgage backed securities was

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[64] Assets which are difficult to value because of the absence of market prices.

facing margin calls and default notices from lenders. Bear had a major exposure to the Carlyle Group which had promoted the hedge fund. On March 13, when CCC collapsed, shares in Bear fell by 17%. But Bear's CEO maintained that the bank was in no trouble.

The final collapse was as much due to a lack of confidence as a lack of capital. The bank's problems escalated when rumors spread about its liquidity crisis which in turn eroded investor confidence in the firm. Bear's liquidity pool started at $18.1 billion on March 10 and then plummeted to $2 billion on March 13. Ultimately, market rumors about Bear's difficulties became self-fulfilling.

On March 14, JP Morgan Chase, backed by the Federal Reserve Bank of New York, agreed to provide a 28-day emergency loan to Bear Stearns. Despite this, belief in Bear's ability to repay its obligations rapidly diminished among counterparties and traders. The Fed sensed that the terms of the emergency loan were not enough to revive Bear. Worried about the possibility of systemic losses if allowed to operate in the markets on the following Monday, the US authorities told Schwartz that he had to sell the firm over the weekend, in time for the opening of the Asian market.

Two days later, on March 16, Bear Stearns finalized its agreement with JP Morgan Chase in the form of a stock swap worth $2 a share. This was a huge climb-down for a stock that had traded at $172 a share as late as January 2007 and $93 a share as late as February 2008. In addition, the Fed agreed to issue a non-recourse loan of $29 billion to JP Morgan Chase, thereby assuming the risk of Bear Stearns's less liquid assets.

US Fed Chairman, Ben Bernanke defended the bailout by stating that Bear's bankruptcy would have affected the real economy and could have caused a "chaotic unwinding" of investments across the US markets. Bear had dealings with many financial firms. Many firms to which Bear owed money would have got into trouble. This in turn would have triggered a wave of defaults. The bailout aimed at giving the financial system time to pay off Bear's debts gradually.

On March 24, a new agreement raised JPMorgan Chase's offer to $10 a share, up from the initial $2 offer. The revised deal was meant to assuage the feelings of upset investors and any subsequent legal action brought against JP Morgan Chase as a result of the deal. The higher price was also meant to prevent employees, whose compensation consisted of Bear Stearns stock, from leaving for other firms.

Bear Stearns Collapse: A Timeline

2007

June 14: Bear reports a 10 percent decline in quarterly earnings.

June 18: Reports say Merrill Lynch has seized collateral from a Bear Stearns hedge fund which invested heavily in subprime loans.

June 22: Bear commits $3.2 billion in secured loans to bail out its High-Grade Structured Credit Fund.

July 17 : Bear reveals that one of its hedge funds has lost all of its value. Another is worth 9 per cent of its value at the end of April.

Aug 1: The two funds file for bankruptcy protection and the company freezes assets in a third fund.

August 5 : Co-president Warren Spector, favourite to succeed chief executive Jimmy Cayne resigns after the collapse of the two exposed hedge funds.

Aug 6: Bear assures clients that the bank is financially sound.

Sept 20: Bear reports 68 percent drop in quarterly income.

October 22: Bears secures a share-swap deal with Citic, China's largest securities firm. Citic pays $1bn for about 6 per cent stake in Bear. The US bank agrees to pay the same for about 2 per cent of Citic.

November 1: A US newspaper suggests that Cayne was out of touch during the collapse of the two hedge funds. Caynes makes light of the media concerns .

Nov. 14: Bear announces it will write down $1.62 billion and book a fourth-quarter loss.

Nov. 28: Bear lays off another 4 percent of its staff, two weeks after cutting 2 percent of its work force.

December 20: Bear reports its first-ever quarterly loss. The loss is nearly four times analysts' forecasts, and includes a $1.9bn writedown on its holdings of mortgage assets. Cayne says he'll skip his 2007 bonus.

2008

January 7: Cayne retires as CEO, but stays on as non-executive chairman. Alan Schwartz becomes president and chief executive**.**

Mid-January: Financial stocks decline as economists predict the U.S. economy will slip into recession.

Mid-February: Subprime woes spread to a broad range of assets, including certain kinds of municipal debt.

February 14 : In reaction to the fall in Bear's share price since the share-swap deal, it emerges that Citic has been renegotiating the agreement.

February 28 : Rebel investors in Bear Stearns seize two of the bank's failed hedge funds in an attempt to regain some of the $1.6bn lost in the previous summer's collapse.

March 7: Carlyle Capital Corporation (CCC) sees its shares suspended in Amsterdam. The $22bn hedge fund with heavy exposure to mortgage backed securities, receives substantial additional margin calls and default notices from its lenders. Bear is seen as heavily exposed to Carlyle Group, which owns 15 per cent of CCC.

March 10: Market rumors say Bear may not have enough cash to do business. Bear denies these rumours.

March 12: Schwartz goes on CNBC to reassure investors that Bear has enough liquidity and will report a profit in the fiscal first quarter.

March 13 : CCC collapses. Bear's shares fall 17 per cent as investors grow anxious about its exposure to CCC.

March 14: JP Morgan and the New York Federal Reserve rush to the rescue of Bear Stearns. Shares crash almost 50 per cent.

March 16 : JP Morgan agrees to buy Bear in a deal that values Bear's shares at $2 each.

March 24: JP Morgan raises its offer for Bear to $10 a share to assuage shareholder sentiments. Cayne sells his 5% stake for $61m.

Ref: The UK Telegraph, USA Today, Financial Times various articles

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Chapter - 4
Value-at-Risk and Stress Testing

"The difficulty is that VaR takes into consideration only the probability of loss and not the potential size of the loss, lending itself to manipulation."

Phelim Boyle, Mary Hardy, Ton Vorst[65]

Introduction

Risk management has come a long way in the past four decades. Over time, various mathematical models and tools have been developed to quantify and control risk. Complete dependence on models without exercising human judgment and intuition can be disastrous as we have seen during the recent sub prime crisis. At the same time, managing risk based on "philosophy and culture" alone will not take an organization far. In this chapter, we look at probably the most important tool used in risk management, Value-at-Risk and its extensions. The aim is not to create "quants" experts. Rather, it is to familiarize business managers across functions with how Value-at-Risk can be used to measure and control the risks facing a company.

Understanding Value-at-risk

VAR is one of the key building blocks in market risk management. *VAR summarizes the worst loss over a target horizon that will not be exceeded at a given level of confidence.* For example, we may state that, "under normal market conditions, the most the portfolio can lose over a month is about $3.6 million at the 99% confidence level." This means that the 99% monthly VAR is $3.6 million. In simple terms, there is a 99% probability that losses will not exceed $3.6 million during a given month. Or there is only a 1% probability that the losses will exceed $3.6 million.

Jayanth Varma in his book, "Derivatives and Risk Management[66]," has explained in a simple way how VAR can be interpreted in four different ways. Thus 99% VAR can mean the:
  a)   level of capital that is sufficient to absorb losses 99% of the time
  b)   level of loss that is exceeded only 1% of the time
  c)   worst of the best 99% of all possible outcomes
  d)   best of the worst 1% of possible outcomes

The main idea behind VAR is to get an aggregated rather than a fragmented view of risk. Initially applied to market risk, VAR is now used to measure credit risk, operational risk and even enterprise wide risk. Banks which meet certain norms prescribed under Basle II can use their own VAR models for measuring market risk.

VAR applications

Before we get into the technicalities of computing VAR, let us understand how VAR can help an organization.

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[65] The Journal of Derivatives, Fall 2005.
[66] Tata McGraw Hill, 2008.

▪ **VAR as a benchmark measure**

VAR can be used as a company wide yardstick to compare risks across different markets and businesses over time. VAR can be used to drill down into risk reports to understand whether the higher risk is due to increased volatility in the markets or conscious risk taking.

▪ **VAR as a potential loss measure**

VAR can give a broad idea of the losses an institution can incur. This in turn can trigger a discussion at the senior levels of management. Are we capable of withstanding such a loss?

▪ **VAR as an integrated measure of risk**

VAR can be used to integrate all the risks facing the institution - market risk, credit risk, operational risk and other risks. Exhibit 5.1 gives details of how UBS, the Zurich based global bank gets an aggregated view of market risk.

Exhibit 4.1

UBS Investment Bank: Value Risk (10-day, 99% confidence, 5 years of historical data)[1]

CHF million	Year ended 31.12.08				Year ended 31.12.07			
	Min.	Max.	Average	31.12.08	Min.	Max.	Average	31.12.07
Risk type								
Equities	82	185	131	117	147	415	209	164
Interest rates (including credit spreads)	217	659	397	544	260	858	450	548
Foreign exchange	12	58	28	30	9	73	28	21
Energy, metals and commodities	14	60	30	22	24	90	51	41
Diversification effect	2	2	(212)	(229)	2	2	(225)	(223)
Total regulatory VaR	240	601	374	485	276	820	514	552
Diversification effect (%)			(36%)	(32%)			(30%)	(29%)
Management VaR[1,3]	239	499	316	424	291	836	537	614

1 From 1 January 2008, excludes US residential sub-prime and Alt-A mortgage-related exposures, super senior RMBS CDOs and the US reference-linked note program, and related hedges.   2 As the minimum and maximum occur on different days for different risk types, it is not meaningful to calculate a portfolio diversification effect.   3 Includes all positions subject to internal management VaR limits (including CVAs since 3Q 2008).

UBS Group: Value-at-Risk (10-day, 99% confidence, 5 years of historical data)[1]

CHF million	Year ended 31.12.08				Year ended 31.12.07			
	Min.	Max.	Average	31.12.08	Min.	Max.	Average	31.12.07
Business divisions								
Investment Bank[1]	240	601	374	485	276	820	514	552
Global Asset Management	1	7	2	6	2	10	4	3
Global Wealth Management & Business Banking	1	17	4	16	2	5	3	2
Corporate Center[2]	3	93	26	10	1	87	18	21
Diversification effect	3	3	(34)	(25)	3	3	(29)	(29)
Total regulatory VaR	246	609	373	492	273	814	509	548
Diversification effect (%)			(8%)	(5%)			(5%)	(5%)
Management VaR[1,4]	246	521	320	459	288	833	535	588

1 From 1 January 2008, excludes US residential sub-prime and Alt-A mortgage-related exposures, super senior RMBS CDOs and the US reference-linked note program, and related hedges.   2 The Corporate Center regulatory VaR only includes FX risk of Group Treasury.   3 As the minimum and maximum occur on different days for different risk types, it is not meaningful to calculate a portfolio diversification effect.   4 Includes all positions subject to internal management VaR limits (including CVAs since 3Q 2008).

UBS: Value-at-Risk (1-day, 99% confidence, 5 years of historical data)[1]

CHF million		Year ended 31.12.08				Year ended 31.12.07			
		Min.	Max.	Average	31.12.08	Min.	Max.	Average	31.12.07
Investment Bank	Regulatory VaR[2]	96	210	132	162	122	249	160	134
	Management VaR[3]	101	171	125	160	124	253	164	149
UBS	Regulatory VaR[2]	97	207	133	163	122	249	159	136
	Management VaR[3]	101	169	125	159	126	254	165	152

1 10-day and 1-day Value at Risk (VaR) results are separately calculated from underlying positions and historical market moves. They cannot be inferred from each other. From 1 January 2008, excludes US residential sub-prime and Alt-A mortgage-related exposures, super senior RMBS CDOs and the US reference-linked note program, and related hedges.   2 Backtesting is based on regulatory capital VaR.   3 Includes all positions subject to internal management VaR limits (including CVAs since 3Q 2008).

Source: UBS Annual Report, 2008

Exhibit 4.2
Deutsche Bank: Value-at-risk of trading units

Value-at-risk of trading units	Total		Diversification effect		Interest rate risk		Equity price risk		Foreign exchange risk		Commodity price risk	
in € m.	2008	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008	2007
Average	122.0	85.6	(74.7)	(57.7)	105.4	61.5	60.7	55.6	18.4	15.3	12.2	11.0
Maximum	172.9	118.8	(104.1)	(76.8)	143.3	95.9	93.8	90.5	42.4	28.9	21.1	18.0
Minimum	97.5	66.5	(48.4)	(40.4)	83.1	42.7	31.0	43.5	8.5	5.9	7.6	5.7
Year-end	131.4	100.6	(84.5)	(59.7)	129.9	90.8	34.5	49.5	38.0	11.3	13.5	8.7

Source: Deutsche Bank Annual Report, 2008.

Exhibit 4.3
Daily VAR at Goldman Sachs
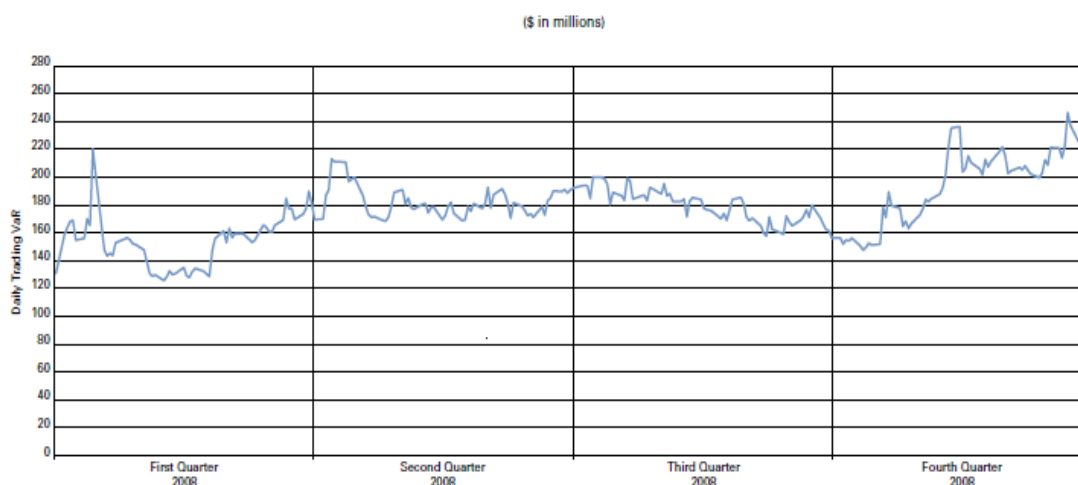
Source: Goldman Sachs 2008 Annual Report.

- **VAR as an information reporting tool**

VAR is a useful information reporting tool that facilitates disclosure of aggregated risk without revealing individual positions. Nearly all large financial institutions report quantitative information about market risk using VAR. Many of them provide summary VAR figures on a daily, weekly or monthly basis. Such disclosures are an effective means of enforcing market discipline.

- **VAR as a risk control tool**

VAR is a useful risk control tool that can supplement position limits. In volatile environments, VAR can be used as the basis for scaling down positions. Here VAR scores over position limits. In addition, VAR accounts for diversification, unlike position limits.

- **VAR as a measure of economic capital**

VAR can be viewed as a measure of risk capital or economic capital, the aggregate capital required as a cushion against unexpected losses. Banks routinely calculate economic capital using a high confidence level, eg: 99.98%.

- **VAR as a risk adjusted performance measure**

VAR can be used to arrive at a risk adjusted performance measure. Without controlling for risk, traders may become reckless. The compensation received by traders has an asymmetric pay off profile. When traders make a large profit, they receive a huge bonus. When they make a loss, the worst that can happen is they will get fired. The pay off profile is similar to that of a long position in a call option, i.e., unlimited upside but limited downside. Risk adjusted compensation can help in curbing the temptation to indulge in reckless behaviour.

- **VAR as a Strategic tool**

VAR can be used as a strategic tool by top management to identify where shareholder value is being added. This can facilitate better decisions about which business lines to expand, maintain or reduce. Executives are forced to examine prospects for revenues, costs and risks in all their business activities. As managers start to learn new things about their business, the general quality of management improves and there is better capital deployment.

Exhibit 4.4
VAR applications

Passive role	Reporting risk	• Disclosure to share holders • Management reports • Regulatory requirements
Defensive role	Controlling risk	• Setting risk limits
Active role	Allocating risk	• Performance evaluation • Capital allocation • Strategic business decisions

Based on the work of Philippe Jorion.

- **VAR & investment management**

VAR is becoming more relevant to the investment management industry, both in asset allocation and Fund Management. Using VAR systems, investors can monitor their market risk better. Passive asset allocation or benchmarking, does not keep risk constant because the composition of the indices can change substantially. VAR can identify such trends. VAR tools are also useful in allocating funds across asset classes.

Active portfolio management may also change the risk profile of the fund. A sudden increase in the reported VAR should prompt a deeper analysis of the situation. Is more risk being taken? Are unauthorized trades being made? Is the risk increase justified by current conditions? Are different managers making similar bets? Different investment managers, acting in isolation, may be simultaneously increasing their exposure to a sector which is looking attractive. So a centralised VAR system can identify such trends and facilitate corrective action, if required.

- **VAR & risk budgeting**

VAR can also facilitate risk budgeting, a concept that is becoming popular in investment management. Risk budgeting essentially means a top down allocation of economic risk

capital starting from the asset classes down to the choice of the active manager and even to the level of individual securities.

VAR Computation

In simple terms, in computing VAR, we first understand the various risk factors that may influence the value of the portfolio. Then we compute the value of the portfolio under various scenarios. Alternatively, we can examine how the portfolio has behaved historically. We study the distribution of the portfolio returns and determine what is the maximum loss likely to be, at a given confidence level. We can do this either by using a simple percentile approach or by using a statistical distribution. We shall examine these methods in more detail a little later in the chapter.

The starting point in VAR is identifying the various risk factors and how they affect the different instruments. If the portfolio consists of a large number of instruments, it would be too complex to model each instrument separately. The first step is mapping. Instruments are replaced by positions on a limited number of risk factors. This simplifies the calculation significantly.

Two broad approaches to valuing the instruments are available. The more straight forward *Local valuation methods* make use of the valuation of the instruments at the current point and incrementally as we move away from the point using the first and perhaps, the second partial derivatives. The entire portfolio is valued only once. The value at other points is calculated by adjusting the base or anchor value suitably. Such an adjustment can normally be made in two ways:

The *delta normal method* assumes that the portfolio measures are linear and the risk factors are jointly normally distributed. Delta is nothing but the rate of change in portfolio value with respect to the underlying asset price. In such cases, daily VAR is adjusted to other periods, by scaling by a square root of time factor. This adjustment assumes that the daily returns are independently and identically distributed. So the variances can be added. The delta normal method is computationally fast even with a large number of assets because it replaces each position by its linear exposure. This method is not appropriate when there are fat tails in the distribution and non linear instruments exist in the portfolio. The delta normal approach can be represented by the equation: dp = Δds. Where dp is change in portfolio value, ds is change in underlying price.

If we have the following data, it is a simple matter to calculate the VAR:
- Size of the position
- Volatility of daily returns
- Confidence level
- Time horizon

If we take the average return of the portfolio as the reference point, then VAR is nothing but the product of the position size, the Z value (the distance from the mean in terms of

standard deviations,) volatility (standard deviation of daily returns), and the square root of time. We shall discuss how to estimate volatility in the next chapter.

Illustration
Consider an asset valued at $1 million with volatility of daily returns being 10%. What is the daily VAR at 95% confidence level? What will be the 10 day VAR?
From normal distribution tables, we read out the value of Z as 1.645. Note that we are applying a left tail situation as we are concerned about the downside, not the upside.

$$\text{VAR} = (1)(.10)(1.645) = \$.1645 \text{ million}$$
$$= \$ 164,500$$

To calculate the 10 day VAR we have to scale by square root of time.
So 10 day VAR = $(164,500) \sqrt{10}$ = $520,195

Illustration
The 10 day 99% regulatory VAR for UBS as given in Exhibit 5.1 is SF 485 million as on 31 Dec 2008. What would be the 95% 10 day VAR? What would be the 99% daily VAR?

Z value for 95% confidence level is 1.645 while that for 99% confidence level is 2.33

So 95% VAR $= \dfrac{1.645}{2.33} \times 485 =$ SF 342.41 million

1 day 99% VAR $= \dfrac{485}{\sqrt{10}} =$ SF 153.37 million

When two assets are combined, the volatility of the portfolio has to be computed, using the well known formula, $\sigma = \sqrt{\sigma_1^{\,2} + \sigma_2^{\,2} + 2\rho\sigma_1\sigma_2}$ where σ_1, σ_2 represent the volatility of individual assets and σ that of the portfolio.
This formula can be adjusted as the number of assets increases. If there are three assets, the portfolio standard deviation $\sigma = \sqrt{\sigma_1^{\,2} + \sigma_2^{\,2} + \sigma_3^{\,2} + 2\rho_{12}\sigma_1\sigma_2 + 2\rho_{13}\sigma_1\sigma_3 + 2\rho_{23}\sigma_2\sigma_3}$

Value-at-Risk at Credit Suisse

Credit Suisse, the Zurich based global bank, uses a ten-day holding period and a confidence level of 99% to model the risk in its trading portfolios. For some purposes, such as backtesting, disclosure and benchmarking with competitors, the resulting VaR figures are scaled down or calculated using one-day holding period values.

Credit Suisse has approval from the regulatory authorities to use its own VaR model in the calculation of trading book market risk capital requirements. The bank uses a historical simulation model for the majority of risk types and businesses within trading portfolios. Where insufficient data is available, an "extreme-move" methodology is used. During 2007, the bank increased the length of the historical time series data set used to calculate VaR from two to approximately three years to capture a wider range of historical events.

Source: Credit Suisse Annual Report, 2008

The *delta gamma* method incorporates a second order correction to the delta normal VAR by using gamma. Gamma,γ is nothing but the rate of change in delta with respect to the underlying spot price. Long positions in options with a positive gamma have less risk than that implied by a linear model, while short positions in options have greater risk.

The delta gamma approach can be represented by the following equation:

$$dp = \Delta ds + \tfrac{1}{2}\,\gamma\,(ds)^2$$

Here dp is the change in portfolio value, $\quad \Delta = \dfrac{dp}{ds} \quad \gamma = \dfrac{d^2 p}{ds^2}$

For more complex pay offs, local valuation is not enough. The entire portfolio must be revalued at different points instead of making adjustments to an anchor value. Take the case of a long straddle, i.e, the purchase of call and a put with the same strike price. The worst pay off (sum of the two premiums) will be realized if the spot rate does not move at all. So if we value the portfolio at a few extreme points, we will not get the full picture. All intermediate values must be checked. This is where *full valuation methods* come in handy. These methods reprice the instruments over a broad range of values for the risk factors. Two popular full valuation methods are Historical Simulation and Monte Carlo simulation. We will now examine them in detail.

Value at Risk at HSBC

The VAR models used by the global bank, HSBC are based predominantly on historical simulation. Typically, these models incorporate the following features:
- Potential market movements are calculated with reference to data from the past two years.
- Historical market rates and prices are calculated with reference to foreign exchange rates and commodity prices, interest rates, equity prices and the associated volatilities.
- VAR is calculated to a 99 per cent confidence level and for a one-day holding period.

HSBC routinely validates the accuracy of its VAR models by back-testing the actual daily profit and loss results. Statistically, HSBC would expect to see losses in excess of VAR only one per cent of the time over a one-year period. The actual number of excesses over this period can therefore be used to gauge how well the models are performing.

Source: HSBC Annual Report, 2008

Historical simulation

The historical simulation method consists of going back in time and examining past data. Many global banks use five years of past data. If a year contains 260 trading days, it means 1300 daily returns on the portfolio are tabulated in ascending order. This method makes no specific assumption about the return distribution. All it needs is historical data. This is an improvement over the normal distribution because historical data typically contain fat tails. Essentially, historical simulation applies the percentile method of calculating dispersion. The past returns on the portfolio are tabulated in ascending order. Depending on the confidence level, the bottom 5% or 1% or .1%, are marked off to get the VAR estimate. The traditional school of thought advocated going far back in time to obtain adequate data from which meaningful inferences can be made. But the problem

here is that this may involve observations that are no longer relevant. Indeed longer sampling paths can mask current trends when a sudden change in the market environment occurs. This was so during the sub prime crisis. A small example will illustrate how historical simulation is done.

Illustration[67]

% Returns	Frequency	Cumulative Frequency
- 14	1	1
- 12	1	2
- 10	1	3
- 8	2	5
- 5	1	6
- 4	3	9
- 3	1	10
- 1	2	12
0	3	15
1	1	16
2	2	18
3	1	19
4	1	20
5	1	21
6	1	22
7	1	23
8	1	24
9	1	26
11	2	27
13	1	28
15	1	29
20	1	30

What is VAR (90%)?

There are 30 observations. These are already arranged in ascending order. 10% of 30 is 3. We notice by inspection that 3 observations lie below – 8. So VAR is – 8. Of course 30 is too small a number. To get a meaningfully accurate VAR estimate, we would need a much larger number of observations.

Monte Carlo Simulation

The most advanced and sophisticated VAR modeling technique is Monte Carlo Simulation. This method does not use historical data. A probability distribution is specified for the random variable based on a good understanding of its past behaviour. Then using random numbers, the portfolio returns are simulated. From these returns, VAR is estimated.

The Monte Carlo method can incorporate a wide range of risks including price risk, volatility risk, fat tails and extreme scenarios. Non linear exposures and complex pricing patterns can also be handled. Monte Carlo analysis can deal with time decay of options,

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[67] Adapted from Philippe Jorion, "Financial Risk Manager Handbook," John Wiley & Sons, 2007.

daily settlements and associated cash flows and the effect of pre specified trading or hedging strategies.

Different random numbers will lead to different results. So a large number of iterations may be needed to converge to a stable VAR measure. The Monte Carlo approach is thus computationally quite demanding. The method may also take far too much time even with the best of computing resources.

To speed up the computation, various methods have been devised. In the *Grid Monte Carlo approach*, the portfolio is exactly valued over a limited number of grid points. For each simulation, the portfolio is valued using a linear interpolation from the exact values at adjoining grid points. Sometimes, the simulation can be speeded up by sampling along the paths that are most important to the problem at hand. For example, if the goal is to measure a tail quantile accurately, there is no point in doing simulations that will generate observations in the centre of the distribution.

To increase the accuracy of the VAR estimator, we can partition the simulation region into two or more zones. An appropriate number of observations is drawn from each region. Using more information about the portfolio distribution results in more efficient simulations. The simulation can be done in two phases. The first pass runs a traditional Monte Carlo. The risk manager then examines the region of the risk factors that cause losses around VAR. A second pass is then performed with many more samples from the region.

The accuracy of the results and the predictive power of a Monte Carlo simulation will be as good as the model underlying it. The Monte Carlo approach requires users to make assumptions about the stochastic process and to understand the sensitivity of the results to these assumptions. Indeed, the first and most crucial step of Monte Carlo simulation consists of choosing a particular stochastic model for the behavior of prices.

Selecting the right probability distribution calls for a good understanding of the market variable. For example, the geometric Brownian motion model adequately describes the behaviour of stock prices and exchange rates but not that of fixed income securities. In Brownian motion models, price shocks are never reversed and prices move as a random walk. This is not an appropriate price process for default free bond prices which are characterized by mean reversion and must converge to their face value at expiration.

Choosing the time horizon

What is the most appropriate measure: 1 day VAR, 10 day VAR, monthly VAR or annual VAR? The longer the time horizon, the greater the VAR measure. As we have seen earlier, volatility is proportional to the square root of time. So the scaling is proportional to the square root of the time horizon. The horizon should be chosen depending on the context. If a portfolio can be modified or rebalanced quickly, a daily VAR is appropriate. In such a situation, increasing the time horizon does not make sense. On the other hand, if the portfolio is "sticky" and cannot be rebalanced quickly, then a longer time horizon makes sense. Loan portfolios for example are not marked-to-market. Moreover,

problems in case of loans may not appear immediately. So where credit risk is the dominating factor, a longer time horizon is preferable. Similarly for illiquid portfolios, a longer time horizon is recommended.

VAR, as mentioned earlier, can also be used as a measure of economic capital. If the VAR number is being used to decide how much capital is to be set aside to avoid bankruptcy, a long time horizon is advisable. Institutions will need time for corrective steps when problems start to develop. Indeed, raising capital itself, can be a challenge during a crisis. The longer the time needed for corrective action, the more the capital that must be set aside. By increasing the time horizon, the bank can be more conservative with respect to its capital needs.

Backtesting

Models must be tested from time to time to check whether they are functioning well. Backtesting is the process of using actual market data to check the accuracy of the model. It helps in verifying whether actual losses are in line with projected losses. A rigorous back testing process forms the underpinning for the Basle framework. If the model is robust, back testing will reveal only a few VAR exceptions, probably a couple of exceptions in a year.

Backtesting at Credit Suisse and UBS

Credit Suisse does backtesting using actual daily trading revenues, which are compared with VaR calculated using a one-day holding period. An exception is recorded when the daily loss exceeds the daily VaR estimate. Credit Suisse had nine backtesting exceptions in 2007, compared with two backtesting exceptions in 2006. The backtesting exceptions in 2007 were primarily driven by a sharp increase in market volatility in the second half of 2007. Credit Suisse made a change to the methodology to take account of the increase in observed correlations between risk categories.

Credit Suisse's arch rival, UBS experienced 29 backtesting exceptions in 2007. Moves in some key risk factors were, on occasions, well beyond the level expected statistically with 99% confidence based on the historical time series in use at the time. Despite regular updates to the time series, backtesting exceptions continued, partly caused by "jump events". Some of these reflected a step change in market conditions, such as the mass downgrade by a rating agency of highly rated US residential mortgage market-linked securities. Others resulted from periodic new information or showed the cumulative impact over several days or weeks of changing conditions in markets with diminished liquidity. UBS also made changes to its valuation approach to certain positions, leading to step changes. For example, as liquidity dried up, certain positions moved from a mark-to-market to a mark-to-model basis.

Source: UBS, Credit Suisse Annual Reports.

The Basle framework has stipulated that if a 99% VAR is backtested with 250 days of data, the results can be divided into green, yellow and red zones. In the green zone, the 99% VAR is exceeded less than 5 times. In the yellow zone, there may be 5 or more exceptions but less than 10. The model could be underestimating VAR in this case but the evidence is not conclusive. In the red zone, there are 10 or more exceptions. This is a clear indication that the model is not working satisfactorily.

The existence of clusters of exceptions indicates that something is wrong. Credit Suisse reported 11 exceptions at the 99% confidence level in the third quarter of 2007, the erstwhile Lehman brothers three at 95%, Goldman Sachs five at 95%, Morgan Stanley

six at 95%, the erstwhile Bear Stearns 10 at 99% and UBS 16 at 99%. Clearly, VAR is a tool for normal markets and it is not designed for stress situations.

What should be the time horizon and confidence level for a backtest? Backtesting must strike a balance between two types of errors: rejecting a correct model vs accepting an incorrect model. For example, too high a confidence level may reduce the expected number of observations in the tail and thus the power of the tests. So backtesting is often done with a somewhat lower confidence level.

Illustration
Based on a 90% confidence level, how many exceptions in back testing a VAR should be expected over a 250 day trading year?

Since the confidence interval is 90%, 10% of the time, loss may exceed VAR
So no. of exceptions   =   (.10) (250)   =   25

Illustration
Let us say we back test a model using 600 days of data.
The VAR confidence level is 99% and there are 9 exceptions.
Should we reject the model?
For each observation,
        Probability of exception   =   .01
        Probability of no exception   =   .99
Let us first find the probability of having 8 or fewer exceptions.

Probability of no exception in the data set   = $(.99)^{600}$ = .0024
Probability of 1 exception in the data set   = $600C_1 (.99)^{599} (.01)$ = .0146
Probability of 2 exceptions in the data set   = $600C_2 (.99)^{598} (.01)^2$ = .0441
Probability of 3 exceptions in the data set   = $600C_3 (.99)^{597} (.01)^3$ = .0888
Probability of 4 exceptions in the data set   = $600C_4 (.99)^{596} (.01)^4$ = .1338
Probability of 5 exceptions in the data set   = $600C_5 (.99)^{595} (.01)^5$ = .1612
Probability of 6 exceptions in the data set   = $600C_6 (.99)^{594} (.01)^6$ = .1614
Probability of 7 exceptions in the data set   = $600C_7 (.99)^{593} (.01)^7$ = .1384
Probability of 8 exceptions in the data set   = $600C_8 (.99)^{592} (.01)^8$ = .1036

Cumulative probability of getting 8 or fewer exceptions
        = .0024 + .0146 + .0441 + .0888 + .1338 + .1612 + .1614 + .1384 + .1036
        = .8483

Probability of getting 9 or more exceptions = 1 - .8483   =   .1517
                                                                                        ≈   15.2%
                                                                                        >   5%
So if we are testing the hypothesis at 5% confidence level, we cannot reject the model.

Suppose we get 10 exceptions

$$
\begin{aligned}
\text{Expected probability} \quad &= \quad 1 - [.8483 + 600C_9\,(.99)^{591}\,(.01)^9] \\
&= \quad 1 - .9171 = .0829 \quad \approx 8.3\% \\
& > 5\%
\end{aligned}
$$

Again we cannot reject the model.

Suppose we get 11 exceptions
$$
\begin{aligned}
\text{Expected probability} \quad &= \quad 1 - [.9171 + 600C_{10}\,(.99)^{590}\,(.01)^{10}] \\
&= \quad 1 - [.9171 + .0411] \\
&= \quad 1 - .9582 \quad = \quad 4.18\% \\
& < \quad 5\%
\end{aligned}
$$

So the model should be rejected if we get 11 or more exceptions.

Illustration
A 99% VAR model reports 5 exceptions in a year.
Assuming there were 250 trading days, test at a 5% significance level whether the model must be rejected. If the model reported 6 exceptions, would your recommendation change?

Solution

Probability of no exception	=	$(.99)^{250}$	=	.0811
Probability of 1 exception	=	$250C_1(.99)^{249}(.01)$	=	.2047
Probability of 2 exception	=	$250C_2(.99)^{248}(.01)^2$	=	.2574
Probability of 3 exception	=	$250C_3(.99)^{247}(.01)^3$	=	.2149
Probability of 4 exception	=	$250C_4(.99)^{246}(.01)^4$	=	.1341
Probability of having 4 or less exceptions	=			.8922
Probability of having 5 or more exceptions	=	1 - .8922	=	.1078
			=	10.78%
			>	5%

So at a 5% significance level, the model cannot be rejected.

$$
\begin{aligned}
\text{Probability of having 6 or more exceptions} \quad &= \quad 1-[.8922 + 250C_5(.99)^{245}(.01)^5] \\
&= \quad 1 - [.8922 + .0666] \\
&= \quad .0412 \\
&= \quad 4.12\% \\
& < \quad 5\%
\end{aligned}
$$

So at a 5% significance level, the model must be rejected if there are 6 exceptions.

Illustration

Suppose we have to scale volatility from one day to 5 days given an autocorrelation of 0.2 between the daily returns of successive days. How will you do this? Assume the daily volatility, σ does not change.

Let the daily volatility be 1.
Then the daily variance is also 1.

Autocorrelation means each day's price movements will have an impact on the next day's movements through the correlation coefficient.   On the other hand, today's price movement will have an impact on the price movement two days later through the square of the correlation coefficient and so on.

So variance for 5 days

$$= \sigma^2 + \sigma^2 + \sigma^2 + \sigma^2 + \sigma^2$$
$$+ (2) (\rho) (\sigma^2) + (2) (\rho^2) (\sigma^2) + (2) (\rho^3) (\sigma^2) + (2) (\rho^4) (\sigma^2)$$
$$+ (2) (\rho) (\sigma^2) + (2) (\rho^2) (\sigma^2) + (2) (\rho^3) (\sigma^2)$$
$$+ (2) (\rho) (\sigma^2) + (2) (\rho^2) (\sigma^2)$$
$$+ (2) (\rho) (\sigma^2)$$

$$= 5\sigma^2 + 8\rho\sigma^2 + 6\rho^2\sigma^2 + 4\rho^3\sigma^2 + 2\rho^4\sigma^2$$

So the variance for 5 days

$$= \quad (5) (1)^2 + (8) (.2) (1)^2 + (6) (.2)^2 (1)^2 + (4) (.2)^3 (1)^2 + (2) (.2)^4 (1)^2$$
$$= \quad 5 + 1.6 + .24 + .032 + .0032$$
$$= \quad 6.8752$$

So 3 day volatility   = $\sqrt{6.8752}$ =   2.62

Problem

The volatility of daily returns does not change but there is auto correlation among the daily returns on different days. We want to scale from one day VAR to 5 day VAR. How can we do this if the correlation between two succeeding days is 0.1?

Solution

Assume the daily volatility is 1 and the daily variance is also 1. The required variance for 5 days

$$= \quad 5\sigma^2 + 8\rho\sigma^2 + 6\rho^2\sigma^2 + 4\rho^3\sigma^2 + 2\rho^4\sigma^2$$
$$= \quad 5 + (8) (.1) + (6) (.1)^2 + (4) (.1)^3 + (2) (.1)^4$$
$$= \quad 5 + .8 + .06 + .004 + .0002$$
$$= \quad 5.8642$$

5 day volatility = $\sqrt{5.8642}$ ≈   2.42

Effectiveness of VAR models

How effective are VAR models? Do they hold good in real life? In the wake of the sub prime crisis, many economists and experts have held VAR models responsible for the failure of risk management systems. Indeed VAR models completely failed in estimating the potential losses arising out of exposure to sub prime mortgage securities, as the environment suddenly transitioned from a period of relatively benign volatility into a highly volatile one.

A 99.7% confidence interval, corresponding to a 3σ test should under ordinary circumstances give us a fairly good handle on the risks involved. But then the sub prime crisis could hardly be described as an "ordinary" set of events. Indeed Goldman Sachs' chief financial officer David Viniar once described the credit crunch as "a 25-sigma event". One could obviously not expect a '3σ' model to be appropriate for a '25σ' situation! The fact that such events can happen is a clear indication that real life probability distributions have fat tails. The normal distribution is not meanigful for such black swans.

Some VAR models failed during the sub prime crisis because they used historical simulation based on five years of historical data. A longer observation period can smoothen out business cycles and incorporate a wider variety of market conditions. But the problem with such models is they do not react quickly to a sudden change in circumstances. The historical data pertaining to the period 2002-2006 completely masked the paradigm shift that took place starting in the second quarter of 2007. Indeed, the type of VAR model that would actually have worked best in the second half of 2007 would have had a frequently updated short data history, that weighted recent observations far more heavily than distant observations.

To make VAR models more responsive, monthly or even quarterly updating of the data series may become the norm. Shifting to weekly or even daily updating would improve the responsiveness of the model to a sudden change in market conditions.

Despite its limitations, the utility of VAR cannot be questioned. VAR methods represent the culmination of a trend towards centralized and integrated risk management. Such a "global" approach to measuring risk makes sense because the sources of risk have multiplied and volatility has increased. A portfolio approach, gives a better picture of risk, compared to a piecemeal view of different instruments. The essence of VAR is a portfolio approach. Ofcourse VAR must be complemented by stress testing. We shall examine stress testing shortly.

Conditional VAR

The problem with VAR is that it tells us about the losses within a reasonable confidence interval. But what if we are outside the confidence interval, i.e., we are in the tail of the distribution. The conditional VAR is a more useful measure in this context. Conditional VAR takes into account the losses when things get out of control. As a concept, conditional VAR is more difficult to understand. It is also difficult to back test. However, conditional VAR can be a useful supplement to VAR. It can be a better basis

for working out risk adjusted compensation for traders. The conditional VAR pays greater importance to the "black swan." The conditional VAR is also called the expected shortfall or tail loss. However, conditional VAR must not be confused with Extreme Value Theory or Stress Testing.

Illustration[68]

Consider an investment with 99.1% VAR being $1 million. The probability of a loss of $10 million has been estimated at .9%. What is the conditional VAR at a 99% confidence level?

We can say that in the 1% tail region, the probability of loss of $1 million is $\frac{.1}{1} = 10\%$

and the probability of loss of $10 million is $\frac{.9}{1} = 90\%$

So the conditional VAR/expected shortfall = (.1) (1) + (.9) (10)
                                            = $ 9.1 million

Extreme Value Theory (EVT)

The normal distribution does not give too much importance to the tails. When we are sure of 99.7% of the value being within a bound, why bother about the remaining .3%? Unfortunately, as past financial crises have amply indicated, tail events can have catastrophic consequences. So we must treat the tails of the distribution with abundant caution. When dealing with exceptional events which stretch far into the tails than a 3σ situation, we need other techniques to supplement VAR. Extreme Value Theory (EVT) comes in handy here.

EVT extends the central limit theorem which deals with the distribution of the average of identically and independently distributed variables from an unknown distribution to the distribution of their tails. The EVT approach is useful for estimating the tail probabilities of extreme events. EVT helps us to draw smooth curves through the extreme tails of the distribution.

EVT has been used in the risk assessment of catastrophic events. The impetus for EVT came from the collapse of sea dikes in the Netherlands in February 1953, which led to the flooding of large parts of the country. EVT led to the design of a dike system that could withstand a 1250 year storm.

Stress Testing[69]

Whether a 10+ sigma event happens or not, it makes sense to be prepared for the same. Stress testing involves examining the performance of the portfolio under extreme market moves, that can cause extraordinary losses. Early stress testing techniques involved sequentially moving key variables by a large amount. These techniques were essentially some form of sensitivity analysis. Now they have become more sophisticated. Some

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[68] John. C. Hull, "Risk Management and Financial Institutions," Pearson Education, 2007.
[69] Read the article by P Kupiec, "Stress testing in a Value at risk framework," Journal of Derivatives, 6 (1999) pp. 7-24.

scenarios are historical, others prospective. Stress tests, which represent abnormal scenarios can be combined with VAR (which corresponds to normal scenarios), to arrive at risk capital. When stress tests indicate large potential losses, either the capital can be enhanced or the exposure can be reduced.

Construction of scenarios is as much art as science. But a few guiding principles can be outlined. Scenarios can be event driven or portfolio driven. In the first case, scenarios can be formulated from plausible events that generate movements in the risk factors. In the second case, the risk vulnerabilities in the portfolio that lead to adverse movements in risk factors are first identified. Some of the well known historical scenarios include:

- The 1987 US stock market crash.
- The 1992 European Monetary System Crisis
- The 1997 Asian currency crisis
- The 1998 LTCM/Russian crisis

During a day, a fall in the equity index by more than 10%, a fall in a globally traded currency by more than 5% against another globally traded currency or an interest rate cut of more than 200 basis points by a central bank are good examples of stress scenarios.

To conclude this section, stress testing is a good complement to VAR because it is difficult to take into account extreme events with the probability distributions with which we are familiar. A five standard deviation move in a market variable would seem unlikely if we go by a standard normal distribution. But in real life, five sigma moves are not uncommon. For example, on October 19, 1987, the S&P 500 moved by 22 standard deviations. On April 10, 1992, 10 year bond yields moved by 8.7 standard deviations. While visualizing such situations and their potential impact, stress testing comes in handy.

Stress testing at HSBC and UBS

HSBC augments VAR with stress testing to evaluate the potential impact on portfolio values of more extreme, although plausible, events or movements in a set of financial variables. Stress tests used by HSBC cover the following scenarios:

- Extreme market moves on any single risk factor or a set of factors. For example, the impact of a break of a currency peg that is unlikely to be captured within the VAR models;
- Technical scenarios, which consider the largest move in each risk factor, without considering any underlying market correlation;
- Hypothetical scenarios, which consider potential macro economic events;
- Historical scenarios, which incorporate historical observations of market moves during periods of stress which would not be captured within VAR.

For UBS, another global bank, stress scenarios include an industrial country market crash with a range of yield curve and credit spread behavior, and emerging market crises, with and without currency pegs breaking. A general recovery scenario is also assessed. The standard scenarios are run daily. Against these, the development of stress loss exposure is tracked and comparisons are made from one period to the next. Stress loss limits, approved by senior management are applied to the outcome of these scenarios for all business groups. Emerging markets stress loss in aggregate and stress loss for individual emerging market countries, measured under the standard stress scenarios, are also separately limited.

UBS revises stress tests based on actual experience. UBS's targeted stress tests did not predict the severe dislocation in US residential mortgage-related markets in 2007 – in particular the breakdown in correlation within and between asset classes and the complete drying up of liquidity.

UBS analyses VaR results beyond the 99% confidence level to better understand the potential risks of the portfolio and to help identify risk concentrations. Although the standard scenarios incorporate generic elements of past market crises, greater granularity of specific historical events is provided by the VaR tail. During 2007, the "worst historical loss" from the VaR distribution was introduced as an additional formal stress scenario. UBS is also considering use of a longer historical time series, where available, to generate this stress exposure.

Source: UBS, HSBC Annual Reports

Managing model risk[70]

Many VAR models failed during the sub prime crisis. So it may not be out of place here to cover briefly the subject of model risk. Models specify a relationship between various inputs and based on this relationship compute the required output. Some models are fundamental and start from first principles to establish a relationship between various input and output variables. In contrast, statistical models use data to determine correlations without any attempt to find causal relationships. Whatever be its technical characteristics, a model is a simplified representation of reality. Various assumptions are made while constructing a model. If these assumptions are violated, the model will naturally not hold good.

Model risk is not a huge issue when we are dealing with simple, linear instruments. But for exotic derivative instruments, model risk can be high because of interactions between risk factors, lack of transparency, etc. In risk management, often attempts are made to aggregate various positions. In such situations, models may give erroneous results.

In general model risk may arise out of:

- Incorrect model specification
- Incorrect model application
- Faulty implementation
- Incorrect calibration
- Programming issues
- Poor quality of data
- Behavioral issues

Models may not be specified correctly due to various reasons. The model may be using a wrong stochastic process, say a normal distribution, when the tails are "fat." Some risk factors might have been ignored while developing the model. Relationships might have been misspecified. Some models also make very simplistic assumptions such as ready liquidity and zero transaction costs.

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[70] This part draws heavily from the book, "Measuring market risk," by Kevin Dowd, John Wiley & Sons, 2005.

Risks also arise when models are incorrectly applied. A wrong model might be in use. Alternatively, the model might not have been updated. For example, models based on 5 year historical simulation would not have worked effectively at the start of the sub prime crisis when market conditions began to change dramatically. In some cases like Monte Carlo simulation, the problem might be too few runs or a poor random number generator.

Models may also be implemented in a faulty manner. No model can specify the method of implementation for all possible scenarios. Decisions need to be made by users with respect to valuation, mapping, etc. If these decisions are wrong, the implementation will be faulty. Incorrect calibration is another source of market risk. Calibration problems are particularly common in case of volatility and correlation. The true volatility can be more or less than the estimated volatility. During a crisis, correlations tend to move towards 1. The model might over estimate the benefits of diversification. Problems could also arise on account of the software. There might be bugs in the program. When programs are revised by people who did not originally write them, there could again be problems.

Data problems also contribute to model risk. How we handle time (Calendar time, trading time), and construct data (actual traded data or end of day data) can make a big difference in the way the model works.

Behavioral issues can also contribute to model risk. Traders often have a good understanding of the errors made while estimating the parameters used in the model. They often know which positions understate risks and which overstate them. If traders receive risk adjusted compensation, they will seek out positions with downward biased VAR estimates. There is a strong incentive for traders to 'game' the system.

To deal with model risk calls for a fundamental understanding of the markets and the instruments involved. Senior managers must have a good understanding of the issues involved, so that they can understand the language of the risk managers.

While developing the model, care should be taken to separate the exogenous (causal) variables from the endogenous (caused) variables. Care should also be exercised to distinguish between measurable and non measurable variables. Then a call should be taken on whether a proxy can be found for the non measurable variable. Alternatively, the non measurable variable must be implicitly solved from other variables.

All the assumptions made while developing the model must be carefully evaluated on an ongoing basis. The models must be tested on simple problems with known solutions to see if there is any unexpected response. Backtesting and stress testing must also be done periodically to check for exceptions. Even small discrepancies should not be brushed aside. Such discrepancies may be an early warning of things likely to go wrong in a big way at a later date.

Senior managers must be aware that when a model which performs well in some situations is extended to other situations, the model may fail. Another point to keep in

mind is that the utility of a model may not be enduring. If more traders start swearing by the same model and as a result, pursue similar trading strategies, the initial profits will rapidly fall. Some firms which rush into the market before understanding the pros and cons may end up making losses.

Senior managers can also encourage a multidisciplinary approach to team building. Such a team should include mathematicians, computer scientists, finance experts, accounting professionals and model users. Diversity of views and constructive criticism by different stakeholders can ensure that mistakes at the model specification stage are reduced, if not eliminated.

All risk models must be carefully documented. The maths involved, the components, computer code and methods of implementation should be recorded carefully. This will enable risk managers to examine and validate the models on an ongoing basis. The middle office should have enough information to be able to check the model or model results at any time. Risk managers must be able to access the log of model performance with a special focus on any problems encountered and how they have been addressed. The independent middle office should have a clear mandate and authority to block any inappropriate trading or asset management activity in the bank and have authority over the use of pricing/risk models. The middle office should take charge of stress testing, back testing and contingency planning to ensure that all models are adequate for the tasks being handled.

Conclusion

Value-at-Risk is one of the staple tools of modern day financial risk management. It is a simple and elegant way of understanding the maximum losses to a portfolio at a given confidence level and time horizon and accordingly arriving at the amount of capital backing that is needed. But in this chapter, we have also seen the limitations of VAR. VAR models must not be blindly applied. Moreover, VAR must be complemented by other tools such as stress testing to arrive at a true understanding of the risk situation facing a financial institution.

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Chapter - 5
Managing Market Risk

"The best traders are not right more than they are wrong. They are quick adjusters. They are better at getting right when they are wrong."

- Lloyd Blankfein,
CEO, Goldman Sachs[71]

Introduction
Market risk can be understood in simple terms as the possibility of losses arising due to fluctuations in currency rates, interest rates, equity markets and commodity prices. By its very nature, market risk is amenable to quantification. Indeed, this is the world of statistics and probability distributions. Data on currencies, interest rates, stock markets and commodity markets are readily available either in the public domain or with specialised vendors. Using this data and making suitable assumptions about the underlying probability distributions, we can answer questions such as "What is our maximum loss likely to be say 90% of the time?" But as in many other uncertain situations, we must be careful while handling data. The current pattern of a market variable may change in the future. Unexpected, worst case scenarios may result. This is exactly what happened as we moved from a benign period into the sub prime crisis. Moreover, the choice of probability distribution is critical. A wrong distribution will obviously lead to erroneous results. We will try to understand the building blocks of market risk management in this chapter – Volatility, Stock price modeling techniques, Ito's Lemma, Risk Neutral valuation and Black Scholes Option Pricing Model.

Volatility: The basics
Volatility is probably the most important concept in market risk management. In simple terms, volatility is the uncertainty about the return provided by the underlying asset. The higher the volatility, the higher the market risk. At this stage, we can define volatility loosely as the standard deviation of the return provided by the underlying asset. To measure volatility, we observe the price of the underlying asset at definite intervals of time, say daily.

If S_i is the price of the asset at the end of the day and S_{i-1} at the beginning of the day, we can define the daily return as $\dfrac{S_i - S_{i-1}}{S_i}$. If we use continuous compounding, the daily return becomes $ln(S_i/S_{i-1})$. A brief explanation is in order here.

Let r be the daily return. If we use a simple measure of return, we can write:

$$S_i \qquad = S_{i-1}(1+r)$$

But if we assume the day is divided into *m* intervals and the returns are compounded *m* times during the day, we can write:

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[71] William D. Cohan, "The rage over Goldman Sachs," Time.com, August 31, 2009.

$$S_i \quad = S_{i-1} \ (1+\frac{r}{m})^m$$

or $\quad S_i \quad = S_{i-1}[(1+\frac{r}{m})^{m/r}]^r$

As *m* becomes very large, we move towards continuous compounding,

But as *m* becomes very large, we also know from basic calculus that:

$$(1+\frac{r}{m})^{m/r} \quad = e$$

So we can write, in the case of continuous compounding,

$$S_i = S_{i-1}e^r$$

or $\quad \dfrac{S_i}{S_{i-1}} = e^r$

Taking natural logarithms on both sides we get

$$ln\ \frac{S_i}{S_{i-1}} = \ lne^r$$

or $\quad ln\ \dfrac{S_i}{S_{i-1}} = r \qquad$ (because ($lne^r = r\ lne = r$)

Since we have worked out *r* for a specific day, we can write $ln\dfrac{S_i}{S_{i-1}} = r_i$.

Thus the daily continuously compounded rate of return is nothing but the logarithm of the ratio of the closing price for the day to the opening price.

Illustration
The stock price at the beginning of a trading day is 40 and at the end of the day it is 41.

Then the continuously compounded daily rate of return $\quad = \ ln\dfrac{41}{40} = .0247$

Whereas the simple compounded daily rate of return $\quad = \dfrac{41-40}{40} = .0250$

If we measure the daily returns over *n* days, we will get *n* data points. Let the mean be $\bar{r}$. The standard deviation of these returns is nothing but the volatility. This is given by the well known formula in statistics:

$$\sigma^2_n = \quad \frac{1}{n-1}\ [(r_1 - \bar{r})^2 + (r_2 - \bar{r})^2 + \ .... + (r_n - \bar{r})^2]$$

$$= \quad \frac{1}{n-1}\sum_{i=1}^{n}(r_i - \bar{r})^2$$

where σ_n is the volatility.

We use n-1, not n, because while calculating the standard deviation of a sample, there are only n-1, degrees of freedom. We have "consumed" one degree of freedom while computing the sample mean. But in many cases "*n*" is a good approximation for "n-1."

For a good estimate of volatility[72], n should be reasonably large, at least 30 and preferably 100. If we use daily trading returns we need to get the data for about 5 months. If we use weekly returns we need to get the data for about 2 years. And if we use monthly returns, we would need the data for about 8 years. Over long periods of time, volatility is unlikely to remain constant. During 5 months, it is reasonable to assume that volatility will not change. That is why, volatility is usually calculated using daily returns and then scaled up suitably. We will examine shortly how this scaling is done.

Illustration

Consider a sum of Rs. 100. The interest rate is 10% per annum. What will be the amount after one year, if the compounding is done annually, semi annually, quarterly, daily and continuously?

Principal = Rs. 100.   Interest rate   = 10%

Compounding	*Amount*		
Annual compounding	$= 100 (1.1)$	$=$	110
Semi Annual	$= 100 (1.05)^2$	$=$	110.25
Quarterly	$= 100 (1.025)^4$	$=$	110.38
Daily	$= 100 (1+.1/365)^{365}$	$=$	110.52
Continuous	$= 100 (1+.10/m)^m$		
	$= 100(1+.10/m)^{m/.10}]^{.10}$		
	$= 100e^{.10}$		
	$= 110.52$		

Illustration

How high must the continuously compounded interest rate r be for the same amount to accumulate as with annual compounding at interest rate R?

Let the capital invested be V_0 and the time period of investment be T

$$V_0 \cdot (1 + R)^T = V_0 \cdot e^{rT}$$

As a result:
$(1 + R)^T = e^{rT}$
or $T \ln(1 + R) = rT \ln e = rT$
      $r = \ln(1 + R)$

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[72] Jayanth Rama Varma, "Derivatives and Risk Management," Tata McGraw Hill, 2008.

Illustration

Consider a stock whose current price is 20 and expected return is 20% per annum. What is the expected stock price, E (S_T) in 1 year ?

$$E (S_T) \quad = S_0 e^{\mu T} \quad = \quad (20)e^{(.20)(1)} \quad = \quad 24.43$$

Illustration

The stock prices at the end of 5 consecutive days of trading are 40, 41, 42, 41 and 40. How do we estimate the daily volatility?

First we calculate the daily continuously compounded rate of return. These will be $ln\dfrac{41}{40}$, $ln\dfrac{42}{41}$, $ln\dfrac{41}{42}$ and $ln\dfrac{40}{41}$. Next we calculate the mean and standard deviation as indicated in the table below:

Day	r	$r - \bar{r}$	$(r - \bar{r})^2$
1	.0247	.0247	**.00061**
2	.0241	.0241	**.00058**
3	- .0241	- .0241	**.00058**
4	- .0247	- .0247	**.00061**
	$\bar{r} = 0$		**.00238**

So the standard deviation of the daily returns is $\sqrt{.00238/3} = .0282$.
(Note that we divided by 3, not 4.)
This is nothing but the volatility.

Scaling Volatility

If the daily volatility is known, how do we calculate the weekly volatility? We can understand intuitively that the longer the time period, the wider the range of movement in the underlying variable. In a day, the value of the variable can move only so much but in a week, it can move more, in a month, it can move even more and so on.

Will this increase in volatility be linear? To answer this question, we can view a one week period as a combination of seven days. So the weekly distribution of returns is the sum of seven daily distributions. If we assume the pattern of movements of the underlying does not change, we can assume all the distributions are identical. Let us also assume that these distributions are independent.

To get the weekly distribution, we have to aggregate the daily distributions. When we do that, the means and variances can be added. So the weekly return will be 7 times the daily return. The weekly variance will be 7 times the daily variance. But volatility refers to the standard deviation, not variance. And standard deviation is the square root of variance. So we can say that the weekly volatility is $\sqrt{7}$ times the daily volatility.

Similarly if the weekly volatility is σ, we could state that the daily volatility is $\dfrac{\sigma}{\sqrt{7}}$. If the annual volatility is σ, we can estimate the daily volatility as $\dfrac{\sigma}{\sqrt{365}}$ and the weekly volatility as $\dfrac{\sigma}{\sqrt{52}}$. Similarly, we could state that the standard deviation of the stock price in 9 weeks is approximately 3 times the standard deviation in 1 week.

Let us derive the scaling rule more formally in the simple case of two trading days. Let the asset prices at different points of time, on the two days be $x_1, x_2 \ldots x_n$ and $y_1, y_2 \ldots y_n$ respectively. Let the volatility of daily returns for the two days be σ_x and σ_y and the average of the daily return be $\bar{x}$ and $\bar{y}$ respectively for the two days considered separately.

Two day variance $\qquad = \qquad \dfrac{1}{n}\sum (x_i + y_i)^2 - (\overline{x_i + y_i})^2$

Now $\quad \sigma_x^2 \quad = \quad \dfrac{1}{n}\sum x_i^2 - \bar{x}^2$

or $\quad \dfrac{1}{n}\sum x_i^2 = \bar{x}^2 + \sigma_x^2 \quad = \quad \sigma_x^2 + \bar{x}^2$

and $\quad \sigma_y^2 \quad = \quad \dfrac{1}{n}\sum y_i^2 - \bar{y}^2$

or $\quad \dfrac{1}{n}\sum y_i^2 = \bar{y}^2 + \sigma_y^2 \quad = \quad \sigma_y^2 + \bar{y}^2$

But $\quad \overline{x_i + y_i} = \quad \bar{x} + \bar{y}$

Also $\quad \sigma_{xy}^2 \quad = \quad \dfrac{1}{n}\sum xy - \bar{x}\,\bar{y}$

or $\quad \dfrac{1}{n}\sum xy = \bar{x}\,\bar{y} + \sigma_{xy}^2 \quad = \quad \sigma_{xy}^2 + \bar{x}\,\bar{y}$

Where $\overline{x_i + y_i} = \quad$ mean of the combined distribution $\quad = \quad \bar{x} + \bar{y}$

$\sigma_{xy}^2 \quad = \quad$ covariance of x, y

Expanding the variance term for the combined distribution, we get:

$$\dfrac{1}{n}\sum x_i^2 + \dfrac{1}{n}\sum y_i^2 + \dfrac{2}{n}\sum x_i y_i - \left(\overline{x_i + y_i}\right)^2$$

Substituting the expressions above we can rewrite this as:

$$\sigma_x^2 + \bar{x}^2 + \sigma_y^2 + \bar{y}^2 + (\sigma_{xy}^2 + \bar{x}\,\bar{y}) - (\bar{x} + \bar{y})^2$$

But $\sigma_{xy} = 0$ if the distributions are independently distributed.
So we can write:

Two day variance $=$ $\sigma_x^2 + \bar{x}^2 + \sigma_y^2 + \bar{y}^2 + 2\,\bar{x}\,\bar{y} - \bar{x}^2 - 2\,\bar{x}\,\bar{y} - \bar{y}^2$

$=$ $\sigma_x^2 + \sigma_y^2$

If the two distributions are assumed to be identically distributed, we can write:

$\sigma_x^2 = \sigma_y^2$ $=$ σ^2

We get the variance of the combined distribution for 2 days as $\sigma^2 + \sigma^2 = 2\sigma^2$ and the standard deviation as $\sqrt{2}\sigma$. Instead of 2 days, if it had been t days, the standard deviation would have been $\sqrt{t}\sigma$.

Research indicates that volatility is much higher during trading days. So while estimating volatility, we ignore the holidays. So we can write:

Annual volatility $=$ Daily Volatilty $\sqrt{No. of\ trading\ days\ per\ annum}$

It must be noted that the scaling approach discussed so far will not work if the movements in asset prices on different days are correlated. This is called *auto correlation*, i.e., correlation between variables of the same time series data.

A brief note about "scaling" the mean is also in order here. Using the earlier nomenclature, change in daily price of the underlying is $\Delta S_i = S_{i+1} - S_i$. The daily return is nothing but the change in price during the day divided by the initial price. To move from daily to annual return we have to divide by Δt. ie. $\mu = \dfrac{\Delta S_i}{S_i}\dfrac{1}{\Delta t}$ or $\mu\,\Delta t = \dfrac{\Delta S_i}{S_i}$

where μ is the annual return. Δt the time interval is $1/260$, if we assume 260 trading days in year.

Illustration
Let us illustrate what we have covered so far.

a)   Suppose the daily volatility is 3%. What is the 9 day volatility?

9 day volatility $= 3\%\ x\ \sqrt{9}$ $=$ 9%

b)   Say the 25 day volatility is 10%. What is the daily volatility?

Daily volatility $= \dfrac{10\%}{\sqrt{25}}$ $= 2\%$

More about volatility
We saw earlier that the daily volatility can be calculated as

$$\sigma_n^{\ 2} = \frac{1}{n-1}[(r_1 - \bar{r})^2 + (r_2 - \bar{r})^2 + ...]$$

$$= \frac{1}{n-1}[(r_1^{\ 2} - 2r_1\bar{r} + \bar{r}^2 + r_2^{\ 2} - 2r_2\bar{r} + \bar{r}^2 + ...]$$

$$= \frac{1}{n-1}[(r_1^{\ 2} + r_2^{\ 2} + r_3^{\ 2} + ...) - (2\bar{r})(r_1 + r_2 + r_3 + ...) + (\bar{r}^2 + \bar{r}^2 + ...)]$$

$$= \frac{1}{n-1}[(r_1^{\ 2} + r_2^{\ 2} + r_3^{\ 2} + ...) - 2n\bar{r}^2 + n\bar{r}^2]$$

or $\qquad \sigma_n^{\ 2} = \frac{1}{n-1}[(r_1^{\ 2} + r_2^{\ 2} + ...r_n^{\ 2}) - n\bar{r}^2]$

where r is the average return.

During a day, the upward and downward movements may cancel out. In other words, the average of the daily change in price may be small compared to the standard deviation. We will appreciate this more if we keep in mind that the standard deviation is calculated by squaring the deviations from the mean and taking their average and then finding the square root. Because of the squaring, the negative numbers become positive. So upward and downward deviations do not cancel out. As a result, the standard deviation may be significantly large compared to the average of the daily change.

Assuming $\bar{r} = 0$ $\qquad$ ($\bar{r}$ is the average return)

$$\sigma_n^{\ 2} = \frac{1}{n-1}[(r_1^{\ 2} + r_2^{\ 2}..... + r_n^{\ 2}]$$

If we assume that n-1 $\approx$ n, we could also write:

$$\sigma_n^{\ 2} \approx \frac{1}{n}\sum_{i=1}^{n} r_i^{\ 2}$$

This is a formula that is easy to remember! It gives us a simple way to estimate volatility. But this is indeed too simple. We are giving equal weights to all the daily returns. We can improve the accuracy of our volatility estimates by using weighting schemes. Thus we could write:

$$\sigma_n^{\ 2} = \sum_{i=1}^{m} \alpha_i r_{n-1}^{\ 2}$$

Where α_i represents the weight and $\Sigma\alpha_i = 1$. Let us now look at some of these weighting schemes.

Exponentially Weighted Moving Average Model

One commonly used weighting scheme is the exponentially weighted moving average model (EWMA) which states:

$$\sigma_n^2 = \lambda \sigma_{n-1}^2 + (1-\lambda) r_{n-1}^2$$

where σ_n is the estimate of volatility we are trying to arrive at while σ_{n-1} and r_{n-1} are the latest estimates available of the daily volatility and daily return respectively. λ is a figure which we arrive at on the basis of our understanding of the past behaviour of the daily returns of the asset under consideration.

But $\quad \sigma_{n-1}^2 = \lambda \sigma_{n-2}^2 + (1-\lambda) r_{n-2}^2$

So $\quad \sigma_n^2 = \lambda [\lambda \sigma_{n-2}^2 + (1-\lambda) r_{n-2}^2] + (1-\lambda) r_{n-1}^2$

$$= \lambda^2 \sigma_{n-2}^2 + \lambda(1-\lambda) r_{n-2}^2 + (1-\lambda) r_{n-1}^2$$

$$= \lambda^2 \sigma_{n-2}^2 + (1-\lambda) [r_{n-1}^2 + \lambda r_{n-2}^2]$$

$$= \lambda^2 [\lambda \sigma_{n-3}^2 + (1-\lambda) r_{n-3}^2] + (1-\lambda) [r_{n-1}^2 + \lambda r_{n-2}^2)]$$

$$= \lambda^3 \sigma_{n-3}^3 + (1-\lambda) [r_{n-1}^2 + \lambda r_{n-2}^2 + \lambda^2 r_{n-3}^2]$$

To use the exponentially weighted model, we need to have only the current estimate of the variance rate and the most recent observation on the value of the market variable. As we get new observations, we can update the data. The value of λ determines how responsive the estimate of the volatility is to the most recent daily percentage change. A low value of λ means a lot of weight is being given to the previous day's change in price. If λ is high, less weight is given. This is because r_{n-1}^2 is multiplied by $1-\lambda$. A high value of λ also means the most recent value of standard deviation largely represents the volatility.

Illustration

The most recent estimate of the daily volatility is 10% and that of the daily return is 4%. What is the updated estimate of volatility if λ is .7?

Updated estimate of variance	$=$	$(.7)(.1)^2 + (1 - .7)(.04)^2$	$= .00748$
Updated estimate of volatility	$=$	$\sqrt{.00748}$	$= .0865$

The EWMA model comes in very handy when there is volatility clustering. Days of high volatility may tend to occur in clusters. In such situations, the EWMA becomes a good predictor of volatility because of the high weightage attached to the most recent volatility estimate.

The GARCH[73] Model

The GARCH model is a further improvement on the exponentially weighted moving average model. The advantage of the GARCH model is that it recognizes that variance rates are *mean reverting*. Mean reversion means that over time the value of a variable comes back to the average[74]. That means that if the value is too high, it will tend to come down. If it is too low, it will tend to go up.   The GARCH model assumes that over time, the variance comes back to a long run average level of V_L.

This model can be represented as:

$$\sigma_n^2 = \gamma V_L + \alpha r_{n-1}^2 + \beta \sigma_{n-1}^2$$

V_L is the long run average variance rate.
$\alpha + \beta + \gamma = 1$.

When the current volatility is above the long term volatility, the Garch model estimates a downward sloping volatility term structure. (Term structure refers to the variation of volatility over time.) When the current volatility is below the long term volatility, it estimates an upward sloping volatility term structure. This is because when volatilities are currently low, there is an expectation that they will go up in future. When current volatility is high, there is an expectation that volatility will decrease in the future.

Illustration
The latest estimate of the volatility of daily returns is .08, that of the daily returns is .01 and the long term variance rate is .01.

If $\alpha = .3,$ $\beta = .3$ and $\gamma = .4$ find the updated estimate of the volatility.

Updated estimate of variance = $(.4)\,(.01) + (.3)\,(.01)^2 + (.3)\,(.08)^2$ $= .00595$
Updated estimate of volatility = $\sqrt{.00595}$ $= .0771$

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[73] GARCH stands for Generalised Autoregressive Conditional Heteroskedasticity.
[74] Recall Francis Galton's pioneering work in Chapter 1.

Implied volatility

The simple average, EWMA and GARCH methods all try to forecast volatility using past volatility data. A somewhat different approach to estimate volatility is to start with the market price of a traded instrument and find out the corresponding value of the volatility. In a well functioning market, this estimate, called "implied volatility" is likely to be more useful than volatility based on historical data. In the Black Scholes Model, to be discussed later in the Chapter, to be discussed later in the chapter, all the option data including the price can be keyed in. Then by a process of trial and error, we can calculate implied volatility. The real utility of implied volatility lies in using the data available for already traded instruments to price a new instrument about to be launched. For such an instrument, past data, in any case would not exist. The implied volatility would be a good way of valuing the instrument.

Modelling stock price movements

Whenever we want to measure the market risk of a derivative, we have to understand the pattern of movement of the underlying. Thus we should be able to model the price of the underlying. Here, we look briefly at how modeling can be done when the underlying is a stock. Some of the most celebrated modeling work has been done for stocks but this work can be extended to other asset classes too.

Before we look at the modeling techniques, we need to gain a basic understanding of stochastic processes. When the value of a variable changes over time in an uncertain way, we say the variable follows a *stochastic* process. In a *discrete time* stochastic process, the value of the variable changes only at certain fixed points in time. In case of a *continuous time* stochastic variable, the changes can take place at any time. Stochastic processes may involve discrete or continuous variables. As their names suggest, discrete variables can only take discrete values while continuous variables can take any value. The continuous variable continuous time stochastic process comes in handy while describing stock price movements. Let us now describe some stochastic processes commonly used for stock price modeling.

Markov Process

In a *Markov process*, the past cannot be used to predict the future. Stock prices are usually assumed to follow a Markov process. This means all the past data have been discounted by the current stock price.

Let us elaborate this through a simple example provided by Paul Wilmott in his book "Quantitative Finance." Suppose we have a coin tossing game such that for every head we gain \$1 and for every tail, we lose \$1. Then the expected value of the gains after i tosses will be zero. For every toss, the expected value of the gain is zero. Suppose we use S_i to denote the total amount of money we have actually won upto and including the ith toss. Then the expected value of S_i is zero. On the other hand, let us say we have already had 4 tosses and S_4 is the total amount of money we have actually won. The

expected value of the fifth toss is zero. Thus the expected value after five tosses given the value after 4 tosses is nothing but S_4. When the expected value equals the current value of the variable, we call it a *martingale*, a special case of the Markov process. The distribution of the value of the random variable, S_i conditional upon all the past events only depends on the previous value, S_{i-1}. This is the *Markov property*. The random walk has no memory beyond where it is now.

Wiener Process

A stochastic Markov process with mean change = 0 and variance = 1 per year is called a *Wiener process*. A variable *z* follows a Wiener process if the following conditions hold:

- The change Δz during a small period of time Δt is given by $\Delta z = \varepsilon \Delta t$, where ε is a standard normal random variable with mean = 0 and std devn = 1.
- The values of Δz for any two different short intervals of time, Δt are independent.

- Mean of Δz =   0
- Variance of Δz = Δt or Standard deviation = $\sqrt{\Delta t}$

Illustration

If a variable follows a Wiener process and has an initial value of 20, at the end of one year, the variable will be normally distributed with a mean of 20 and a standard deviation of 1.0. For a period of 5 years, the mean will remain 20 but the standard deviation will be $\sqrt{5}$. This is an extension of the principle we used earlier in the chapter to "scale" volatility as we go further out in time.

Generalized Wiener process.
Here the mean does not remain constant. Instead, it "drifts." This is unlike the basic Wiener process which has a drift rate of 0 and variance of 1. The generalized Wiener process can be written as:

$$dx = a\,dt + b\,dz$$
$$\text{or} \quad dx = a\,dt + b\varepsilon\sqrt{\Delta t}$$

Where "a" is the drift rate.

Illustration

Suppose the value of a variable is currently 40. The drift rate is 10 per year while the variance is 900 per year. At the end of 1 year the variable will be normally distributed, with a mean of $40+10 = 50$ and a std deviation of $\sqrt{900} = 30$. At the end of 6 months, the variable will be normally distributed with a mean of $40+5 = 45$ and std devn of $30\sqrt{.5} = 21.21$.

Ito Process

An *Ito process* goes one step beyond the generalized Wiener process. The Ito process is nothing but a generalized Wiener process in which each of the parameters, a, b, is a function of both the underlying variable *x* and time, *t*. In an Ito process, the expected drift rate and variance rate of an Ito process are both liable to change over time.

$$\Delta x = a\,(x, t)\,\Delta t + b\,(x, t)\,\varepsilon\sqrt{\Delta t}$$

We will later discuss a process called Ito's Lemma that will come in handy while developing the Black Scholes equation. But let us for now get back to how stock prices can be modeled.

Brownian Motion

In the coin tossing experiment, we saw an interesting phenomenon. The expected winnings after any number of tosses is just the amount we already hold. As we mentioned earlier, this is called the *Martingale* property.

The *quadratic variation* of a random walk[75] is defined by
$$[(S_1 - S_0)^2 + (S_2 - S_1)^2 + \ldots + (S_i - S_{i-1})^2]$$

For each toss, the outcome is $+\$1$ or $-\$1$. So for the coin tossing experiment, each of the terms in the bracket will be $(1)^2$ or $(-1)^2$ i.e., exactly equal to 1. Since there are *i* terms within the square bracket, the quadratic variation is nothing but *i*.

Let us now advance the discussion by bringing in the time element. Suppose we have *n* tosses in the allowed time, *t*. We define the game in such a way that each time we toss

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[75] Paul Wilmott on Quantitative Finance, www.wilmott.com

the coin, we may gain or lose an amount of $\sqrt{\dfrac{t}{n}}$. Now each term in the small bracket is

$$\left[\sqrt{\frac{t}{n}}\right]^2 \text{ or } \left[\sqrt{\frac{-t}{n}}\right]^2 = \frac{t}{n}$$

Since there are n tosses, the quadratic variation is $(\dfrac{t}{n})(n) = t$.

Thus the expected value of the pay off is zero and that of the variance is t.

The limiting process as time steps go to zero is called Brownian motion.

Geometric Brownian Motion

Brownian motion is useful but needs to be modified to make it useful for modelling stock prices. We need to introduce drift into Brownian motion. The most widely used model of stock price behaviour is given by the equation:

$$\frac{dS}{S} = \mu dt + \sigma dz$$

σ is the volatility of the stock price.
μ is the expected return.

This model is called *Geometric Brownian motion*. The first term on the right is the expected return which is somewhat predictable and the second is the stochastic component, which is somewhat unpredictable. In general, many variables can be broken down into a predictable deterministic component and a risky stochastic or random component. When we construct a risk free portfolio, our aim will be to eliminate the stochastic component. The component which moves linearly with time is deterministic and has no risk.

Illustration

Suppose a stock has a volatility of 20% per annum and provides an expected return of 15% per annum with continuous compounding. The process for the stock price can be written as:

$$\frac{dS}{S} = .15dt + .20dz$$

$$\text{or} \quad \frac{\Delta S}{S} = .15\,\Delta t + .20\,\Delta z$$

$$\text{or} \quad \frac{\Delta S}{S} = .15\,\Delta t + .20\,\varepsilon\,\sqrt{\Delta t}$$

If the time interval $= 1$ week $= \dfrac{1}{52} = .0192$ years and the initial stock price is 50.

$$\Delta S \quad = \quad 50 \,(.15 \text{ x } .0192 + .20 \,\varepsilon \,\sqrt{.0192})$$
$$= \quad .144 + 1.3856 \,\varepsilon$$

To get a good intuitive understanding of Geometric Brownian motion, we draw on the work of Neil A Chriss. Readers are strongly advised to refer to his book, "Black Scholes and beyond" to get an intuitive common sense understanding of stock price modeling in general and the Black Scholes option pricing model in particular.

Consider a heavy particle suspended in a medium of light particles. These particles move around and crash into the heavy article. Each collision slightly displaces the heavy particle. The direction and magnitude of this displacement is random. It is independent of other collisions. Using statistical jargon, we can describe each collision as an *independent, identically distributed random event.*

The stock price is equivalent to the heavy article. Trades are equivalent to the light particles. We can expect stock prices will change in proportion to their size as the returns we expect do not change with the stock prices. Thus we would expect 20% return on Reliance shares whether they are trading at Rs. 50 or Rs. 500. So the expected price change will depend on the current price of the stock.

So we write:
$$\Delta s = \quad S \,(\mu dt + \sigma dz).$$
Because we "scale" by S, it is called Geometric Brownian Motion.

In the short run, the return of the stock price is normally distributed. The mean of the distribution is $\mu \Delta t$. The std devn is $\sigma \sqrt{\Delta t}$. μ is the instantaneous expected return. σ is the instantaneous standard deviation.

In the long term, things are different. Let S be the stock price at time, t. Let μ be the instantaneous mean. Let σ be the instantaneous standard deviation.

The return on S between now (time t) and future time, T is normally distributed with a mean of $(\mu - \sigma^2/2)\,(T-t)$ and std devn of $\sigma \sqrt{T-t}$. Why do we write $(\mu - \sigma^2/2)$ and not μ? What is the intuitive explanation?

We need to first understand that volatility tends to depress the returns below what the short term returns suggest. Expected returns reduce because volatility jumps do not cancel themselves. A 5% jump multiplies the current stock price by 1.05. A 5% fall multiplies the amount by .95. If a 5% jump is followed by a 5% fall or vice versa, the stock price will reach 0.9975, not 1! In general, if a positive return x (x being defined in decimal terms) is followed by a negative return x, the price will reach $(1+x)\,(1-x) = 1- x^2$

How do we estimate the value of x? Consider a random variable x. We can calculate the variance of x as follows:

$$\sigma^2 = E\,[x^2] - \{E[x]\}^2 = \qquad E\,[x^2] \qquad \text{(assuming } E[x] = 0, \text{ ie., ups and downs in } x \text{ cancel out)}$$

Thus the expected value of x^2 is the variance. But the amount by which the returns are depressed when a positive movement of x is followed by an equal negative movement is x^2. For two moves, the depression is x^2. So we could say that the average depression per move is $x^2/2$. But the expected value of x^2 is σ^2. $\left(\dfrac{1}{n}\sum x^2 = \sigma^2\right)$ So we can write $\sigma^2/2$ as the expected value of the amount by which the returns fall from the mean. That is why we write $(\mu - \sigma^2/2)$ and not μ.

[76]Can we make some prediction about the kind of distribution followed by the stock price under the assumption of a Geometric Brownian Motion? Let us begin with the assumption that the stock returns are normally distributed.

Let us first scale the returns to cover a period of one year.

$$\text{Annualised return from } t_0 \text{ to T} \qquad = \qquad \frac{1}{T - t_0} ln \frac{S_T}{S_{t_0}}$$

S_T = future price S_{t0} = current price, $T-t_0$ is expressed in years.

$$\text{Annualised return} \qquad = \qquad \frac{1}{T - t_0} ln S_T - \frac{1}{T - t_0} ln S_{t_0}$$

$$\text{Let us define random variable X} \qquad = \qquad \frac{1}{T - t_0} ln S_T - \frac{1}{T - t_0} ln S_{t_0}$$

Let us define a new random variable

$$X + \frac{1}{T - t_0} ln S_{t_0}$$

The second term of the expression is a constant. So the basic characteristics of the distribution are not affected. Only the mean changes.

$$\text{Also} \quad X + \frac{1}{T - t_0} ln S_{t0} \qquad = \qquad \frac{1}{T - t_0} ln S_T$$
$$\text{or } (T-t_0)\,X + ln\ S_{t0} \quad = \qquad ln\ S_T$$

X is normally distributed. This means $ln\ S_T$ is normally distributed or S_T is lognormally distributed. So the price of a stock following a Geometric Brownian Motion is lognormally distributed.

The mean return on S from time t to time T is $(T-t)\,(r-\sigma^2/2)$, while the std devn is $\sigma\sqrt{T-t}$

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[76] Draws heavily from the work of Neil A Chriss, "Black Scholes and beyond – Option pricing models," McGraw Hill, 1997.

The return on S from time t to T $= ln\ S_T/S_t$

So the random variable $\dfrac{ln\dfrac{S_T}{S_t}-(T-t)(r-\dfrac{\sigma^2}{2})}{\sigma\sqrt{T-t}}$ is normally distributed with mean $= 0$

and std devn $= 1$. In other words, we have converted a normal random variable into a standard normal random variable. This will make it easy for us to do computations using the standard normal tables.

Suppose a call option on the stock with strike price, K is in the money at expiration. That means the stock price exceeds the strike price. We want to estimate the probability of this happening. The required condition can be written as:

$$S_T \geq K$$
$$\Rightarrow \quad S_T/S_t \geq K/S_t$$
$$\Rightarrow \quad ln\ (S_T/S_t) \geq ln\ (K/S_t)$$
$$\Rightarrow \quad \frac{ln\dfrac{S_T}{S_t}-(T-t)(r-\dfrac{\sigma^2}{2})}{\sigma\sqrt{T-t}} \geq \frac{ln\dfrac{K}{S_T}-(T-t)(r-\dfrac{\sigma^2}{2})}{\sigma\sqrt{T-t}}$$
$$\Rightarrow \quad \frac{ln\dfrac{S_t}{S_T}+(T-t)(r-\dfrac{\sigma^2}{2})}{\sigma\sqrt{T-t}} \leq \frac{ln\dfrac{S_T}{K}+(T-t)(r-\dfrac{\sigma^2}{2})}{\sigma\sqrt{T-t}} \quad \text{(Taking the negative of both}$$

sides and noting that $ln\dfrac{K}{S_T} = -ln\dfrac{S_T}{K}$ and $ln\dfrac{S_T}{S_t} = -ln\dfrac{S_t}{S_T}$

The probability of the stock price exceeding the strike price can be written as:

$$P\ (S_T \geq K) = \quad N[\frac{(ln\dfrac{S_T}{K}+(T-t)(r-\dfrac{\sigma^2}{2})}{\sigma\sqrt{T-t}}]$$

$$Or\ \ P\ (S_T \geq K) = \quad N\left[\frac{(ln\dfrac{S_T}{k})+(r-\dfrac{\sigma^2}{2})(T-t)}{\sigma\sqrt{T-t}}\right]$$

This expression reminds us of the Black Scholes formula! The term within brackets is referred to as d_2 in the Black Scholes model. Indeed, GBM is central to Black Scholes pricing. GBM assumes stock returns are normally distributed. But empirical data reveals that large movements in stock price are more likely than a normally distributed stock price model suggests. The likelihood of returns near the mean and of large returns is greater than that predicted by GBM while other returns tend to be less likely. Research also indicates that monthly and quarterly volatilities are higher than annual volatility. Daily volatilities are lower than annual volatilities. So stock returns do not scale as they are supposed to.

Ito's lemma[77]

Let us move closer to the Black Scholes formula. Black and Scholes formulated a partial differential equation which they later solved, with the help of Merton by setting up boundary conditions. To understand the basis for their differential equation, we need to appreciate Ito's lemma. Consider G, a function of x. The change in G for a small change is x can be written as:

$$\Delta G = \frac{dG}{dx} \Delta x$$

We can understand this intuitively by stating that the change in G is nothing but the rate of change with respect to x multiplied by the change in x.

If we want a more precise estimate, we can use the Taylor series:

$$\Delta G = \frac{dG}{dx} \Delta x + \frac{1}{2} \frac{d^2 G}{dx^2} (\Delta x)^2 + \frac{1}{6} \frac{d^3 G}{dx^3} (\Delta x)^3 + \dots..$$

Now suppose G is a function of two variables, x and t. We will have to work with partial derivatives. This means we must differentiate with respect to one variable at a time, keeping the other variable constant. We could write:

$$\Delta G = \frac{\partial G}{dx} \Delta x + \frac{\partial G}{dt} \Delta t$$

Again, if we want to get a more accurate estimate, we could use the Taylor series:

$$\Delta G = \frac{\partial G}{\partial x} \Delta x + \frac{\partial G}{\partial t} \Delta t + \frac{1}{2} \frac{\partial^2 G}{\partial x^2} (\Delta x)^2 + \frac{\partial^2 G}{\partial x dt} (\Delta x)(\Delta t) + \frac{1}{2} \frac{\partial^2 G}{\partial t^2} (\Delta t)^2 + \dots..$$

Note: $\left[\frac{1}{2} \frac{\partial^2 G}{\partial x \partial t} (\Delta x)(\Delta t) + \frac{1}{2} \frac{\partial^2 G}{\partial t \partial x} (\Delta x)(\Delta t) = \frac{\partial^2 G}{\partial x \partial t} (\Delta x)(\Delta t) \right]$

Suppose we have a variable x that follows the Ito process.

$$dx = a\,(x,t)\,dt + b(x,t)\,dz$$
or $\quad \Delta x = a(x,t)\,\Delta t + b(x,t)\varepsilon\sqrt{\Delta t}$
or $\quad \Delta x = a\,\Delta t + b\,\varepsilon\sqrt{\Delta t}$

ε follows a standard normal distribution, with mean $= 0$ and standard deviation $= 1$.

We can write $(\Delta x)^2 = b^2 \varepsilon^2 \, \Delta t +$ other terms where the power of Δt is higher than 1.

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[77] This section and the following draw heavily from John C Hull, "Option, Futures and Other Derivatives," Prentice Hall, 2006.

If we ignore these terms (as Δt approaches zero) assuming they are too small, we can write:

$$\Delta x^2 = b^2 \varepsilon^2 \, \Delta t$$

All the other terms have Δt with greater power. They can be ignored. But Δx^2 itself is big enough and cannot be ignored.

Let us now go back to G and write:

$$\Delta G = \frac{\partial G}{\partial x} \Delta x + \frac{\partial G}{\partial t} \Delta t + \frac{1}{2} \frac{\partial^2 G}{\partial x^2} (\Delta x)^2$$

But $\Delta x^2 = b^2 \varepsilon^2 \, \Delta t$ as we just saw a little earlier.

It can be shown (beyond the scope of this book) that the expected value of $\varepsilon^2 \Delta t$ is Δt, as Δt becomes very small.
Thus $(\Delta x)^2 = b^2 \Delta t$

Since we are approaching the limiting case, we replace ΔG by dG, Δx by dx and Δt by dt. So we can write the equation for change in G as:

$$dG = \frac{\partial G}{\partial x} dx + \frac{\partial G}{\partial t} dt + \frac{1}{2} \frac{\partial^2 G}{\partial x^2} b^2 dt$$

But dx = a(x,t) dt + b(x,t) dz

So we can rewrite:

$$dG = \frac{\partial G}{\partial x}(a dt + b dz) + \frac{\partial G}{\partial t} dt + \frac{1}{2} \frac{\partial^2 G}{\partial x^2} b^2 dt$$

$$= (a\frac{\partial G}{\partial x} + \frac{\partial G}{\partial t} + \frac{1}{2} \frac{\partial^2 G}{\partial x^2} b^2) dt + b \frac{\partial G}{\partial x} dz$$

This is called Ito's lemma.

The Black Scholes differential equation

The Ito's lemma is very useful when it comes to framing the Black Scholes differential equation.

Let us assume that the stock price follows Geometric Brownian motion, i.e.,

$$\frac{\Delta s}{s} = \mu \Delta t + \sigma \varepsilon \sqrt{\Delta t}$$

Or $\Delta s = \mu s \Delta t + \sigma s \Delta z$

Let f be the price of a call option written on the stock whose price is modeled as S. f is a function of S and t. The change in stock price is given by:- $\Delta S = a\,(s,t)\,dt + b\,(s,t)\,ds$.

Applying Ito's lemma, we can relate the change in *f* to the change in S .

Comparing with the general expression for Ito's Lemma, we get:
$G = f$, $a = \mu s$ and $b = \sigma s$, $x = s$,

or $\quad \Delta f = \left\{ \dfrac{\partial f}{\partial s} \mu s + \dfrac{\partial f}{\partial t} + \dfrac{1}{2} \dfrac{\partial^2 f}{\partial s^2} \sigma^2 s^2 \right\} \Delta t + \dfrac{\partial f}{\partial s} \sigma s \Delta z$

Our aim is to create a risk free portfolio whose value does not depend on S, the stochastic variable. Suppose we create a portfolio with a long position of $\dfrac{\partial f}{\partial s}$ shares and a short position of one call option. The value of the portfolio will be:-

$$\pi = \text{-f} + \dfrac{\partial f}{\partial s} \text{s}$$

Value refers to the net positive investment made. So a purchase gets a plus sign and a short sale gets a negative sign.

We will see later that $\dfrac{\partial f}{\partial s}$ is nothing but *delta* and the technique used to create a risk free portfolio is called *delta hedging*. Assume delta is constant over a short period of time.

Change in the value of the portfolio will be:

$\Delta \pi \quad = \quad \text{-} \Delta \text{f} + \dfrac{\partial f}{\partial s} \Delta \text{s}$

$\quad = \quad \text{-} \left(\dfrac{\partial f}{\partial s} \mu s + \dfrac{\partial f}{\partial t} + \dfrac{1}{2} \dfrac{\partial^2 f}{\partial s^2} \sigma^2 s^2 \right) \Delta t - \dfrac{\partial f}{\partial s} \sigma S \Delta z + \dfrac{\partial f}{\partial s} \Delta s$

But $\Delta s = \mu S \Delta t + \sigma S \Delta z$

or $\Delta \pi = \quad \text{-} \dfrac{\partial f}{\partial s} \mu s \Delta t - \dfrac{\partial f}{\partial t} \Delta t - \dfrac{1}{2} \dfrac{\partial^2 f}{\partial s^2} \sigma^2 s^2 \Delta t - \dfrac{\partial f}{\partial s} \sigma s \Delta z + \dfrac{\partial f}{\partial s} (\mu s \Delta t + \sigma s \Delta z)$

$\quad = \quad \text{-} \dfrac{\partial f}{\partial s} \mu S \Delta t - \dfrac{\partial f}{\partial t} \Delta t - \dfrac{1}{2} \dfrac{\partial^2 f}{\partial s^2} \sigma^2 s^2 \Delta t - \dfrac{\partial f}{\partial s} \sigma S \Delta z + \dfrac{\partial f}{\partial s} \mu s \Delta t + \dfrac{\partial f}{\partial s} \sigma s \Delta z$

or $\Delta \pi = \quad \text{-} \dfrac{\partial f}{\partial t} \Delta t - \dfrac{1}{2} \dfrac{\partial^2 f}{\partial s^2} \sigma^2 s^2 \Delta t$

$\quad = \quad \text{-} \left(\dfrac{\partial f}{\partial t} + \dfrac{1}{2} \dfrac{\partial^2 f}{\partial s^2} \sigma^2 s^2 \right) \Delta t$

This equation does not have a Δs term. It is a riskless portfolio, with the stochastic or risky component having been eliminated. The total return depends only on the time. That means the return on the portfolio is the same as that on other short term risk free securities. Otherwise, arbitrage would be possible. So we could write the change in value of the portfolio as:

$\Delta \pi = r \pi \Delta t$ where r is the risk free rate. (Because this is a risk free portfolio)

But $\pi = -f + \dfrac{\partial f}{\partial s} s$

or $\Delta \pi = r(-f + \dfrac{\partial f}{\partial s} s)\Delta t$

Also $\Delta \pi = -(\dfrac{\partial f}{\partial t} + \dfrac{1}{2}\dfrac{\partial^2 f}{\partial s^2}\sigma^2 s^2)\Delta t$

So $-\left(\dfrac{\partial f}{\partial t} + \dfrac{1}{2}\dfrac{\partial^2 f}{\partial s^2}\sigma^2 s^2\right)\Delta t = r\left(-f + \dfrac{\partial f}{\partial s} s\right)\Delta t$

or $rf = \dfrac{\partial f}{\partial t} + \dfrac{1}{2}\dfrac{\partial^2 f}{\partial s^2}\sigma^2 s^2 + r\dfrac{\partial f}{\partial s} s$

or $rf = \dfrac{\partial f}{\partial t} + rs\dfrac{\partial f}{\partial s} + \dfrac{1}{2}\sigma^2 s^2 \dfrac{\partial^2 f}{\partial s^2}$

This is the Black Scholes differential equation.

It must be remembered that the portfolio used in deriving the Black Scholes differential equation is riskless only for a very short period of time when $\dfrac{\partial f}{\partial s}$ is constant. With change in stock price and passage of time, $\dfrac{\partial f}{\partial s}$ can change. So the portfolio will have to be continuously rebalanced to achieve what is called a perfectly hedged or zero delta position. This is also called *dynamic hedging*.

Risk neutral valuation

The variables in the Black Scholes differential equation are current stock price, time, stock price volatility and the risk free rate of interest. These variables are independent of the risk preferences of investors. Nowhere does the expected return, μ feature in the equation. This approach is called *risk neutral valuation*.

Risk neutral valuation is a very important concept in derivatives pricing theory. Essentially we adjust the probability of upward and downward movement of the price of

the underlying asset in such a way that the value of the portfolio remains the same irrespective of the market outcome.   If the outcome becomes independent of the market fluctuations, we can equate the return on the portfolio we have created with that of a risk free portfolio. The key benefit we enjoy with this approach is that the risk free rate is reasonably well known whereas the risk adjusted rate is subjective and contextual and hence difficult to establish.

The "probabilities" that we work out using the Black Scholes Model are not the actual probability of the stock being above or below the strike price of the option at expiration. The risk neutral probability is only a "notional probability" that we calculate by assuming that the underlying asset earns the risk free rate of return. As Delianedis and Geske[78] mention, risk neutral probability not only simplifies option valuation but also provides a deeper understanding of option models. To get the actual probability, we need to work out the expected return of the underlying asset. While that is not an easy task, the risk free rate of return can be more easily estimated. And as Duffie and Pan mention[79], the consistency of the risk neutral approach with efficient capital markets does not mean that investors are actually risk neutral. The actual risk represented by a position would typically differ from that represented by models based on risk neutral valuation. Over a short period, when markets are not very volatile and there is no jump risk, risk neutral behaviour and actual behaviour are quite similar. But the distinction between the two is significant over longer time horizons.

Illustration
Suppose there is an investment which yields 30% in a favorable scenario and -10% in an unfavorable scenario. The probability of a favorable scenario is 50% and that of an unfavorable one is also 50%. So the expected return is 10%. There is a risk free portfolio with a return of 5% that gives the same utility as the risky portfolio. What is the risk neutral probability?

Let p be the risk neutral probability of a favourable scenario happening.

Then   .05   = $p(.30) + (1 - p)(-.10)$
or   .4p   =   .15
or   p   =   .375.

So the risk neutral probabilities are .375 for a favourable scenario and .625 for an unfavourable scenario.

Replicating portfolio
The Black and Scholes model is built on the principle of *portfolio replication*. Black and Scholes showed that a derivative security can be priced by replication i.e., by creating a portfolio of underlying assets whose returns exactly match the discounted expected value of the derivative's pay off at maturity using risk neutral probability. This portfolio may

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[78] "Credit Risk and Risk Neutral Probabilities: Information about rating migrations and defaults," Working paper, May 1999.
[79] "An overview of value-at-risk," Working paper, January 21, 1997.

consist of say an option and the underlying stock. The Black Scholes model tells us how to create a perfect hedge. The cost of setting up the hedged position and any additional costs incurred in maintaining it can be calculated ahead of time. The kind of hedging associated with Black Scholes involves only set up costs, no maintenance costs. Such an approach is called a self financing strategy.

Let us introduce one more term now, *complete market*. A market is said to be complete if any derivative can be replicated using only the underlying assets. In a complete market, any derivative, how much ever complex, has an unique arbitrage free price. It can be shown that a model of security prices is complete if and only if the model admits exactly one risk neutral probability. We shall explore this theme in more detail little later in the Chapter.

Computing risk neutral probability[80]

The Black Scholes model can be considered as nothing but the binomial model, in the limiting case where the time period becomes infinitesimal. A brief note on the binomial model is in order here. In the binomial model, the stock price can take only two values at the end of a time period. Consider a risk free bond and a derivative whose value X will either be X_u or X_d after a period of time. Let $X = \Delta S + a$, i.e., X consists of Δ units of the underlying stock and '*a*' units of bond. At the end of a given period, the stock price can be u S (upper bound) or d S (lower bound), where $d < r < u$. The corresponding values of X are X_u and X_d respectively. The bond value will be *ar* at the end of the period, irrespective of the price of the security.

Let $\Delta = \dfrac{X_u - X_d}{uS - dS}$

and a = $\dfrac{uX_d - dX_u}{r(u - d)}$

In a bullish scenario, the value of the portfolio will be:

$$\Delta uS + ar \quad = \frac{X_u - X_d}{uS - dS}uS + \frac{uX_d - dX_u}{r(u - d)}r$$

$$= \frac{X_u - X_d}{u - d}u + \frac{uX_d - dX_u}{u - d}$$

$$= \frac{uX_u - uX_d + uX_d - dX_u}{u - d}$$

$$= \frac{X_u(u - d)}{(u - d)} = X_u$$

Similarly, in a bearish scenario, the value of the portfolio will be:

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[80] Draws heavily from Rangajaran K Sundaram, "Equivalent Martingale measures and risk neutral pricing: An expository note," Journal of Derivatives, Fall 1997.

$$\Delta dS + ar \quad = \frac{X_u - X_d}{uS - dS} dS + \frac{uX_d - dX_u}{r(u-d)} r$$

$$= \frac{dX_u - dX_d + uX_d - dX_u}{u - d}$$

$$= \frac{X_d(u-d)}{(u-d)} = X_d$$

Thus the portfolio we have constructed, is a replicating portfolio. It replicates the pay off of the derivative. The portfolio itself consists of the underlying stock and a risk free bond. Now, it is easy to find out the current value of the derivative.

The current value of the portfolio is:

$X = \Delta S + a$ (by definition)

$$= \frac{X_u - X_d}{uS - dS} S + \frac{uX_d - dX_u}{r(u-d)}$$

$$= \frac{(X_u - X_d)r + uX_d - dX_u}{r(u-d)}$$

$$= \frac{1}{r}\left[\frac{rX_u - rX_d + uX_d - dX_u}{(u-d)} \right]$$

$$= \frac{1}{r}\left[\frac{r-d}{u-d} X_u + \frac{u-r}{u-d} X_d \right]$$

So the risk neutral probabilities are $\frac{r-d}{u-d}$ (for the stock price reaching u S) and $\frac{u-r}{u-d}$ (for the stock price reaching d S).

We can derive the risk neutral probability in a different way. If the expected returns for the portfolio are to be the same as that for the risk free bond

	pu + (1-p) d	=	r
or	pu + d − pd	=	r
or	pu − pd	=	r-d
or	$p = \dfrac{r-d}{u-d}$		
and	1 − p	=	$\dfrac{u-r}{u-d}$

Pricing derivatives using risk neutral probabilities is computationally convenient. The risk neutral probability depends only on the underlying assets in the problem and not on the particular claim being valued. A risk neutral probability must satisfy two conditions:

- The prices that occur under the risk neutral probability must be identical to those that occur in the original model.
- The expected returns on all assets in the model should be the same.

In some models, the risk neutral probability is uniquely defined but in general, a model may allow more than one risk neutral probability. Or in some cases, it may not admit one at all. The risk neutral probability does not exist if and only if there are arbitrage opportunities. Multiple risk neutral probabilities can occur if and only if there are contingent claims in the model that cannot be priced by arbitrage because they are not replicable.

More about risk neutral probability

What is the economic interpretation of risk neutral probability? To answer this question, let us first define an *Arrow security*. An Arrow security is a security associated with a particular future state of the world that pays $1 if that state occurs and zero otherwise. All other contingent claims and derivative securities can be expressed in terms of portfolios of Arrow securities and priced accordingly.

As Rangarajan Sundaram[81] explains, the state price associated with a particular state is simply the risk neutral probability of the state discounted at the risk free rate. Risk neutral probabilities are just the prices of certain contingent claims. Multiplying a claim's pay offs in a particular state by the state price is exactly the same as multiplying it by the discounted risk neutral probability of that state. Thus there is a one-to-one relationship between risk neutral probabilities and state prices. *Identifying risk neutral probabilities, essentially means identifying the state prices.*

We have already seen that in the binomial model with two possibilities, i.e., the stock price changing to uS and dS, the risk neutral probability is given by:

$$p = \frac{r-d}{u-d}$$

and $\quad 1-p = \frac{u-r}{u-d}$

The discounted risk neutral probabilities are given by:

$$\frac{p}{r} = \frac{1}{r}\frac{(r-d)}{(u-d)}$$

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[81] Journal of Derivatives, Fall 1997.

and $\quad \dfrac{1-p}{r} = \dfrac{1}{r}\dfrac{(u-r)}{(u-d)}$

Let us get back to Arrow securities. The pay offs in the case of Arrow security are 0 and 1. In the Binomial model

$$X = \frac{1}{r}\left[\frac{r-d}{u-d}X_u + \frac{u-r}{u-d}X_d\right]$$

Now, the statement made by Sundaram is clear.
A model does not permit arbitrage if and only if it admits at least one risk neutral probability. There is no arbitrage only if $u > r > d$.

If we put $X_u = 1$; $X_d = 0$, we get one state price
$$X_u = \frac{1}{r}\frac{r-d}{u-d}$$

If we put $X_u = 0$; $X_d = 1$, we get another state price
$$X_d = \frac{1}{r}\frac{u-r}{u-d}$$
By comparing with the earlier equation, we get:

$$p_u = \frac{p}{r}; \qquad p_d = \frac{1-p}{r}$$

Thus, the binomial model is consistent with risk neutral valuation.
Let us now take the example of a model that does not admit any risk neutral probability. Consider a portfolio with two risky assets and a bond. Assume that after one period, the prices can be either : rB, $(u_1 S_1, d_1 S_1)$ or rB, $(u_2 S_2, d_2 S_2)$. If we want this to be a risk free portfolio, we can write:

$$p\,u_1 + (1\text{-}p)\,d_1 = \quad r$$
$$p\,u_2 + (1\text{-}p)\,d_2 = \quad r$$

Simplifying these equations, we get:
$$p\,(u_1\text{-}d_1) = r - d_1 \qquad \text{and} \qquad p\,(u_2\text{-}d_2) = r - d_2$$

or $\quad p = \dfrac{r-d_1}{u_1-d_1} = \dfrac{r-d_2}{u_2-d_2}$

We can choose r, u_1, d_1, u_2, d_2 such that this last equation is violated. So no risk neutral probability exists.

Let us now examine a model where there can be more than one risk neutral probability. Suppose S can take three values at the end of the period, uS, mS and dS, where u > m > d. To be a risk free portfolio, we can write:

$$p_u u + p_d d + p_m m \quad = \quad r$$
with $\quad p_u + p_d + p_m \quad = \quad 1$

There are two equations and three unknowns. So there are infinitely many solutions here. Thus the trinomial model is also not complete. Let us illustrate this.

Suppose we have invested in "a" shares of stock and "b" dollars of bond.

We can then write:
$$a\,u\,S + b\,r \quad = \quad X_u$$
$$a\,m\,S + b\,r \quad = \quad X_m$$
$$a\,d\,S + b\,r \quad = \quad X_d$$

If we combine the first two equations, we get:
$$a\,u\,S - a\,m\,S \quad = \quad X_u - X_m$$
or $\quad a = \dfrac{X_u - X_m}{uS - mS}$

Similarly from the second and third equations, we get:

$$a = \dfrac{X_m - X_d}{mS - dS}$$

Suppose we put $X_u = X_m = 1$ and $X_d = 0$. Then the two equations are inconsistent. In one case, $a = 0$ and in the other case, $a = \dfrac{1}{mS - dS}$

Let us make a final point before we close the discussion on risk neutral probability. In the binomial model, we had two states uS and dS at the end of a period. The risk free rate was r.

Without making any explicit attempt to arrive at the probability of state uS and probability of state dS, we get:

$$X = \frac{1}{r}\left[\frac{r-d}{u-d} X_u + \frac{u-r}{u-d} X_d \right]$$

So that $p = \dfrac{r-d}{u-d}$

and $1 - p = \dfrac{u-r}{u-d}$

Why did we not have to explicitly assume the probabilities for state uS and dS and compute them? We have made it a risk free portfolio. The composition of the portfolio is the same irrespective of whether one state occurs 50% of the time or 70% the time. In short, calculating the price of the replicating portfolio does not require knowledge of the probabilities of the two states. It certainly looks puzzling! The dilemma is resolved if we intuitively understand that *the probabilities of the two states are embedded into the current stock price*. As the current stock price changes, the probabilities of the two states will also change.

The Black Scholes Merton Formula[82]

We have already seen the Black Scholes differential equation. Now let us move on to the Black Scholes Merton formula. Suppose the stock price follows the Geometric Brownian motion $dS = \mu\,Sdt + \sigma sdz$.

We saw a little earlier that the price of a call option, f could be related to the stock price S through the equation:

$$\Delta f = \left(\frac{\partial f}{\partial s}\mu s + \frac{\partial f}{\partial t} + \frac{1}{2}\frac{\partial^2 f}{\partial s^2}\sigma^2 S^2\right)\Delta t + \frac{\partial f}{\partial s}\sigma s\Delta z$$

If $f = lnS$, $\dfrac{\partial f}{\partial s} = \dfrac{1}{s}$, $\dfrac{\partial^2 f}{\partial s^2} = \dfrac{-1}{s^2}$, $\dfrac{\partial f}{\partial t} = 0$

or $$\Delta f = \frac{1}{s}\mu s\Delta t - \frac{1}{2s^2}\sigma^2 s^2\Delta t + \frac{1}{s}\sigma s\Delta z$$

or $$\Delta f = \left(\mu - \frac{\sigma^2}{2}\right)\Delta t + \sigma\Delta z$$

or $$df = \left(\mu - \frac{\sigma^2}{2}\right)dt + \sigma dz$$

What this shows is that $f = lns$ follows a generalized Wiener process with a constant drift rate of $\left(\mu - \dfrac{\sigma^2}{2}\right)$ and a constant variance rate of σ^2. We have already seen earlier why the drift is $\left(\mu - \dfrac{\sigma^2}{2}\right)$ and not μ.

The change in S between 0 and future time T is normally distributed with mean $\left(\mu - \dfrac{\sigma^2}{2}\right)$T and variance σ^2T. or standard deviation $\sigma\sqrt{T}$.

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[82] Draws from John C Hull, "Options, Futures and Other Derivatives," Prentice Hall, 2006.

$$ln\ S_T - lnS_0 \sim \varnothing \left[\left(\mu - \frac{\sigma^2}{2} \right) T, \sigma\sqrt{T} \right]$$

or $\quad ln\ S_T \sim \varnothing \left[lnS_0 + \left(\mu - \frac{\sigma^2}{2} \right) T, \sigma\sqrt{T} \right]$

Now we are ready to write the Black-Scholes-Merton formulae for valuing European call and put options. Let c denote the price of the European call option and p that of the European put option.

European call option: $\quad$ c $\quad = \quad$ S N(d_1) $-$ e^{-rT}(K) N (d_2)
European put option: $\quad$ p $\quad = \quad$ e^{-rT}(K) N ($-d_2$) $-$ S N ($-d_1$)
Where:

$\quad$ S $\quad = \quad$ current value of stock price
$\quad$ N (d) $\quad = \quad$ cumulative normal distribution at d
$\quad$ K $\quad = \quad$ strike price
$\quad$ r $\quad = \quad$ continuously compounded risk free rate of interest
$\quad$ T $\quad = \quad$ time to expiration
$\quad$ σ $\quad = \quad$ volatility
$\quad$ d_1, d_2 are more complex terms as mentioned below:

$$d_1 \quad = \quad \frac{ln\dfrac{S}{K} + (r + \dfrac{\sigma^2}{2})T}{\sigma\sqrt{T}}$$

$$d_2 \quad = \quad \frac{ln\dfrac{S}{K} + (r - \dfrac{\sigma^2}{2})T}{\sigma\sqrt{T}}$$

$$\quad = \quad d_1 - \sigma\sqrt{T}$$

Let us take a simple illustration. Let S = 100, K = 110, r = 9.50%
$\quad$ T $\quad = \quad$ 6 months = .5 years, $\quad$ σ $\quad = \quad$ 20%

$$\text{Then} \quad d_1 \quad = \quad \frac{ln\dfrac{100}{110} + (.0950 + \dfrac{.2^2}{2})(.5)}{.2\sqrt{.5}}$$

$$\quad = \quad \frac{-.09531 + .0575}{.1414}$$

$\quad = \quad$ - .2674
$\quad$ d_2 $\quad = \quad$ - .2674 $-$ (.2) $\sqrt{.5}$
$\quad = \quad$ - .4088

From tables,

$$N(d_1) = .3950$$
$$N(d_2) = .3417$$
$$C = SN(d_1) - Ke^{-rt} N(d_2)$$
$$= (100) (.3950) - (110) e^{-(.0950)(.5)} (.3417)$$
$$= 39.50 - 35.83$$
$$= 3.67$$

Let us sum up the assumptions of the original Black Scholes Model.

- The model applies only to European options.
- No dividends are paid.
- The market is complete, efficient and frictionless.
- Options and securities are perfectly divisible.
- There are no riskless arbitrage opportunities.
- Borrowing and lending can take place at the risk free rate.
- The risk free rate is constant during the life of the option.
- Stock prices follow a lognormal distribution.

Thus the original Black Scholes model operates within a restrictive framework. Fortunately, the model can be extended by relaxing many of these assumptions. A lot of work has indeed been done in this regard.

Illustration
A European call option has the following characteristics. Current price of stock: 50; strike price: 45; risk free rate of return: 5%; maturity: 1 year; annual volatility: 25%. What is the value of the call?

$$d_1 = \frac{ln(\frac{50}{45}) + [.05 + (.5)(.25)^2](1)}{.25\sqrt{1}}$$

or d_1 = (.1054 + .08125) / .25   =   .7466
d_2 = .7464 - (.25) $\sqrt{1}$ =   .4966
$N(d_1)$ = .7723
$N(d_2)$ = .6902
C = (50) (.7723) - (45e$^{-.05}$ x .6902)
= 38.615 - 29.544
≈ 9.071

Illustration
A stock trades for 60. The annual std devn is 10%. The continuously compounded risk free rate is 5%. Calculate the value of both call and put if the exercise price is 60 and maturity is 1 year.

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$$d_1 = \frac{ln(\frac{60}{60}) + [.05 + (.5) \times (.10)^2](1)}{.10\sqrt{1}}$$

-

$$= 0.55$$

$d_2 = d_1 - \sigma\sqrt{T} = \quad .55 - 10\sqrt{1} \quad = \quad .45$

$N(d_1) = .7088 \qquad N(d_2) = .6736$

$\text{Value of call} = (S_0)(N(d_1)) - [Ke^{-rt} \times N(d_2)]$

$\qquad = (60)(.7088) - [60e^{-(.05)} \times .6736]$

$\qquad = 42.53 - 38.44 \qquad = \quad 4.09$

We can calculate the value of the put by applying the put call parity.

According to put call parity, $p + s \quad = \quad c + ke^{-rT}$

where p is the value of the put option

c is the value of the call option

s is the current stock price

k is the strike price for both the options

r is the risk free rate

T is the time to maturity

Value of put $= 4.09 - 60 + 60\ e^{-(.05)(1)} \quad = \quad 1.16$

Conclusion

In this chapter we have attempted to understand the sources of market risk. We have also covered briefly some of the tools and techniques available to measure market risk. A basic understanding of how stock prices can be modeled has also been provided. We have examined one of the key building blocks of market risk measurement, risk neutral valuation. The coverage has been kept basic and as non technical as possible. Readers must consult more specialized books to get a more indepth understanding of the topics covered in this chapter.

Case Illustration: Market Risk Management at HSBC[83]

Introduction
Like any other global bank, HSBC is affected by market risk. HSBC separates exposures to market risk into trading and non-trading portfolios. Trading portfolios include those positions arising from market-making, proprietary position-taking and other marked-to-market positions. Non-trading portfolios primarily arise from HSBC's retail and commercial banking assets and liabilities, financial investments classified as available for sale and held to maturity.

Organisation and responsibilities
An independent unit within Group Risk, develops the Group's market risk management policies and measurement techniques. Each major operating entity has an independent market risk management and control function which is responsible for measuring market risk exposures in accordance with group policies and monitoring and reporting them on a daily basis.

Each operating entity is required to assess the market risks which arise on each product in its business and to transfer these risks to either its local Global Markets unit for management, or to separate books managed under the supervision of the local Asset and Liability Management Committee. This way all market risks are consolidated within operations which have the necessary skills, tools and management capabilities to handle such risks professionally. Each operating unit must ensure that market risk exposures remain within the limits specified for that entity. The nature and degree of sophistication of the hedging and risk mitigation strategies performed across the Group corresponds to the market instruments available within each operating jurisdiction.

Measurement and monitoring of market risk
Sensitivity analysis
Sensitivity measures are used to monitor the market risk positions within each risk type, for example, for interest rate risk, the present value of a basis point movement in interest rates. Sensitivity limits are used to monitor diversification of risk both across and within asset classes.

Interest rate risk
Interest rate risk arises principally from mismatches between the future yield on assets and their funding cost as a result of interest rate changes. HSBC uses a range of tools to monitor and limit interest rate risk exposures. These include the present value of a basis point movement in interest rates, VAR, stress testing and sensitivity analysis.

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[83] Draws heavily from HSBC's Annual Reports.

Foreign exchange risk

HSBC controls foreign exchange risk within the trading portfolio by limiting the open exposure to individual currencies, and on an aggregate basis. VAR and stress testing are also used to measure and control this kind of risk.

Foreign exchange exposures also arise from net investments in subsidiaries, branches or associated undertakings, the functional currencies of which are currencies other than the US dollar. HSBC's aim is to ensure that consolidated capital ratios and the capital ratios of individual banking subsidiaries are protected from the effect of changes in exchange rates. For each subsidiary bank, the ratio of structural exposures in a given currency to risk-weighted assets denominated in that currency must broadly equal the capital ratio of the subsidiary in question. HSBC hedges structural foreign exchange exposures only in limited circumstances.

Specific issuer risk

Specific issuer (credit spread) risk arises from a change in the value of debt instruments due to a perceived change in the credit quality of the issuer or underlying assets. Besides VAR and stress testing, HSBC manages such exposure through the use of limits referenced to the sensitivity of the present value of a basis point movement in credit spreads.

Equity risk

Equity risk arises from the holding of open positions, either long or short, in equities or equity based instruments. Besides VAR and stress testing, HSBC controls the equity risk within its trading portfolios by limiting the net open equity exposure.

Equity risk within the non-trading portfolios typically arises as a result of investments in private equity and strategic investments. Investments in private equity are subject to limits on the total amount of investment. While evaluating potential new commitments, HSBC attempts to ensure that industry and geographical concentrations remain within acceptable levels for the portfolio as a whole.

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Chapter - 6
Managing Credit Risk

"This ability of structured finance to repackage risks and create "safe" assets from otherwise risky collateral led to a dramatic expansion in the issuance of structured securities, most of which were viewed by investors to be virtually risk-free and certified as such by the rating agencies. At the core of the recent financial market crisis has been the discovery that these securities are actually far riskier than originally advertised.[84]"

-   Joshua Caval , Jakub Jurek, Erick Stafford.

Introduction

Credit risk arises from the possibility of default by counterparty. Credit risk lay at the heart of the sub prime crisis. The most important point to note about credit risk is that it is more difficult to model and measure compared to market risk. Unlike market risk, where a lot of data is available in the public domain, data is scanty and sometimes non existent in case of credit risk. Moreover, credit risk is far more contextual, i.e., firm specific compared to market risk. Despite these challenges, there has been significant progress in credit risk modeling in recent years. In this chapter, we will examine the three building blocks of credit risk management – *probability of default, exposure at default* and *recovery rate*. We will also discuss briefly some of the commonly used credit risk modeling techniques. These techniques can help us to estimate the potential loss in a portfolio of credit exposures over a given time horizon at a specified confidence level. The aim of this chapter is to provide a high level understanding of credit risk management.

Pre-settlement and Settlement risk

Credit risk can be defined as the likelihood of a counterparty failing to discharge its obligations. Any credit transaction typically involves two stages: pre settlement and settlement.

Pre-settlement risk refers to the probability of failure of the counterparty to discharge its obligation during the life of the transaction. This includes the possibility of defaulting on bond interest or principal repayment or not making margin payment in case of a derivative transaction.

Settlement risk arises at the time of maturity. Suppose a bank fulfils its obligation at the time of expiry of a contract. Till the time the bank receives its dues from the counterparty, settlement risk exists. A good example of such risk is foreign currency payments made by two parties in different time zones.

To deal with settlement risk, banks have developed *real time gross settlement systems*. Such systems reduce the time interval between the point a stop payment instruction can no longer be made and the point of receipt of dues from the counterparty. Another technique used is *netting*. Instead of paying the gross amounts to each other, only the net

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[84] "The Economics of Structured Finance," Harvard Business School, Working Paper, 09-060, 2008.

amount is paid by one of the counterparties. This reduces the exposure and contains the damage even if things go wrong. (*See box item: Managing settlement risk at UBS*)

Settlement risk at UBS

Settlement risk arises in transactions involving exchange of value when UBS must honor its obligation to deliver without first being able to determine that the counter-value has been received.

In 2008, settlement risk on 78% of gross settlement volumes was eliminated through risk mitigation. The most significant source of settlement risk is foreign exchange transactions. UBS is a member of Continuous Linked Settlement (CLS), a foreign exchange clearing house which allows transactions to be settled on a delivery versus payment basis. The proportion of UBS's overall gross volumes settled through CLS increased to 55% during 2008 compared to 53% in 2007.

The avoidance of settlement risk through CLS and other means does not, of course, eliminate the credit risk on foreign exchange transactions resulting from changes in exchange rates prior to settlement. Such counterparty risk on forward foreign exchange transactions is measured and controlled as part of the overall credit risk on OTC derivatives.

Source: UBS Annual Reports, 2008.

Probability of default

The probability of default is a key concern in credit risk management. Two kinds of factors must be evaluated to arrive at the probability of default – borrower specific and market specific.

Borrower specific factors include:
- collateral
- leverage
- volatility of earnings/cash flows
- reputation.

Market specific factors include:
- the phase of the business cycle
- industry conditions
- interest rates
- exchange rates

Exhibit 6.1
S&P's Corporate Finance Cumulative Default Rates 1981-2008 (%)

%	Years after the issue of security		
	5	10	15
AAA	0.27	0.55	0.65
AA	0.34	0.83	1.20
A	0.72	1.94	2.91
BBB	2.43	5.16	7.70
BB	9.07	16.02	19.33
B	20.58	28.41	33.14
CCC/C	44.93	50.44	52.93

Corporate finance refers to long-term local currency credit ratings. It includes industrials, utilities and financial institutions, but excludes public sector ratings and all structured finance vehicles.

Source: S&P

Ref: The Turner Review - A regulatory response to the global banking crisis, published by: UK Financial Services Authority, www.fsa.gov.uk/pubs/other/turner_review; March 2009

Illustration

A portfolio consists of 5 bonds each with a probability of default of .01. What is the probability that there will be no default? What is the probability that there will be at least one default? What is the probability of exactly one default? What is the probability of exactly two defaults?

Probability of no default	=	$(.99)^5$	=	.951
Probability of at least one default	=	$1 - .951$	=	.049
Probability of exactly one default	=	$5C_1 (.99)^4 (.01)$	=	.0480
Probability of exactly two default	=	$5C_2 (.99)^3 (.01)^2$	=	.00097

Illustration

The cumulative probability of default of an instrument over two years is 5%. The probability of default in the first year is 2%. What is the probability of default in the second year?

Probability of no default over the two years   = $1 - 0.05$ =   0.95
Probability of no default during the first year =   0.98
Let probability of default in the second year be p
In order that there is no default over the two years, there must be no default at in year 1 or year 2.
Then $(.98) (1-p)$ =   .95

$$\Rightarrow \quad p \quad = \quad 1 - \frac{.95}{.98} \quad = \quad 0.0306$$

So probability of default: =   3.06%

Traditional methods

Default risk models can range in complexity from simple qualitative models to highly sophisticated quantitative models. Let us look first at some of the more simple and traditional ways of estimating the probability of default. These typically use financial statement data. Then we will examine some of the more sophisticated models.

Altman's Z Score

Altman's[85] Z score is a good example of a credit scoring tool based on data available in financial statements. It is based on multiple discriminant analysis. The Z score is calculated as:

Z	=	$1.2x_1 + 1.4x_2 + 3.3x_3 + 0.6x_4 + .999x_5$
x_1	=	Working capital / Total assets
x_2	=	Retained earnings / Total assets
x_3	=	Earnings before interest and taxes / Total assets
x_4	=	Market value of equity / Book value of total liabilities
x_5	=	Sales / Total assets

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[85]. E.I Altman, "Financial Ratios, Discriminant Analysis and the Prediction of Corporate Bankruptcy," *Journal of Finance,* September 1968, pp. 589-609

Once Z is calculated, the credit risk is assessed as follows:

$Z > 3.0$	means low probability of default	(Safe zone)
$2.7 < Z < 3.0$	means an alert signal	(Grey zone)
$1.8 < Z < 2.7$	means a good chance of default	(Grey zone)
$Z < 1.8$	means a high probability of default	(Distress zone)

A variant of the Altman score has been used in the case of mortgage loans in the US. This is called the FICO score. FICO scores are tabulated by independent credit bureaus using a model created by Fair Issac Corporation (FICO). A lower FICO score denotes a higher risk of default and vice versa. In mid-2007, the average FICO scores were 725, 739, 712 and 628 for agency[86], jumbo, Alt-A and sub prime mortgages.

Estimating probability of default from market prices

The problem with financial statements is that they tend to be backward looking. A simple but forward looking way to measure the probability of default is to examine the market prices of bonds which are traded. Suppose the one year T Bill yields 2% while a one year corporate bond yields 3%. Assume that no recovery is possible in case of a default, what is the probability of default?

We can invest in either the T Bill or the risky instrument. Let us say we make an investment of $1 for exactly one year.

If we assume the probability of default is p, the following equation must hold good:

$$1.02 = 1.03 \, (1\text{-}p)$$

If this equation does not hold, arbitrage is possible by going long in one of the instruments (which fetches higher return) and short in the other (which fetches lower return).

Solving we get: $p = 1 - \dfrac{(1.02)}{(1.03)}$ $= \quad .0097$

$$= \quad .97\%$$

Suppose in the earlier illustration, the recovery in the case of default has been estimated as 50%. This means that in the case of default, 50% of the exposure can be recovered. Then we can rewrite the equation as follows:

1.02	$=$	$(1.03) \, (1\text{-}p)$	$+$	$(1.03) \, (p) \, (.5)$
	$=$	$1.03 - 1.03p + .515 \, p$		
$.515 \, p$	$=$	$.01$		
p	$=$	$.0194$		
	$=$	1.94%		

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[86]. Agency mortgages are backed by Fannie Mac/Fraddic Mac. Jumbo mortgages as the name suggests are large loans. Limited documentation is the key feature of Alt-A loans. Subprime mortgages have the highest probability of default. For more details, see Chapter 3.

More generally, let i be the yield of the risky bond, r that of the risk free instrument. Let p be the probability of default and f the recovery rate, i.e., fraction of the amount which can be collected from the debtor in case of a default. Then for a loan of value, 1, to prevent arbitrage, the following condition must hold:

$$1+r = (1+i)\ (1-p) + (1+i)\ pf$$

or $\quad 1+r = \ 1 + i - p - pi + pf + ipf$

or $\quad i - r = p + pi - pf - ipf.$

Ignoring $pi, ipf,$ as these will be small quantities, we get:

$$i - r = p\ (1\text{-}f).$$

Since f is the recovery rate, (1-f) is nothing but the loss given default. $(i - r)$ is the credit spread. *Thus the spread or risk premium equals the product of the default probability and the loss given default.* There is nothing surprising about the result. Since we have assumed the loan value to be 1, the left side of the equation is the excess amount received by investors for the risky loan in comparison to a risk free loan and the right side is the expected loss on the risky loan. In other words, the left side represents the risk compensation to the investor and the right side, the expected loss. To prevent arbitrage, the risk compensation must equal the expected loss.

Measuring Probability of default at UBS

UBS assesses the likelihood of default of individual counterparties using rating tools tailored to the various counterparty segments. A common Masterscale segments clients into 15 rating classes, two being reserved for cases of impairment or default. The UBS Masterscale reflects not only an ordinal ranking of counterparties, but also the range of default probabilities defined for each rating class. (See Exhibit 6.2)

Clients migrate between rating classes as UBS's assessment of their probability of default changes. External ratings, where available, are used to benchmark UBS's internal default risk assessment. The ratings of the major rating agencies are linked to the internal rating classes based on the long-term average 1-year default rates for each external grade. Observed defaults per agency rating category vary year-on-year, especially over an economic cycle. So UBS does not expect the actual number of defaults in its equivalent rating band in any given period to equal the rating agency average. UBS monitors the long-term average default rates associated with external rating classes. If these long-term averages change in a material and permanent way, their mapping to the Masterscale is adjusted. At the Investment Bank, rating tools are differentiated by broad segments - banks, sovereigns, corporates, funds, hedge funds, commercial real estate and a number of more specialized businesses. The design of these tools follows a common approach. The selection and combination of relevant criteria (financial ratios and qualitative factors) is determined through a structured analysis by credit officers with expert knowledge of each segment, supported by statistical modeling techniques where sufficient data is available.

The Swiss banking portfolio includes exposures to a range of enterprises, both large and small- to medium-sized ("SMEs") and the rating tools vary accordingly. For segments where sufficient default data is available, rating tool development is primarily based on statistical models. Typically, these "score cards" consist of eight to twelve criteria combining financial ratios with qualitative and behavioral factors which have proven good indicators of default in the past. For smaller risk segments with few observed defaults, a more expert based approach is chosen, similar to that applied at the Investment Bank. For the Swiss commercial real estate segment, which is part of the retail segment, the probability of default is derived from simulation of potential changes in the value of the collateral and the probability that it will fall below the loan amount. Default expectations for the Swiss residential mortgage segment are based on the internal default and loss history, where the major differentiating factor is the loan to value ratio – the amount of the outstanding obligation expressed as a percentage of the value of the collateral.

Source: UBS Annual Reports

Exhibit 6.2

UBS internal rating scale and mapping of external ratings

UBS Rating	Description	Moody's Investor Services equivalent	Standard & Poor's equivalent
0 and 1	Investment grade	Aaa	AAA
2		Aa1 to Aa3	AA+ to AA−
3		A1 to A3	A+ to A−
4		Baa1 to Baa2	BBB+ to BBB
5		Baa3	BBB−
6	Sub-investment grade	Ba1	BB+
7		Ba2	BB
8		Ba2	BB
9		Ba3	BB−
10		B1	B+
11		B2	B
12		B3	B−
13		Caa to C	CCC to C
14	Defaulted	D	D

Source: UBS Annual Report - 2008

Illustration

Calculate the implied probability of default if the   one year T Bill yield is 9% and a one year zero coupon corporate bond is fetching 15.5%. Assume recovery in the event of default is zero.

Let the probability of default be p

Expected returns from corporate bond   = $1.155 (1-p) + (0) (p)$

Expected returns from treasury   =   1.09

or $1.155 (1-p)$ =   1.09

p   = $1 - 1.09/1.155$ =   .0563

=   5.63%

Illustration

In the earlier problem, if the recovery is 80% in the case of a default, what is the default probability?

$1.155 (1-p)$ $+ (.80) (1.155) (p)$ =   1.09

or .231 p   =   0.065

or   p   =   0.2814

=   28.14%

A brief note on Credit Rating Agencies[87]

Rating agencies specialize in evaluating the creditworthiness of debt securities and also the general credit worthiness of issuers. The rating given by the agencies are a good indication of the likelihood of all interest payment and principal repayments being made on time. Where capital markets have replaced banks as the major source of debt capital, rating agencies have a particularly important role to play. Basle II refers to the credit rating agencies as external credit assessment institutions. The three main rating agencies in the US are Moody's Standard and Poor's and Fitch.

The origin of rating agencies in the US goes back to 1909 when John Moody initiated bond ratings for the rail roads. In 1962, Dun and Bradstreet acquired Moody's After flourishing till the 1930s, rating agencies began to struggle as the bond markets were reasonably safe, dominated by government debt and investment grade corporates. But in the 1970s, the debt markets became more volatile, a landmark event being the bankruptcy of Penn Central in 1970.

In the 1970s, the rating agencies also revamped their revenue model, moving away from subscription paying investors to fee paying issuers. The agencies also widened the scope of coverage to include asset backed securities, commercial paper, municipal bonds, insurance companies, etc.

As credit quality can change over time, rating agencies publish updates on issuers at periodic intervals. While issuing ratings, the agencies can indicate whether the outlook is positive, i.e., it may be raised, negative, i.e., it may be lowered or stable, meaning neutral.

The revenue model of rating agencies remains a source of concern. The independence of rating agencies and their role during the sub prime crisis has been questioned. The International organization of Securities Commissions (IOSCO) published a code of conduct for the rating agencies in December 2005.

While rating bonds, the rating agencies consider various factors. S&P for example looks at the following while rating bonds:
▪ Business risk
▪ Industry characteristics
▪ Competitive positioning
▪ Management
▪ Financial risk
▪ Financial characteristics
▪ Financial policies
▪ Profitability
▪ Capitalization
▪ Cash flow protection
▪ Financial flexibility

The agencies compute a number of financial ratios and track them over time. The agencies typically study a range of public and non public documents related to the issuer and the specific debt issue. They review the accounting practices. Meetings are usually held with the management to seek clarifications regarding key operating and financial plans and policies. Some amount of subjectivity in the rating process, however, cannot be avoided.

Following the sub prime crisis, the rating agencies have been revisiting the default and loss assumptions, in their models. They have also been reviewing the assumptions made about correlations across asset classes. The agencies maintain that their approach is transparent. They also swear by their independence. The agencies, however, have acknowledged that there have been problems with the quality of information. They have also acknowledged the need to go beyond ability to pay, to include other factors such as liquidity.

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[87] John B Caouette, Edward I Altman, Paul Narayanan and Robert W J Nimmo, "Managing Credit Risk – The great challenge for global financial markets," John Wiley & Sons, 2008.

While the role of the rating agencies is under intense scrutiny, they will continue to play a major role in the capital markets. The agencies, provided they can reinvent themselves, may still provide a transparent, independent and affordable institutional framework for evaluating credit risk.

Exposure at default

Now that we have covered probability of default, it is time to move on to the second building block of credit risk management – credit exposure. At the time of default, the amount of exposure determines the extent of losses. The larger the exposure, more the losses. So along with the probability of default, we must also determine the amount of exposure. The amount of credit exposure at the time of default is called exposure at default (EAD). In traditional banking, the exposure is usually the face value of the loan. But when derivatives and structured products are involved, the face value is not the relevant parameter. Determining the exposure is a more involved process. Guarantees and commitments further complicate the problem.

In case of derivative contracts, three situations may arise. The contract may be a liability to the bank, an asset to the bank or either of the two.
- Where the derivative position is a liability, there is no credit exposure.
- When the derivative position is an asset, there is credit exposure.
- In the third case, the position can be an asset or a liability depending on the market fluctuation. So there is a possibility of loss when the position is an asset and no loss when the position is a liability.

Credit exposure can be broken down into two components – current exposure and potential exposure.

- Current exposure is the exposure which exists today.
- Potential exposure is the likely exposure in case the credit deteriorates.
- Adjusted exposure takes into account both current and potential exposure.

Credit exposure can be managed proactively in various ways. By marking to market, any variations in the position can be settled daily, through a margin account, instead of allowing an accumulation over the life of the contract. Collateral also helps a company to protect itself against current and potential exposure. The collateral will typically exceed the funds owed, by an amount called *haircut*. Downgrade triggers can also be used to modify exposure. A clause can be inserted stating that if the credit rating of the counterparty falls below a certain level, the bank has the option to close out the derivatives contract at its market value.

Exposure at default at UBS

Exposure at default represents the amounts UBS expects to be owed at the time of default. For outstanding loans, the exposure at default is the drawn amount or face value. For loan commitments and for contingent liabilities, it includes any amount already drawn plus the additional amount which is expected to be drawn at the time of default, should it occur.

For traded products, the estimation of exposure at default is more complex, since the current value of a contract can change significantly over time. For repurchase and reverse repurchase agreements and for securities borrowing and lending transactions, the net amount is assessed, taking into account the impact of market moves over the time it would take to close out all transactions ("close-out exposure"). Exposure at default on OTC derivative transactions is determined by modeling the potential evolution of the replacement value of the portfolio of trades with each counterparty over the lifetime of all transactions – "potential credit exposure" – taking into account legally enforceable close-out netting agreements where applicable.

For all traded products, the exposure at default is derived from a Monte Carlo simulation of potential market moves in all relevant risk factors, such as interest rates and exchange rates. The randomly simulated sets of risk factors are then used as inputs to product specific valuation models to generate valuation paths, taking into account the impact of maturing contracts and changing collateral values, including the ability to call additional collateral.

The resultant distribution of future valuation paths supports various exposure measures. All portfolio risk measures are based on the expected exposure profile. By contrast, in controlling individual counterparty exposures, UBS limits the potential "worst case" exposure over the full tenor of all transactions, and therefore applies the limits to the "maximum likely exposure" generated by the same simulations, measured to a specified high confidence level.

Cases where there is material correlation between factors driving a counterparty's credit quality and the factors driving the future path of traded products exposure – "wrong-way risk" – require special treatment. In such cases, the potential credit exposure generated by the standard model is overridden by a calculation from a customized exposure model that explicitly takes this correlation into account.

Source: UBS Annual Report

Loss given default

The third building block of credit risk management is the loss given default. In case of a default, it may be possible to recover part of the amount owed. The proportion of the amount which cannot be recovered is called *loss given default*.

The amount which can be recovered depends on various factors.
- The first factor is seniority. Senior claims have priority while settling claims. Thus secured bonds have priority over unsecured ones.
- The ease, with which assets can be sold to recover the amounts due, depends on the legal system and bankruptcy procedures.
- Collateralization i.e., the amount of collateral backing the loan, is another key factor in determining the recovery rate.
- Recovery rates are also more significantly negatively correlated with default rates. A bad year for defaults is also bad for recovery.

Before we take up a couple of simple illustrations, we need to define a few terms. A *commitment* represents the total amount the bank is prepared to lend to the borrower. On the other hand, *outstandings* refers to the actual amount loaned. Thus the commitment consists of two components – the outstanding and the unused portion of the commitment. The undrawn portion is nothing but a borrower's call option to draw on the full credit line in distress. During distress, the borrower will indeed draw on the remaining amount, fully or partly. The Adjusted exposure is nothing but the prior exposure adjusted for this drawdown. Adjusted exposure is calculated taking into account the bank's total

commitment, undrawn amount and the likely draw down in the case of credit deterioration. Banks of course may put in place covenants that limit such drawdowns.

Expected and unexpected loss

- *Expected loss* is the average loss in value over a period of time for a given exposure. The expected loss is best handled by building it into the product price.
- The *unexpected loss* refers to the variability of potential loan loss around the average loss level.
- The unexpected loss can be viewed as some multiple of the standard deviation of the expected loss. *The essence of credit risk management is arriving at a good estimate of the unexpected loss*. The unexpected loss in turn can be divided into two components.
- The *statistical losses* can be measured using techniques such as VAR.
- *Losses in the tails* can be estimated by stress testing or by applying extreme value theory.

Expected losses ← Statistical losses → Stress losses →
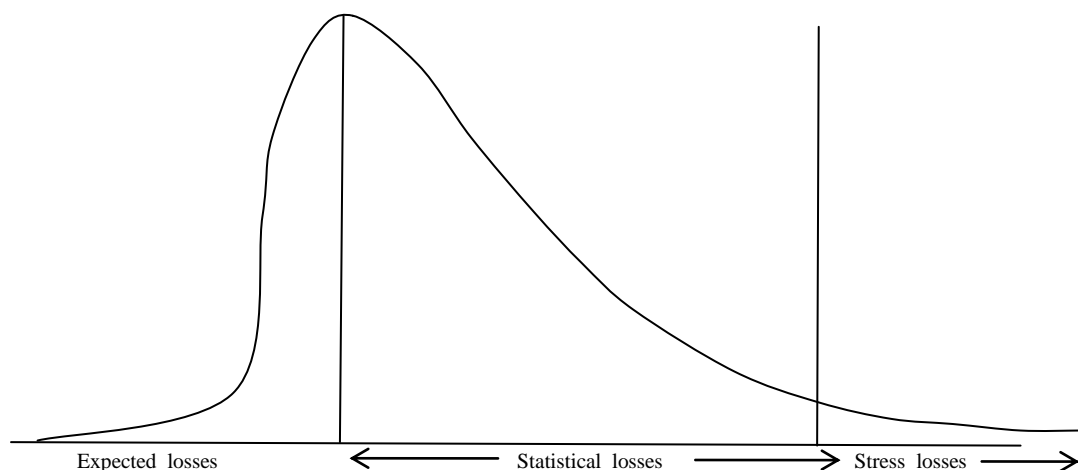
Loss given default at UBS

Loss given default represents UBS's expectation of the extent of loss on a claim should default occur. Loss given default includes loss of principal, interest and other amounts due and also the costs of carrying the impaired position during the work-out process.

In the Investment Banking group, loss given default estimates are based on expert assessment of the risk drivers (country, industry, legal structure, collateral and seniority), supported by empirical evidence from internal loss data and external benchmark information where available.

In the Swiss portfolio, loss given default differs by counterparty and collateral type and is statistically estimated using internal loss data. For the residential mortgage portfolio, further distinctions are achieved by statistical simulation based on loan to value ratios.

Source: UBS Annual Report

Exhibit 6.3
Exposure to credit risk at UBS

Exposure to credit risk – UBS Group

CHF million	IFRS[1] reported values — Maximum exposure to credit risk[2]	Adjustments: Maximum exposure to internal risk view	Credit exposure before hedges[3]	Credit exposure after hedges[4]	IFRS[1] reported values — Maximum exposure to credit risk[2]	Credit exposure before hedges[3]	Credit exposure after hedges[4]
	31.12.2008				31.12.2007		
Balances with central banks	29,156		29,156		16,433	16,434	
Due from banks	64,451	(45,419)	19,032		60,907	26,304	
Loans	340,308	(68,627)	271,681		335,864	285,093	
Contingent claims	19,699	(807)	18,892		20,824	20,347	
Undrawn irrevocable credit facilities	60,316	(3,326)	56,990		83,980	80,971	
Banking products	513,930	(118,179)	395,750	347,900	518,008	429,149	377,622
Derivative instruments	854,100	(626,448)	227,652		428,217	184,809	
Securities lending / borrowing	122,897 }	(300,694)	46,851	....	207,063 }	58,896	....
Repurchase / reverse repurchase agreements	224,648 }				376,928 }		
Traded products	1,201,645	(927,142)	274,503	263,677	1,012,208	243,704	237,790
Financial assets designated at fair value – debt instruments	5,153				4,116		
Financial investments available-for-sale – debt instruments	3,567				1,383		
Trading portfolio assets – debt instruments	224,862				376,928		
Accrued income	3,238				9,200		
Other assets	6,189				12,874		
Irrevocable commitments to acquire ARS	16,571				N/A		
Other products	259,580				404,501		
Total at the year-end	1,975,155	(1,304,902)	670,253	611,577	1,934,717	672,853	615,412

1 International Financial Reporting Standards (IFRS). 2 These amounts are considered the best representation of "maximum exposure to credit risk" as defined by the IFRS, without taking into account credit conversion factors for off-balance sheet positions. 3 Includes temporary exposure, before risk transfer, deduction of collateral and risk mitigation. 4 Exposure after risk transfer, deduction of allowances, provisions, credit valuation adjustments, credit default swaps and credit linked notes.

Source: UBS Annual Report, 2008

Exhibit 6.4

Gross credit exposure by UBS internal ratings – UBS Group

CHF million	Banking products		Traded products		Total exposure	
UBS internal rating	31.12.08	31.12.07	31.12.08	31.12.07	31.12.08	31.12.07
0–1	27,462	21,367	55,729	60,463	83,191	81,830
2–3	128,763	157,221	150,364	144,317	279,127	301,538
4–5	108,963	121,940	42,055	23,394	151,018	145,334
6–8	89,865	81,959	14,933	12,300	104,798	94,259
9–13	27,327	40,913	2,852	2,123	30,180	43,036
Total 0–13 (net of past due)	382,380	423,400	265,933	242,597	648,313	665,997
Defaulted	7,622	2,468	6,909	1,013	14,531	3,481
Past due but not defaulted	3,526	2,268			3,526	2,268
Other[1]	2,222	1,013	1,661	94	3,883	1,107
Total	395,750	429,149	274,503	243,704	670,253	672,853

1 Includes Global Asset Management and the Corporate Center.

Source: UBS Annual Report, 2008

Capturing correlations: Structural and Reduced Form Models

So far we have considered simple situations. In reality, banks face multiple exposures. Correlations may exist among different exposures. For example, there tends to be higher default rates across all ratings grades during a recession. To capture correlations among different credit events, there are broadly two approaches: *Structural models* and *Reduced form models*.

Structural models try to establish a relationship between default risk and the value of the firm. For example, equity prices can be used to estimate the probability of default of the bond of a company whose shares are listed on the stock exchange. In structural models, debt and equity are viewed as contingent claims on firm value. The probability of default is calculated from the difference between the current value of the firm's assets and liabilities and the volatility of the assets. Structural models are difficult to apply if the capital structure is complicated or if the assets are not traded.

Structural models view a firm's equity as an option on the firm's assets with a strike price equal to the value of the firm's debt. Option pricing models, typically, Black-Scholes are used to identify the fair value of these claims. Two approaches are cited in the literature. The first was developed by the Nobel prize winning economist, Robert Merton. The second, called KMV is a modification of Merton's model by the credit rating company, Moody's. Let us briefly examine these two models.

Merton Model
The value of a firm, V equals the sum of the values of debt, D and equity, E. The Merton model attempts to measure the value of D and thus forecast the probability of default. The model frames the situation in such a way it reduces to an option pricing problem. The key assumption in the Merton model is that the firm has made a single issue of zero coupon debt that will be paid back in one shot, at a future point in time. Other assumptions include perfect financial markets, no bankruptcy costs and no costs to enforce contracts. All these assumptions can be suitably modified to extend the Merton Model.

Let us use the following notations:

V_O = Current value of the company's assets.
V_T = Value of the company's assets at time T.
E_O = Value of the company's equity today.
E_T = Value of the company's equity at time T.
D = Amount of zero coupon debt maturing at time T.
σ_V = Volatility of assets.
σ_E = Volatility of equity.
T = Time of maturity of the debt.

Two situations can arise.
If $V_T < D$, the company will default on its debt. Debt holders will receive V_T. Equity holders will not receive any thing, i.e., $E_T = 0$.

If $V_T > D$, debt holders will receive their full payment, D. Equity holders will receive $V_T - D$.

We can now combine the two possibilities into a more generalized equation:
$$E_T = \max (V_T - D, 0)$$

As the minimum value of equity is 0 and the maximum value is unlimited, the pay off profile is that of a call option with strike price = D. We can now apply the Black Scholes model to value the equity.

$$E_O \quad = \quad V_0 \, N \, (d_1) - De^{-rt} \, N \, (d_2)$$

$$d_1 \quad = \quad \frac{ln(V_0/D)+(r+\sigma_v^2/2)T}{\sigma_v\sqrt{T}}$$

$$d_2 \quad = \quad d_1 - \sigma_v\sqrt{T}$$

N refers to the cumulative normal probability. The probability of default on the debt is N $(-d_2)$. To calculate d_2, we need to know the value of V_0 and σ_v. Both figures will in general not be readily available. So, assuming the company's shares are listed, we have to start with E_0. There is a relationship available based on Ito's lemma. (Derivation of this relationship is beyond the scope of this book.)

$$\sigma_E \, E_0 = \frac{dE}{dV} \; \sigma_v \, V_0$$

Using this relationship we can estimate V_0 and σ_v.

We could also approach the problem in a different way by stating that the amount received by the debt holders of the company is:

$$D - Max \, [(D-V_T), 0].$$

D is the pay off obtained by investing in a risk free zero coupon bond maturing at time T with a face value of D.

The second term, - Max $\{D-V_T, 0\}$ is the pay off from a short position in a put option on the firm's assets with strike price, D and maturity date, T.

By subtracting the value of the put from the risk free debt, we can value risky debt. The value of the put can be calculated by applying the Black-Scholes formula:

$$P = De^{-r(t)} \, N \, (-d_2) - V_0 N(-d_1)$$

Illustration

What is the value of a firm's equity if the total value of the firm is $600 million and the debt repayment is $100 million? What will be the value of equity if the total value of the firm drops to $75 million?

In the first case, value of equity   = $600 – 100$ = $500 million
In the second case, value of equity   =   0 as the value of debt repayment exceeds the total firm value.

Illustration

The market value of a firm is $60 million and the value of the zero coupon bond to be redeemed in 3 years is $50 million. The annual interest rate is 5% while the volatility of the firm value is 10%. Using the Merton Model, calculate the value of the firm's equity.

Let us first calculate the curent firm value, S.

$$S = 60 \times N(d_1) - (50)e^{-(.05)(3)} \times N(d_2)$$

$$d_1 = \frac{ln\frac{60}{50} + (.05 + \frac{.10^2}{2})(3)}{.10\sqrt{3}}$$

$$= \frac{.1823 + .165}{.17321}$$

$$= 2.005$$

$$d_2 = d_1 - \sigma\sqrt{t} = 2.005 - (.1)(\sqrt{3}) = 2.005 - .17321 \quad = \quad 1.8318$$

$$S = 60\,N(2.005) - (50)(.8607)\,N(1.8318)$$

$$= 60\,N(2.005) - (43.035)\,N(1.8318)$$
$$= (60)(.9775) - (43.035)(.9665)$$
$$= \$17.057 \text{ million}$$

We can now calculate the current value of the firm's debt.

$$D_t = De^{-r(t)} - p_t$$
$$= 50e^{-.05(3)} - p_t$$
$$= 43.035 - p_t$$

Based on put call parity

$$P_t = C_t + Fe^{-r(t)} - V$$
Or P_t = $17.057 + 43.035 - 60$ =   .092
       D_t = $43.035 - .092$ = $42.943 million

We can verify our calculation by adding up the market values of debt and equity and noting that we get the market value of the firm.

KMV Model

Moody's KMV approach adjusts for some of the limitations of the Merton model. The Merton Model assumes that all debt matures at the same time and the value of the firm follows a lognormal diffusion process. The KMV model assumes that there are only two debt issues. The first matures before the chosen horizon and the other matures after that horizon.

The KMV model uses a concept called *distance to default*. This is defined as the number of standard deviations by which the asset price must change in order for a default to happen in T years. The distance to default can be calculated as:

$$\frac{lnV_0 - lnD + (r - \sigma_v^2/2)T}{\sigma_v\sqrt{T}}$$

From the formula we can see that this is nothing but the value of d_2 in the Black Scholes formula. The distance to default is a proxy measure for the probability of default. As the distance to default decreases, the company becomes more likely to default. As the distance to default increases, the company becomes less likely to default. The KMV model, unlike the Merton Model does not use a normal distribution. Instead, it assumes a proprietary algorithm based on historical default rates.

Using the KMV model involves the following steps:

a) Identification of the default point, D.
b) Identification of the firm value V and volatility σ.
c) Identification of the number of standard deviation moves that would result in the firm value falling below D, thereby leading to default. This is the firm's distance to default, δ.
d) Reference to the KMV database to identify the proportion of firms with distance-to-default, δ who actually defaulted with a year. This is the expected default frequency. KMV takes D as the sum of the face value of the all short term liabilities (maturity < 1 year) and 50% of the face value of longer term liabilities.

Illustration

Consider the following figures for a company. What is the probability of default?

Book value of all liabilities   : $2.4 billion
Estimated default point, D   : $1.9 billion
Market value of equity   : $11.3 billion
Market value of firm   : $13.8 billion
Volatility of firm value   :   20%

We first calculate the distance to default.

Distance to default (in terms of value)   =   13.8 – 1.9   = $11.9 billion
Standard deviation   =   (.20) (13.8)   = $2.76 billion
Distance to default (in terms of standard deviation) = $\dfrac{11.9}{2.76}$ = 4.31

We now refer to the default database. If 3 out of 100 firms with distance to default of 4.31 actually defaulted, probability of default is .03

Illustration
Given the following figures, compute the distance to default:

Book value of liabilities	:	$5.95 billion
Estimated default point	:	$4.15 billion
Market value of equity	:	$ 12.4 billion
Market value of firm	:	$18.4 billion
Volatility of firm value	:	24%

Distance to default (in terms of value)	=	18.4 – 4.15	=	$14.25 billion
Standard deviation	=	(.24) (18.4)	=	$4.416 billion

Distance to default (in terms of standard deviation) $\dfrac{14.25}{4.416}$ = 3.23

If in the default database, 2 out of 100 firms with a distance to default of 3.23 actually defaulted, the probability of default is .02.

Reduced form models
These models assume that default events occur unexpectedly due to one or more exogenous background factors which are independent of the firm's asset value. These factors may be observable such as GDP growth, interest rates, exchange rates, inflation or unobservable. Correlations arise because these background factors affect all the exposures. Reduced form models typically assume that default follows a Poisson distribution or similar hazard rate process. Using the Poisson distribution, we can determine the number of default events occurring during a specified period of time.

Credit Risk models
Credit risk models are used by banks to calculate the credit loss for a given time horizon. The output of these models is a portfolio loss distribution which describes the potential credit losses and their probabilities. A credit loss is nothing but a decrease in the value of a portfolio over a specified period of time. To estimate credit loss, we need to establish the portfolio value today and at the end of the time horizon.

There are two conceptual approaches to measuring credit loss. In the *default mode paradigm*, a credit loss occurs only when there is an actual default. The credit loss is nothing but the difference between the exposure-at-default and the recovery value. In the *mark-to-market paradigm* a credit loss occurs if the borrower defaults or if the borrower's credit quality deteriorates.

To measure the value of the obligations, two techniques are commonly used – *discounted contractual cash flow approach* and *risk neutral valuation approach*. In the first approach, the credit spreads are used to discount cash flows. Changes in the value of the loan are the result of changes in market spreads or changes in credit rating. In case of a

default, the future value is determined by the recovery rate. In risk neutral valuation, we apply risk free rates and risk neutral probabilities.

Credit Risk Plus
The global bank, Credit Suisse[88] has developed a model for estimating default probability and Value at Risk. This model, called Credit Risk Plus, is based on actuarial, analytical techniques and does not use simulation. Credit risk is modeled on the basis of sudden events. Default rates are treated as continuous random variables.

Suppose there are N counterparties of a type and the probability of default by each counterparty is p. If we consider that there are only two possibilities – default or no default and apply the binomial distribution, the mean number of defaults, μ, for the whole portfolio is Np. If p is small, the probability of n defaults is given by the Poisson distribution, i.e, the following equation:

$$p\,(n) \quad = \quad \frac{e^{-\mu}\mu^{n}}{n!}$$

The next step is to specify the recovery rate for each exposure. Then the distribution of losses in the portfolio can be estimated.

Credit Risk + allows only two outcomes – default and no default. In case of default, the loss is of a fixed size. The probability of default depends on credit rating, risk factors and the sensitivity of the counterparty to the risk factors. Once the probability of default is computed for all the counterparties, the distribution of the total number of defaults in the portfolio can be obtained. When the probability of default is multiplied successively by exposure at default and loss given default, we get the credit loss.

Through the use of sector analysis, Credit Risk Plus can measure the impact of concentration risks and the benefits which can be obtained through diversification.

Credit Metrics
Credit Metrics, another popular model, has been developed by J P Morgan. Unlike Credit Risk Plus, this model does not view credit risk as a binary situation. Instead, Credit Metrics tries to determine the probability of a company moving from one rating category to another during a certain period of time.

Credit Metrics first estimates the rating class for a debt claim. The rating may remain the same, improve or deteriorate, depending on the firm's performance. A ratings transition matrix, usually provided by the rating agencies, gives us the probability of the credit migrating from one rating to another during one year.

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[88] The subsidiary of Credit Suisse, Credit Suisse First Boston pioneered this model.

Exhibit 6.5
Largest CRAs Global Structured Finance 1 Year Transition Rates

%	2007			2008		
	Downgrade	**Upgrade**	**Stable**	**Downgrade**	**Upgrade**	**Stable**
AAA	1.0	n/a	99.0	23.4	0.0	76.6
AA	4.4	3.5	92.1	34.9	1.8	63.3
A	11.3	4.2	83.9	36.9	2.1	61.0
BBB	20.2	2.9	77.0	40.2	1.0	58.1
BB	21.0	2.3	76.6	44.8	1.7	53.9
B	11.1	1.8	87.1	55.5	1.3	43.5
CCC	34.9	0.7	32.7	78.5	1.0	21.4

CCC figures for 2007 may not add to 100% because transitions to default are excluded.

Source: 1991-2006 & 2007 figures are average from Fitch Ratings, Moody's Investors Services and S&P, while the 2008 figures are for S&P only.

Ref: The Turner Review - A regulatory response to the global banking crisis, published by: UK Financial Services Authority, www.fsa.gov.uk/pubs/other/turner_review; March 2009.

Next, we construct the distribution of the value of the debt claim. We compute the value we expect the claim to have for each rating in one year. Based on the term structure of bond yields for each rating category, we can get today's price of a zero coupon bond for a forward contract to mature in one year. If the bond defaults, we assume a recovery rate. If the migration probabilities are independent, we can compute the probabilities for the transition of each bond independently and multiply them to obtain the joint probability. By computing the value of the portfolio for each possible outcome and the probability of each outcome, we can construct the distribution for the portfolio value. We can then find out the VAR at a given level of confidence.

But in general, while determining credit losses, the credit rating changes for different counterparties cannot be assumed to be independent. A *Gaussian Copula Model* comes in useful here. Gaussian Copula allows us to construct a joint probability distribution of rating changes. The Copula correlation between the ratings transitions for two companies is typically set equal to the correlation between their equity returns using a factor model. A brief explanation of the rationale behind this approach follows.

The historical record of rating migration can be used to estimate the different joint probabilities. However, this approach is often not enough. Credit Metrics proposes an approach based on stock returns. Using the rating transition matrix, we know the probability of the firm migrating to different credit ratings. We use the distribution of the company's stock returns to find out the ranges of returns that correspond to the various ratings. We can produce stock returns corresponding to the various rating outcomes for each firm represented in the portfolio. In short, the correlations between stock returns can be used to compute the probabilities of various rating outcomes for the credits. For example, if we have two stocks we can work out the probability that one stock will be in

the A rating category and other in AAA category. When a large number of credits is involved, a factor model can be used.

Correlations and Gaussian Copula

A more detailed explanation of the Gaussian Copula is in order here. But before that, we need to delve into the world of correlations. In credit risk management, correlations are extremely important. During a crisis, default correlations across instruments tend to increase. This is essentially because the underlying factors are the same. In the same industry, many companies may default simultaneously. More generally, if a market participant has exposure to two different market variables, the total exposure will be very high when there is a strong positive correlation. The exposure will be far less when there is a zero correlation and would actually decrease if there is a negative correlation.

In credit risk management, correlations have to be monitored as closely and systematically as volatility in case of market risk management. The coefficient of correlation between two variables x, y can be written as: $\dfrac{\dfrac{1}{n}\sum xy - \bar{x}\,\bar{y}}{\sigma_x \sigma_y}$

The covariance between x and y can be written as: $\dfrac{1}{n}\sum xy - \bar{x}\,\bar{y}$. In other words, the correlation coefficient is nothing but the covariance divided by the product of the two standard deviations.

While the coefficient of correlation is a useful parameter, it does not tell us the full story. It measures only the linear dependence between two variables. We need other parameters to understand the non linear dependence. This is where copulas come in handy. We will come to copulas a little later.

Let us get back to covariance. How do we compute covariance? Let us define the covariance of daily returns per day between two variables, x, y. If x_i, y_i are the values of the two variables at the end of day i, the returns on day i are $\dfrac{x_i - x_{i-1}}{x_{i-1}}$ and $\dfrac{y_i - y_{i-1}}{y_{i-1}}$. The covariance between x, y is $\dfrac{1}{n}\sum x_n y_n - \bar{x}_n\,\bar{y}_n$. If we assume the expected daily returns are zero, the same assumption we made while calculating volatility, $Cov_n = \dfrac{1}{n}\sum x_n y_n$. The variances of x_n and y_n are $\dfrac{1}{n}\sum x_n^2$ and $\dfrac{1}{n}\sum y_n^2$.

As in the case of volatility, we can use an exponentially weighted moving average model to get updated values of the covariance. $Cov_n = \lambda Cov_{n-1} + (1-\lambda)\, x_{n-1}\, y_{n-1}$.

We could also use a GARCH model to estimate the covariance. If we use a GARCH model, we could write: $Cov_n = \gamma + \alpha x_{n-1} y_{n-1} + \beta Cov_{n-1}$.

It is important that variances and covariances are calculated consistently. For example, if variances are calculated by giving equal weight to the last *m* data points, the same should be done for covariances. If we use an EWMA (Exponentially Weighted Moving Average) model, the same λ should be used for variances and covariances.

Now we are ready to discuss copulas. Let us say there are two variables V_1, V_2, which are not completely independent. The marginal distribution of V_1 is its distribution assuming we know nothing about V_2. The marginal distribution of V_2 is its distribution assuming we know nothing about V_1.

Country risk management at UBS

Credit risk and country risk are closely related. UBS assigns ratings to all countries to which it has exposure. Sovereign ratings express the probability of occurrence of a country risk event that would lead to impairment of UBS's claims.

For all countries rated three and below, UBS sets country risk ceilings for all exposures to clients, counterparties or issuers of securities from the country, and to financial investments in that country. Country risk measures cover both cross-border transactions and investments, and local operations by UBS branches and subsidiaries in countries where the risk is material. Extension of credit, transactions in traded products and positions in securities may be denied on the basis of a country ceiling, even if exposure to the name is otherwise acceptable.

Counterparty defaults resulting from multiple insolvencies or general prevention of payments by authorities are the most significant effects of a country crisis. But UBS also considers the probable financial impact of market disruptions arising prior to, during and following a country crisis. These might take the form of severe falls in the country's markets and asset prices, longer-term devaluation of the currency, and potential immobilization of currency balances. The potential financial impact of severe emerging markets crises is assessed by stress testing.

UBS also considers the possibility of restrictions on, cross-border transfers of funds which might prevent a liquidity surplus in one country being used to meet a shortfall in another. Unexpected economic stress situations or sovereign defaults, might induce a government to limit or prohibit the transfer of funds outside the country. UBS assesses the potential impact on its liquidity position of potential transfer risk events in countries with a one-year probability of default of 5% or more as indicated by UBS's internal sovereign rating.

Emerging markets exposure by UBS internal rating category
In %
On 31.12.08

25   75

- Investment grade
- Sub-investment grade
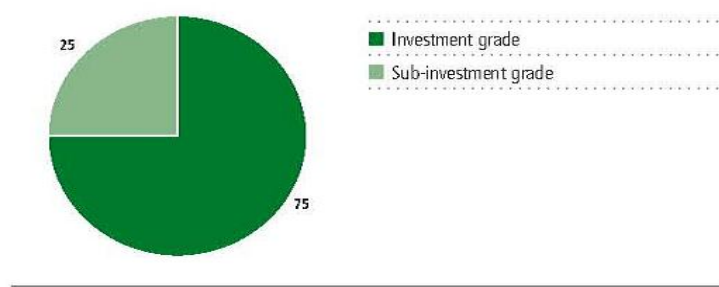
Source: UBS Annual Report, 2008

How do we establish the correlation structure between V_1 & V_2? If the two marginal distributions are normal, we can assume that the joint distribution of the two variables is also normal. But when the marginal distributions are not normal, we run into a problem. So we use the Gaussian Copula. We map V_1 into U_1 and V_2 into U_2 such that U_1 and U_2 are normal variables. To elaborate, the 1 percentile point of the V_1 distribution is mapped to the 1 percentile point of the U_1 distribution and so on. Similar mapping is done between V_2 and U_2. Thus copulas enable us to define a correlation structure between V_1 and V_2 indirectly. Copulas can also be used to establish the correlation structure between more than two variables. Lastly, instead of the Gaussian copula, we could also use the *t* Copula. As the name suggests, the variables U_1, U_2 are now assumed to have a bivariate *t* distribution.

Credit Risk Capital: Basle II framework
One of the key objectives of any risk measurement exercise is to understand how much capital must be set aside. Three different approaches are available to calculate the credit risk capital under Basel II norms. We shall cover this topic in more detail in a separate chapter. What follows here is a brief account.

Standardised approach
In the standardized approach, the risk weights are determined on the basis of ratings provided by an external credit rating agency. Fixed risk weights are used corresponding to the degree of risk in each asset category. Basel I had only five weights. Basle II is more granular with 13 categories of risk weights ranging from 20 to 150% depending on the type of counterparty and rating status. In such cases as low rated securitized assets, the weights can go up to 350%.

Internal Ratings Based approach
Here, banks can use their own estimates of credit risk. The exposures are categorized into six broad classes of assets – corporate, sovereign, bank, retail, equity and purchased receivables. Within the corporate asset class, five sub classes of specialized lending have been separately identified. Similarly in case of retail assets, there are three sub classes of exposures - exposures secured by residential properties, qualifying revolving retail exposures and all other retail exposures.

IRB is divided into two categories – *Foundation* and *Advanced*.
- Under the Foundation approach, banks estimate the probability of default and rely on supervisory estimates for other risk components.
- In the advanced method, banks provide their own estimates of probability of default, loss given default and exposure at default. To use the IRB approach, banks must meet various criteria laid down by the regulatory authorities.

Credit derivatives
On paper, banks manage their credit risk through diversification. But there are limits to diversification. For example, banks may not like to turn down customers with whom they have a valuable relationship even if the exposure has crossed prudent limits. Assignment

of loans to another counterparty is also not that easy. Customers may not like their loans being sold off by the bank to another entity. Due to these reasons, the concentration of credit risk on the banking books is often much higher than desirable.

Credit derivatives have emerged to deal with such problems. *In simple terms, a credit derivative can be defined as an instrument that allows one party to transfer an asset's credit risk to another party without passing on the ownership of the asset.* The two parties in a credit derivative transaction are the *protection buyer* who pays a premium and *protection seller* who stands ready to provide compensation in case of a credit event. The instrument or group of instruments with respect to which the credit risk is being traded is called *referenced obligation*. The reference obligation is sometimes called reference asset or reference credit. Credit derivatives till now have been privately negotiated, over-the-counter (OTC) instruments. But now there are proposals from regulatory authorities in the US and Europe to establish central clearing arrangements for various OTC derivatives.

Thanks to credit derivatives, banks can continue to make loans and hedge the risks involved. At the same time, the counterparty which goes short on the credit derivative can gain access to an exposure which seems to make business sense. Indeed, credit derivatives can be used to create almost any desired risk profile. Say the bank is fine with the credit exposure to a specific client but is worried about a downturn in the industry. A suitable credit derivative can be structured. Credit derivatives also help in increasing the liquidity for banks. By limiting the bank's downside risk, banks will be more willing to lend more to many businesses. This will ensure healthy growth of credit, so vital to maintain economic growth.

From a systemic point of view, credit derivatives represent an efficient way of separating and trading credit risk by isolating it from other risks such as market risk and operational risk. Thanks to the International Swaps & Derivatives Association, ISDA, credit default agreements have become standardized. So buying and selling credit protection has become easy and straightforward.

Credit derivatives also have a useful signaling value. They provide an additional source of market based information about the company's financial health. There is an argument that Credit Default Swap (CDS) prices because they are market determined convey better information about the probability of default, than credit ratings which only reflect the views of an agency.

Credit derivatives support market completion by providing access to credit exposure in ways that would not have been possible otherwise. For example, a bank may not actually lend to a company but by going short on the CDS, it can assume an equivalent risk exposure. And even if a company's bonds are not traded, synthetic exposures can be created.

Credit derivatives have also helped in the integration of different segments of financial markets. For example, the dividing line between bonds and loans has become considerably thinner, thanks to CDS.

The rise and fall of credit derivatives
The origin of OTC credit derivatives can be traced back to bond insurance which involves compensation in the event of a default. Bond insurance has been around for several decades now, but credit derivatives have become popular only in the past 15 years or so. In 1993, transactions began to be structured which involved a periodic fee payment by the banks. Investors would pay compensation in case of a credit event. The first synthetic credit derivatives product was launched by J P Morgan in 1997. The outstanding notional value of credit derivatives grew from $180 million in 1997 to more than $1 trillion in 2001, reaching $5 trillion at the end of 2004. The credit derivatives market exploded in the build up to the sub prime crisis, reaching a notional value of $62 trillion at the peak. Since then due to netting and "trade compression," the value has come down. But even now the figure is significant.

Credit derivatives played an important role in the subprime crisis. AIG collapsed due to huge credit default swap positions it built on its books. Not surprisingly regulators and economists have expressed deep concerns about the indiscriminate use of credit derivatives. Rather than segregate and transfer credit risk, economists argue that these instruments seem to have added to the systemic risk. Let us understand the basis for these concerns.

Banks which lend to clients but offload their credit risk by purchasing credit derivatives, have little incentive to monitor their clients, even though they are the best equipped to do so in several respects. This has a negative impact on the way credit risk is managed at a system level. The protection seller in a CDS may have the motivation but is not as well equipped as the bank to monitor credit risk. The net effect is less monitoring oversight than what is desirable. It also leads to the moral hazard problem as far as borrowers are concerned. When they know that they are not being actively monitored, borrowers can afford to indulge in imprudent risk taking.

In the case of Enron, which went bankrupt in a spectacular way, JP Morgan Chase, Citigroup and other banks had lent billions of dollars. But they had simultaneously used credit derivatives to limit their credit exposure. According to one estimates, the banks used 800 swaps to lay off $8 billion of Enron risk.

Another perverse incentive which seems to have developed is that buyers of CDS on a company's bonds may be more keen on the company filing for bankruptcy rather than reviving it during a crisis. The CDS compensation is likely to be received immediately whereas restructuring initiatives are long drawn out, cumbersome and uncertain in terms of outcome. In other words, CDS buyers actually have a strong incentive to support value destruction. This phenomenon has by no means been uncommon in the aftermath of the sub prime crisis as many companies have run into trouble.

The CDS markets have also been heavily criticized for their opaqueness. The markets are of the OTC type and unregulated. So the quality of disclosure by the players involved is clearly not adequate. Moreover, a party can unwind its position by offloading it to another counterparty without informing the original counterparty. As Frank Partnoy & David Skeel mention[89], "If suppliers, bond holders or other stakeholders do not know whether the bank is hedged, the informational content of the bank's actions will be muddied. This uncertainty is itself an important cost of the credit default swap market."

Many investors place highly leveraged bets on CDS. So even a relatively small change in the market position can trigger a crisis. If there is a rush by market participants to unwind a vast array of interconnected contracts, there would be a serious liquidity crisis. Such concerns were serious when Bear Stearns and Lehman Brothers approached bankruptcy. That also probably explains why the US Treasury was desperate to save AIG.

Credit derivatives are relatively less liquid instruments compared to currency or interest rate derivatives. This is because of the unique nature of individual reference credits. Because of the lack of liquidity, the protection sellers can face problems if they try to hedge their derivative position. In many situations, the credit derivative may also be vulnerable to basis risk. There may be an imperfect correlation between the reference obligation and the underlying risk.

In case of Collateralised Debt Obligations (CDOs), there is another serious problem – the mispricing of credit. Similar assets should have similar values. If CDOs are able to create value by repackaging assets, it means there must be some inefficiencies in the corporate debt market. But this mispricing should logically be removed by the buying and selling of bonds. Arbitraging opportunities rarely persist unless there is an information asymmetry or a regulatory issue. The investors in CDO tranches are usually sophisticated people. And there is no regulatory explanation that can be offered for synthetic CDOs.

What seems to be the case is that the complex arbitrary and opaque rating methodologies create arbitrage opportunities without actually adding any real value. In short the "value" may be the result of errors in rating the assets, errors in calculating the relationship between the assets and the tranche payouts or errors in rating the individual CDO tranches.

As Partnoy & Skeel mention[90], "Put another way, credit rating agencies are providing the markets with an opportunity to arbitrage the credit rating agencies' mistakes… The process of rating CDOs becomes a mathematical game that smart bankers know they can win. A person who understands the details of the model can tweak the inputs, assumptions and underlying assets to produce a CDO that appears to add value, even though in reality it does not." In other words, there is a very strong argument emerging

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[89] "The promise and perils of credit derivatives," Working Paper, University of San Diego School of Law.
[90] "The promise and perils of credit derivatives," Working Paper, University of San Diego School of Law.

that CDOs have been used to convert existing fixed income instruments that are priced correctly into new ones that are overvalued.

Types of credit derivatives
The term credit derivatives may have been coined in recent decades. But many traditional instruments have carried features of credit derivatives. For example, letters of credit guarantee payment in case of a default. But credit derivatives, as we know them today, differ significantly from these traditional instruments. Let us understand some of the key features of credit derivatives. In general, credit derivatives can be classified on the basis of:

- *Underlying credit* – single entity or a group of entities
- *Conditions of exercise* – default, rating downgrade, increase in credit spread.
- *Pay off function* – fixed amount, linear pay off, non linear pay off.

In a *single name CDS*, the contract is between a protection buyer and a protection seller. In a *basket CDS*, there is a portfolio of assets. In a *first to default CDS*, compensation is payable after the first default. The structure is terminated after the first event. In an nth *to default CDS*, the pay off occurs only when the nth default happens. In a *standard basket CDS*, compensation is payable for each and every default.

The key factor in determining the spread for a basket CDS is the default correlation of the reference entitles in the basket. If the default correlation between the reference entities is zero, the probability of multiple defaults will be very low. In other words, the value of a first-to-default CDS will be significantly higher than that of say a 10th-to-default CDS. On the other hand, if the default correlation among the reference entities is perfect, either all the reference entities will default or none will default. In such a case, a first-to-default and an 10th-to-default CDS will have the same value.

The conditions of exercise depend on how the credit events are defined. Credit events can be default, bankruptcy, failure to pay, restructuring, widening of credit spread, etc.

The pay off is usually linked to the amount that cannot be recovered. This is often measured by par value – price of the bond after the credit event. Alternatively the protection buyer can hand over the reference asset to the protection seller and receive a cash payment equal to the par value. Finally, a credit derivative may also be structured with a binary payout. This means in case of a credit event, the payment is fixed and independent of the actual impairment.

Credit Default Swaps
We have already been referring to Credit Default Swaps (CDS) in this Chapter. Now, it is time to understand CDS in more detail. In many ways, the CDS is the simplest form of credit derivative. It is also by far the most popular credit derivative. In a CDS, one party sells protection against default on an underlying instrument to another party. Unlike insurance contracts, the two parties involved in a CDS may have nothing to do with the reference entity. In other words, the parties may be betting on the probability of default

of an instrument issued by a third party. It is precisely because of this element of speculation, that the CDS market hit $62 trillion in notional value at its peak. (In the past 18 months, however, the market has shrunk significantly due to offsetting of contracts.)

The protection buyer pays a premium while the protection seller stands ready to compensate the buyer in case of a credit event. As mentioned earlier, the compensation may be fixed or variable. Variable compensation may be either in cash or payment of face value against the receipt of the underlying bond. Cash settlement is preferred when transfer of the ownership of the obligation is difficult. On the other hand, the protection seller may prefer physical settlement if this enables direct interaction with the bankrupt entity during post default negotiations. The protection buyer too may prefer this arrangement as the payment is transparent and not subject to any uncertainty or dispute about the exact recovery value of the underlying asset.

CDS is certainly a form of credit insurance. But it does not eliminate credit risk. All that happens is that exposure to the underlying credit is replaced by that to the protection seller. The effectiveness of CDS as a credit insurance mechanism implicitly assumes a low correlation between the default risk of the underlying credit and the protection seller.

Let us briefly understand the important terms used in the context of CDS:

- The premium amount paid by the protection buyer, as a percentage of the notional principal is called the *CDS spread*. The premium is often expressed as basis points. The premium can also be a lumpsum amount.
- The *reference entity* is defined as the entity on which the protection is bought and sold.
- A *credit event* is defined as the situation that will trigger the payment of compensation by the protection seller to the protection buyer.
- The three most important credit events are *bankruptcy*, *failure to pay* and *restructuring*.
- In case of a credit event, the purchaser of the CDS can sell a bond issued by the reference entity to the seller of the CDS and receive the par value. This bond is called the *reference obligation*.
- The par value of the reference obligation is termed as the swap's *notional principal*.
- Alternatively, *cash* compensation is possible. The protection seller can pay the difference between the reference obligation's par and market value.

A CDS can be unwound in three ways.
- The counterparties can exchange the current market-to-market value. All the future cash flow streams are cancelled. The ongoing legal risk is eliminated.

- The second way to unwind a CDS is to replace the current investor by a new counterparty. Assignment will be subject to the protection buyer agreeing to take on the counterparty risk of the protection seller.

- The third way to unwind a CDS is through an offsetting transaction. An offsetting long or short protection can be entered into with another counterparty. But such an unwinding involves signing of further documentation and adds to legal risk. Where the position is illiquid and assignment is not possible, this kind of unwinding may make sense. Intuitively, the mark-to-market value of a CDS is equal to the cost of entering into an offsetting transaction.

Other variations of CDS

An *asset default swap* is essentially a single name CDS where the underlying reference is an asset backed security.

In an *equity default, swap,* compensation is payable if the stock value falls below a pre specified level.

A *callable default swap* is a CDS that can be terminated by the protection buyer at some strike spread at a future date. Thus it is nothing but a CDS with an embedded short receiver option. Effectively, this means the protection buyer has the right to "sell back" to the protection seller. The protection buyer will be motivated to do so if there is sufficient spread tightening. This way, the protection buyer can avoid paying what looks like a high premium, going by the current market scenario. In return for this facility, the callable default swap spread tends to be higher.

A *total rate of return swap* (TRORS) is another way of transferring credit risk. One party passes on the total return on a security, in exchange for a fixed return calculated as LIBOR plus some spread. The cash flows are exchanged on specific payment dates. At the end of the swap, the accumulated gain or loss in the value of the security is exchanged. The different elements of a TRORS are *reference asset*, *total return payer* and *total return receiver*. If the underlying asset is a portfolio of bonds owned by the total return payer, the payer transfers the credit risk of the portfolio to the total return receiver. If the credit quality of the portfolio deteriorates, and there are capital losses, the receiver will bear the loss.

The reference asset may be a bond, index or basket of assets. Usually, it is a widely quoted and traded bond. The total return payer is the legal owner of the reference asset. The payer pays the total income from the reference asset in return for a floating rate of interest. The total return receiver derives the economic benefit of owning the reference asset without actually holding the asset on the balance sheet. The total return includes interest/dividends, gains/losses due to market movements and credit losses. There is no exchange of the notional principal of the swap. But if the reference asset is amortised over the life of the swap, the notional principal is reduced accordingly. TRORS are sometimes collateralized and marked-to-market daily. The cash flows may be exchanged periodically or at maturity.

Any increase or decrease in the value of the asset leads to cash flows. If the asset has increased in value, the total return payer must pass on the increase in value to the total return receiver. If the asset has decreased in value, the total return receiver must

compensate the total return payer. In case of a default, the TRORS terminates and the total return receiver must pay compensation.

Special purpose vehicles and CDOs

Collateralised Debt Obligation (CDO) is the general term for an asset backed security that issues securities and pays principal and interest from an underlying pool of debt instruments. If the underlying pool consists entirely of bonds, it called a Collateralised Bond Obligation (CBO). If it consists only of loans, it is called Collateralized Loan Obligation (CLO).

CDOs are used to repackage securities to create structured products with a completely different risk complexion, compared to the underlying debt instruments. CDOs are divided into tranches with different degrees of certainty regarding payments and consequently different credit ratings. The tranche with the lowest credit rating is called the *equity tranche*. The highest credit rated tranche is referred to as *senior or super senior*. In between there are *mezzanine tranches*. Usually, the originator of the CDO retains the equity tranche.

In a *balance sheet CDO*, the main motivation is to remove selected assets from the balance sheet to manage credit risk, improve liquidity, etc. *Arbitrage CDOs* focus on creating structured products that take advantage of the spread between assets in the pool and the promised payments to security holders. Whereas balance sheet CDOs tend to be "static," arbitrage CDOs are managed actively. *Cash flow arbitrage CDOs* depend primarily on cash flows from the underlying pool of assets to discharge the obligations towards investors. *Market value arbitrage CDOs* sell securities in the pool from time to time to meet the obligations towards investors. The degree of active management has an impact on the legal and accounting aspects of the CDO.

Many structured credit products can be created through securitization. A special purpose vehicle (SPV) often substitutes the investment bank. The SPV is a legal trust that purchases and holds the notes as collateral and simultaneously enters into a CDS as a protection seller. The SPV issues securities to investors.

In a synthetic CDO, the money collected is invested in risk free instruments. At the same time, a portfolio of CDS is sold to third parties. In the absence of a credit event, the SPV makes the coupon payment as well as the premium on CDS to investors. After a credit event is triggered, the SPV liquidates the notes. First the CDS protection buyers are taken care of. Then the remainder is distributed to the shareholders.

In a synthetic CDO, unlike cash CDO, assets are retained by the sponsoring organization. They are not transferred to the SPV. The performance of a synthetic CDO is not linked to an underlying revenue stream but to a reference portfolio of assets. Referencing a portfolio can be done through a CDS, total return of rate swap or credit linked note. Unless stated specifically, a synthetic CDO normally uses CDS to transfer risk.

Essentially, in a synthetic CDO, CDS and government bonds are combined to substitute corporate loans as the assets in the SPV. The premium from the CDS and the interest earned on risk free securities are paid to investors in a way that reflects the risk they are bearing. When the CDS is triggered, the asset value is reduced. The pay off for the lower tranches depends on the amortizing rate of the assets, which is determined by the number of CDSs triggered.

The market has standard definitions of CDO tranches. So individual tranche trading is also possible. A Single Tranche CDO, (STCDO) is a contract between two parties on a particular tranche of a synthetic CDO on a standalone basis. In a single tranche, one side sells protection against losses on a tranche and the other side agrees to buy the protection. If the correlation between the CDO assets is low, the equity tranche will be very risky. But the senior tranches will be relatively safe. On the other hand when the correlation is perfect, all the tranches will be equally risky. It is clear that during the sub prime crisis, correlations turned out to be higher than expected. Banks such as UBS got into big trouble with their super senior tranches.

We need to differentiate between corporate CDS and ABS (Asset Backed Securities) CDS. In the corporate market, the focus is on the corporate entity. Less emphasis is placed on the credit's individual obligations. In the ABS market, the focus is on a specific instrument typically a particular tranche from a particular securitization of a particular originator.

In case of corporate CDS, the usual practice is for all obligations of a seniority to be reference obligations. In the corporate CDS market, it does not much matter which senior unsecured obligation is tendered for physical settlement or marked to market for cash settlement. In the case of ABS CDO, each tranche has a distinct credit quality and a distinct credit rating. ABS CDS focus on the specific tranche.

The credit problem in case of a corporate CDS is clearly defined. Credit events are easily discernable. On the other hand, credit problems in ABS securitization are not that clearly defined. The flexibility of an ABS tranche's cash flows means that the existence or extent of a credit problem is ambiguous. Problems may resolve themselves. They will usually not rise to the same level of distress as a defined credit event in a corporate CDS. Many ABS tranches stipulate deferment of interest payments if collateral cash flow is insufficient due to delinquencies and defaults. Later, if cash flow recovers, deferred interest can be made up.

Credit spread Forward

The protection buyer and protection seller agree to a credit spread. The buyer receives the difference between the credit spread at maturity and an agreed – upon spread, if positive. On the other hand, if the difference is negative, a payment is made. If i is the prevailing spread and r is the agreed upon spread and the modified duration is D, then the compensation payable to the buyer is given by:

Compensation = (i - r) (D) (Notional amount).

Credit spread options

Credit-spread options are options on asset swaps. They are used to hedge against the risk of changes in credit spreads. A reference asset is selected and a strike spread and maturity are set. The pay off depends on whether the actual spot spread on the exercise date is above or below the spread on the reference security. The credit spread can be relative to a risk free instrument or any other bond. Credit spread options may be of the European or American type.

The buyer of a call option has the right to buy the spread at a pre specified strike price. Such an option has value if the spread at exercise is greater than the specified strike spread. The buyer of a credit spread put option has the right to sell the spread at a pre specified strike price on the exercise date. The option has value if the spread at exercise is less than the strike spread.

Credit Swaptions

A credit swaption involves payment streams that are contingent on the occurrence of a credit event. A swaption is nothing but an option on a swap. The holder of a swaption can enter into a swap with a pre specified fixed payment stream over a specified period of time.

A credit swaption can be an option to buy or sell credit protection at a pre specified CDS strike spread. The underlying is the forward CDS spread from the option expiry date to the maturity date of the CDS. A swaption can be European, American or Bermudan. In a *payer default swaption*, there is a right to buy the protection. The option holder benefits if the spread widens sufficiently enough by the maturity date. The *receiver default swaption* confers the right to sell protection. The option holder benefits if the spread tightens sufficiently enough by the maturity date. A credit default swaption can also be structured with a provision for a knockout. If there is a credit event between the trade date and the expiry date, the knock out provision cancels the default swaption with immediate effect. The payer default swaption buyer will have the right to buy the protection at the strike spread. In case of a receiver default swaption, the reference spread would widen and the option would not be exercised after a credit event. So a knock out provision is not needed.

Credit default swaptions may be structured such that the underlying asset is a credit index. This may be preferred if the investor wants to take a macro view as opposed to a view on a specific credit. Portfolio volatility also tends to be lower.

Credit linked note

A credit linked note (CLN) is a funded credit derivative. Features of the derivative are embedded in a generic cash instrument. Typically, a CLN combines a credit derivative with a regular bond. The credit risk is transferred through the issue of bonds either directly by the protection buyer or by a Special Purpose Vehicle (SPV).The investor is the credit protection seller while the issuer of the note is the protection buyer. The investor/protection seller pays up front the par value of the bond and receives interest payments at LIBOR plus a spread. In case of a credit event, the investor will receive the recovery value of the underlying asset in the CDS and lose claim over the principal. Or to put it differently, the investor will receive the principal less the amount that cannot be recovered.

A true credit derivative CLN has a third party as reference name. The settlement process is similar to that of CDS. The protection buyer, in case of a cash settlement, will pay the recovery value to the protection seller. In case of physical settlement, the note is terminated. The reference security is handed over to the protection seller.

Some CLNs may be issued by a party which is also the reference name. The occurrence of a credit event implies immediate termination of the bond. No settlement process is needed because the protection seller is already holding the bond.

A standard CLN is issued with reference to a specific bond. A CLN that is referenced to more than one credit is called *basket credit linked note*. A variant of the basket CLN is the *first-to-default CLN*, in which the investor is selling protection on the first credit-to-default. The return on the CLN is a multiple of the average spread of the basket. In a physical settlement, the defaulted asset is delivered to the bond holder. In cash settlement, the CLN issuer pays redemption proceeds to the bond holder. This is nothing but the difference between the principal and recovery value.

Synthetic CLN can be issued by a SPV that holds collateral securities financed by the issue. The SPV uses the issue proceeds to purchase the collateral and then sells credit protection to a counterparty. The SPV also provides interest on the collateral against the SPV's future performance under the CDS. The SPV may also enter into an interest rate swap to modify cash flows suitably. For example, the cash flows on the collateral may be fixed rate but the CLN cash flows may be required in floating rate form.

The CLN coupon is the sum of the returns on the collateral and the CDS premium. Investors in the CLN receive their coupon and principal at the time of redemption in the absence of any credit event. If a credit event happens during the life of the CLN, the collateral is sold to form the par payment made by the SPV to the CDS counterparty. The CLN is redeemed by the issuer at zero percent. Accrued interest payments from the collateral/CDS premium form an accrued CLN coupon which the investor receives.

The CDS counterparty is only eligible for 100% of the notional amount. Excess value of the collateral belongs to the investors. If the collateral has lower than market value, the CDS counterparty receives the compensation. The counterparty reduces the amount of defaultable obligations it delivers. When the market value of the collateral falls sharply, the investor loses the entire notional value of the CLN. The CDS counterparty will also suffer a loss.

The collateral provides a base return to the investors and acts as a collateral for the CDS counterparty. So the collateral must be acceptable to both the parties. The collateral should be chosen such that the probability of things going wrong with the reference entity and collateral, simultaneously is minimized.

In general, the CLN investors are exposed to three kinds of risk:
- Credit risk of the reference entity
- Credit risk associated with the securities making up the collateral
- Counterparty risk associated with the protection buyer.

If the collateral is highly rated and the CDS counterparty is highly rated, the focus shifts to the credit risk of the reference entity. When the SPV uses interest rate swaps to modify the cash flows, there is an additional source of risk.

Effectively, CLNs give investors an opportunity to exploit anomalies in pricing between the cash and credit protection markets. CLNs enable investors to customize their exposure with respect to currencies, maturities and coupon structures. CLNs can be traded in the same way as bonds. But CLNs lack liquidity, when compared to bonds. Moreover, there are fixed costs associated with the creation of the SPV and the various aspects of the CLN. So CLNs may make more sense for medium term rather than short term investors.

A good example of CLN use is Citigroup which had considerable exposure to Enron in 2000. Though Enron at that time was flying high, Citigroup decided to hedge the exposure using securities which resembled credit linked notes. Citi created a trust which issued the securities in the form of five year notes with interest payments. The proceeds were invested in high quality debt. If Enron did not go bankrupt, investors would receive the principal after 5 years. In the event of bankruptcy, Citi could swap the loan it had made to Enron, for the securities in the trust.

Conclusion
Credit risk management is more complex compared to market risk management with regard to data availability and modeling. Credit risk is also firm specific unlike market risk. Is this chapter, we have tried to understand the basic principles of measuring credit risk. We have also seen how credit risk can be managed using credit derivatives. As financial instruments become more and more complex and specialized, the distinction between market and credit risk is becoming increasingly blurred. We shall examine this theme in more detail in a later chapter.

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Chapter - 7
Managing Operational Risk

"Operational risk is a daily and continuous 24 X 7 X 365 process. A way of life. Not an event or a meeting at the end of the quarter. Each person and stakeholder at you organization or institution is responsible for it and should live each day embracing it[91]."

Introduction

Operational Risk Management has become increasingly important in recent years. Many of the big scams of the past two decades including Barings, have been due to the failure of Operational Risk Management. In an increasingly complex and volatile business environment, organizations are realizing the importance of robust systems, processes and controls to ensure that human errors and fraud do not occur. The management of operational risk has received added impetus thanks to regulators. The Sorbanes Oxley Act enacted in the US in 2002, after the collapse of Enron has put pressure on organizations to strengthen their approach towards operational risk management. The Act requires boards of directors to become much more involved with day-to-day operations. They must monitor internal controls to ensure that risks are being assessed and handled well. Meanwhile, Basle II has come up with detailed guidelines for identifying and measuring operational risk.

In this chapter, we try to understand the sources of operational risk, how it can be measured and the risk mitigation techniques which can be applied.

Understanding Operational Risk

Operational risk can be defined as the risk of loss due to inadequate or failed internal processes, people, systems or external events. Some operational risks directly affect the financial performance of the organization. Others do so by interacting with credit and market and other risks.

The nature of operational risk is somewhat different from that of market or credit risk. (See Exhibit 1.1). Banks make a conscious decision to take a certain amount of credit and market risk. Operational risk, by contrast, is a necessary part of doing business. More often than not, operational risks are "inherent" not "chosen." The only way to avoid operational risk is by exiting the business!

It is much more difficult to identify, quantify and manage operational risk than credit or market risk. Data on operational risk is not exhaustive. Most banks are still in the process of collecting data. Developing statistical models for operational risk is thus challenging.

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[91] Operationalrisk.blogspot.com

Exhibit 7.1
Market, Credit & Operational Risks: A quick comparison[92]

Step	Market Risk	Credit Risk	Operational Risk
Risk categories	• Interest rate • Equity • Currency • Commodity	• Default • Downgrade	• Processes • People • Systems • External events
Risk factors	• Volatility • Correlations	• Default and recovery distributions • Correlation	• Loss frequency
Risk measurement	• Market VAR	• Credit VAR • Expected loss	• Operational VAR • Expected loss

Identifying operational risk

As mentioned earlier, operational risks are not consciously taken. But they invariably arise in the course of conducting business activities. The key challenge is often to identify and anticipate the various kinds of operational risk that may arise. The Basle committee has provided a useful framework in this regard.

Internal fraud: Examples include intentional misreporting of trading positions, employee theft, and insider trading on an employee's own account. This risk is considered *low frequency, high severity*.

External fraud: Examples include computer hacking, robbery and forgery. This risk is considered *high/medium frequency, low/medium severity*.

Employment practices and workplace safety: Examples include worker compensation claims and sexual discrimination claims. This risk is considered *low frequency, low severity*.

Clients, products, and business practices: Examples include fiduciary breaches, misuse of confidential customer information, improper trading activities on the bank's account and money laundering. This risk is considered *low/medium frequency and high/medium severity*.

Damage to physical assets: Examples include earthquakes, fires and floods. This risk is considered *low frequency/low severity*.

Business disruption and system failures: Examples include hardware and software failures, telecommunication problems, and utility outages. This risk is considered *low frequency/low severity*.

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[92] Draws from Philip Jorion's book "Value at Risk – The New Benchmark for Managing Financial Risk," *McGraw Hill,* 2007, p. 497.

Execution, delivery and process management: Examples include data entry errors, collateral management failures, incomplete legal documentation, unapproved access given to clients' accounts. This risk is considered *high frequency, low severity*.

These seven distinct types of operational risk, as indicated above, vary in terms of frequency and severity. So they need to be handled differently.

- Low frequency, high severity risks can put the future of a firm at risk. These risks cannot be actively managed on a day-to-day basis. The expected losses cannot also be built into the product price.
- The high frequency low severity risks have high expected loss but low unexpected loss. These risks must be covered by the general provisions of the business. They can also be managed with suitable systems and processes.
- It is the medium frequency medium severity risks that are often the main focus of operational risk capital measurement.

Quantifying operational risk

The following tools, listed in order of increasing sophistication, can be used for assessing operational risk.

- *Critical self-assessment:* Each department submits a subjective evaluation of the sources of operational risk, along with expected frequency and costs.
- *Key risk indicators:* A centralized unit develops subjective risk forecasts through risk indicators, such as trading volume, number of mishandled transactions, staff turnover, and so on.
- *Formal quantification:* Operational risk managers prepare an objective distribution of operational risk losses from an event database.

As mentioned earlier, a major challenge in quantifying operational risk is that data on the severity and frequency of historical losses are often not available. Internal historical data on high frequency risks is relatively easy to obtain but these risks are not the important ones from the point of view of measuring operational risk capital. It is the low frequency, high severity and medium frequency medium severity risks that are the most important risks to measure from a risk capital perspective. But there is little historical data available.

If frequency and severity are the two key issues, by inference, there are two distributions that are important in estimating potential operational risk losses. One is the loss frequency distribution and the other is the loss severity distribution.

The *loss frequency* is a measure of the number of loss events over a fixed interval of time. The *loss severity* is a measure of the size of the loss once it occurs. The *loss-distribution approach* (LDA) then combines these two variables into a distribution of total losses over the period considered. Often, it is assumed that these distributions are independent. But such an assumption can be unrealistic at times.

For loss frequency, the most commonly used distribution is the Poisson distribution. Under this distribution, losses happen randomly. The probability that "n" losses will occur in time T is $\dfrac{e^{-\lambda T}(\lambda T)^{n}}{\angle n}$. λ is the expected value of losses defined in such a way that during a short period of time, Δt, there is a probability $\lambda \Delta t$ of a loss occurring. In other words, λ is nothing but the average number of losses per unit time.

Loss severities can be tabulated from a combination of internal and relevant external data. The risk manager can measure the loss severity from historical observations and adjust it for inflation and some measure of current business activity. For loss severity, a lognormal probability distribution is often used. The parameters of this probability distribution are the mean and standard deviation of the logarithm of the loss.

The loss frequency distribution is combined with the loss severity distribution for each loss type and business line to determine a total loss distribution. Monte Carlo simulation is often used for this purpose.

For most banks, the historical data available internally to estimate loss severity and loss frequency distributions is limited. As a result of regulatory requirements, banks have started to collect data systematically in recent years, but it may be some time before a reasonable amount of historical data is available. As we saw earlier in the chapter on credit risk, data can be a problem even in the case of credit risk management. But, traditionally banks have done a much better job at documenting their credit risk losses than their operational risk losses. Moreover, in the case of credit risks, a bank can rely on a wealth of information published by credit-rating agencies to assess the probability of default and the expected loss given default. Similar data on operational risk does not exist. Moreover, banks may conceal a large operational risk loss from the market if they feel it will damage the reputation.

Operational risk failure at Deutsche Morgan Grenfell[93]

In September 1996, the investment bank Deutsche Morgan Grenfell (DGM) decided to suspend a star fund manager, Peter Young, in its asset management unit. DMG also halted trading on its three main European equity funds, worth some $2.2 billion.

Young had breached the limit of 10 percent that such funds could invest in unlisted securities. This limit had been imposed because of the difficulty of confirming market values for these securities. After a stellar performance in 1995, the funds managed by Young ranked last in their category in the first half of 1996.

Deutsche Bank, DMG's German owner agreed to compensate the shareholders in the funds. It set aside some $720 million to cover the total losses. The total cost was even higher as a result of the business lost due to the bank's tarnished reputation.

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[93] Philippe Jorion, "Value at Risk: The New Benchmark for Managing Financial Risk," McGraw Hill, 2007.

The loss frequency distribution should be estimated from the bank's own data as far as possible. For the loss severity distribution, regulators allow banks to use their own data along with external data. Part of the external data may come from the banks provided they are willing to share data among themselves. The remaining can be sourced from data vendors.

One way to deal with the problem of inadequate data is to use scenario analyses to supplement internal and external loss data. Managers can use their judgement to generate scenarios where large losses occur. The scenario analysis approach forces managers to start thinking proactively and creatively about potential adverse events. The main drawback of scenario analysis is that it requires a great deal of senior management time.

Scaling

Losses due to operational risk can be scaled up if we know the exponent for scaling. In general the exponent will lie between zero and 1. Thus if a division with revenue R_1 has incurred losses of 100, a division with revenue $= R_2$ will have losses of $\left(\dfrac{R_2}{R_1}\right)^K \times 100$;

where k is the exponent.

Power Law

A simple but powerful tool for forecasting operational risk is the power law. This law states that the probability of a random variable x exceeding a value V is given by:

$$p\,(x > v) \quad = \quad K\,V^{-\alpha} \text{ where K is constant, } \alpha \text{ is the power law parameter.}$$

Illustration

A bank with annual revenues of $2 billion has incurred a loss of $100 million on account of operational risk. What would be the losses for a bank with a similar business profile but with revenues of $6 billion? Assume the exponent for scaling losses is 0.23.

$$\text{Loss for Bank B} \quad = \quad \left(\frac{Revenue\ of\ Bank\ B}{Revenue\ of\ Bank\ A}\right)^{.23} \times \text{ loss for Bank A}$$

$$= \quad \left(\frac{6}{2}\right)^{.23} \times 100$$

$$= \quad 3^{.23} \text{ x } 100$$

$$= \quad \$128.75 \text{ million}$$

Illustration

There is a 90% probability that operational risk losses will not exceed $20 million. The power law parameter is given as .8. Find the probability of the losses exceeding:
(a) $40 million   (b) $80 million   (c) $200 million

The power law states :   Prob $(x > v)$ = $K v^{-\alpha}$
We are given that   :   .1   = $(K) (20)^{-.8}$
     or   K   =   1.0986
Thus we get   probability $(v > x)$ = $1.0986 x^{-.8}$
When x = 40, probability   = $(1.0986) (40)^{-.8}$ =   5.74%
When x = 80, probability   = $(1.0986) (80)^{-.8}$ =   3.30%
When x = 200, probability   = $(1.0986) (200)^{-.8}$ =   1.58%

Illustration[94]
Consider the following distribution

Frequency Distribution		Severity Distribution	
Probability	*Frequency*	*Probability*	*Severity*
0.5	0	0.6	$2,000
0.3	1	0.3	$5,000
0.2	2	0.1	$100,000

The losses due to operational risk can be tabulated as follows:

Tabulation of Loss Distribution

Number of Losses	*First Loss*	*Second Loss*	*Total Loss*	*Probability*
0	0	0	0	0.500
1	2,000	0	2,000	.3 x .6 = 0.180
1	5,000	0	5,000	.3 x .3 = 0.090
1	100,000	0	100,000	.3 x .1 = 0.030
2	2,000	2,000	4,000	.2 x .6 x .6 = 0.072
2	2,000	5,000	7,000	.2 x .6 x .3 =0.036
2	2,000	100,000	102,000	.2 x .6 x .1 =0.012
2	5,000	2,000	7,000	.2 x .3 x .6 =0.036
2	5,000	5,000	10,000	.2 x .3 x .3 =0.018
2	5,000	100,000	105,000	.2 x .3 x .1 =0.006
2	100,000	2,000	102,000	.2 x .1 x .6 =0.012
2	100,000	5,000	105,000	.2 x .1 x .3 =0.006
2	100,000	100,000	200,000	.2 x .1 x .1 =0.002

Loss Distribution approach
Basle II allows various ways of quantifying operational risk. One of them is the Loss Distribution Approach (LDA). The LDA consists of the following steps:

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[94] Adapted from Philippe Jorion's book "Value at Risk – The New Benchmark for Managing Financial Risk," *McGraw Hill,* 2007, pp. 499-500.

- Organizing and grouping loss data: Loss data are grouped according to business lines/event type. When enough data does not exist internally, data may have to be collected from outside.
- Weighting the data points: Equal weights are attached to all the data points, with three exceptions. Split losses are those that affect more than one business line. Old losses are given lower weight. External data and scenarios may have to be scaled to capture the biases involved.
- Frequency of loss distribution: This is usually done using the Poisson/Negative binomial/Binomial distribution. Internal data are usually preferred because they are more relevant.
- Severity distribution: In general, severity distributions are more difficult to construct, compared to frequency distributions. Recent internal loss data are often insufficient to calibrate the tails of severity distributions. Extrapolating the values to values beyond those observed is a challenge. Sometimes, it may be better to model the body and the tail separately. Extrapolations can lead to the inclusion of extremely severe hypothetical losses and an overestimation of the needed capital reserve.
- The frequency and severity distribution are combined using Monte Carlo simulation.
- The capital requirements are determined, based on the estimates of expected, unexpected and stress losses.

The Basle framework

The Basle Committee has recommended some best practices in the area of operational risk.

- Board approval – The board of directors should approve and periodically review the Operational Risk Management framework.

- Independent internal audit – The board should subject the operational risk management framework to comprehensive and independent internal audit.

- Management implementation – Senior management should develop policies, processes and procedures for managing operational risk in the bank's important products, activities, processes and systems.

- Risk identification and assessment – Banks should identify and assess the operational risk inherent in all materials, products, activities, processes and systems.

- Risk monitoring and reporting – Operational risk profiles and material exposures to losses must be regularly monitored and reported to the senior management and the board of directors.

- Risk control and mitigation – Policies, processes and procedures must be put in place to control/mitigate material operational risks.

- Contingency and continuity planning – Contingency and continuity plans must be in place to cope with severe business disruption.

- Disclosure – Banks should make adequate disclosures to allow the markets to assess the approach of the bank towards managing operational risk.

Sarbanes Oxley Section 404

The linkages between Sarbanes Oxley and Operational Risk Management are often not fully appreciated. Section 404 of Sarbanes Oxley (SOX) pertains to the effectiveness of internal controls over financial reporting. Internal controls must provide reasonable assurance regarding the reliability of financial reporting. SOX 404 has been supplemented by the rules for auditors developed by the Public Company Accounting Oversight Board (PCAOB). These rules specify what auditors must do when performing an audit of internal control over financial reporting.

As Nick Bolton and Judson Berkey[95] mention, it would seem at first sight as though there is nothing specific in SOX about operational risk. But the connection is that control failures can lead to material financial misstatements. A single assessment process serving both Basel II and SOX 404 needs can help integrate the risk management process and achieve efficiencies. UBS, the global Zurich based bank has embraced such a philosophy. The UBS operational risk framework is built around the following:

- Clear definition of roles and responsibilities
- Control objectives
- Explanatory notes to control objectives
- Control standards
- Quality metrics / key risk indicators

Sound Practices for the management and supervision of operational risk

Developing an Appropriate Risk Management Environment
Principle 1: The board of directors should be aware of the major aspects of the bank's operational risks as a distinct risk category that should be managed, and it should approve and periodically review the bank's operational risk management framework. The framework should lay down the principles of how operational risk is to be identified, assessed, monitored, and controlled/mitigated.

Principle 2: The board of directors should ensure that the bank's operational risk management framework is subject to effective and comprehensive internal audit by operationally independent, appropriately trained and competent staff. The internal audit function should not be directly responsible for operational risk management.

Principle 3: Senior management should have responsibility for implementing the operational risk management framework approved by the board of directors. The framework should be consistently implemented throughout the whole banking organisation. Senior management should develop policies, processes and procedures for managing operational risk in all of the bank's material products, activities, processes and systems.

Risk Management: Identification, Assessment, Monitoring, and Mitigation/Control
Principle 4: Banks should identify and assess the operational risk inherent in all material products, activities, processes and systems. Banks should also ensure that before new products, activities, processes and systems are introduced or undertaken, the operational risk inherent in them is assessed.

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[95] "Aligning Basel II Operational Risk & Sarbanes Oxley 404 projects," in "Operational Risk: Practical approaches to Implementation," ed Ellen Davis, Risk Books, 2005.

Principle 5: Banks should implement a process to regularly monitor operational risk profiles and material exposures to losses. There should be regular reporting of pertinent information to senior management and the board of directors that supports the proactive management of operational risk.

Principle 6: Banks should have policies, processes and procedures to control and/or mitigate material operational risks. Banks should periodically review their risk limitation and control strategies and should adjust their operational risk profile, in light of their overall risk appetite and profile.

Principle 7: Banks should have in place contingency and business continuity plans to ensure their ability to operate on an ongoing basis and limit losses in the event of severe business disruption.

Role of Supervisors
Principle 8: Banking supervisors should require that all banks, regardless of size, have an effective framework in place to identify, assess, monitor and control/mitigate material operational risks.

Principle 9: Supervisors should conduct, directly or indirectly, regular independent evaluation of a bank's policies, procedures and practices related to operational risks. Supervisors should ensure that there are appropriate mechanisms in place which allow them to remain apprised of developments at banks.

Role of Disclosure
Principle 10: Banks should make sufficient public disclosure with regard to operational risk management.

Ref : Basle II Approach Paper, www.bis.org

Operational Risk Capital

Under Basle II, banks have three alternatives for determining operational risk regulatory capital. The simplest approach is the *basic indicator approach.* In this approach, operational risk capital is set equal to 15% of annual gross income over the previous three years. Gross income is defined as net interest income plus non interest income[96].

In the *standardized approach,* the bank's activities are divided into eight business lines (See Exhibit 7.2).

Exhibit 7.2

Business Line	Beta
▪ Corporate finance,	18%
▪ Trading and sales,	18%
▪ Retail banking,	12%
▪ Commercial banking,	15%
▪ Payment and settlement,	18%
▪ Agency services,	15%
▪ Asset management,	12%
▪ Retail brokerage.	12%

The average gross income over the last three years for each business line is multiplied by a "beta factor" for that business line and the result summed to determine the total capital.

In the *Advanced measurement approach*, the regulatory capital requirement is calculated by the bank internally, using various qualitative and quantitative criteria. Banks must

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[96] Net interest income is the excess of income earned on loans over interest paid on deposits and other instruments that are used to fund the loans.

measure the operational risk capital requirement for each risk type in each of the eight lines of business. Each of the seven types of risk (see earlier part of the chapter) is mapped to these eight business lines to arrive at 56 separate estimates of operational risk capital.

Systems and processes

Effective management of operational risk calls for sound systems and processes that enable managers to know what risks are being taken, measure them and assess whether they are within prescribed limits. These systems should impose the necessary checks and balances and facilitate corrective action, where necessary.

The various scams and disasters in recent times have made it clear that top management cannot let treasurers and other managers operate freely without being questioned when they are taking major financial decisions. Good management control systems help in defining performance standards, measuring actual performance and taking corrective action on a regular basis. By evaluating, monitoring and controlling the various sub-units, an organisation can ensure that there is optimal risk taking.

Systems and processes must be regularly monitored to ensure that they are working properly. Auditing should be undertaken periodically to check the robustness of the systems, procedures and controls. Auditing can also help to set standards and assess the effectiveness and efficiency of the system in meeting these standards. This way, managers can identify the scope for improvement, besides understanding how systems and processes are currently working.

A comprehensive audit must ideally review all the processes associated with measuring, reporting and managing operational risk. It must verify the independence and effectiveness of the risk management function and check the adequacy of the documentation. Audits should be held regularly to take into account changes in the circumstances and to monitor progress. The frequency of audits would depend on how integral it is to the company's strategy, the time and expenditure involved, etc. Audits can be performed in various ways – surveys, questionnaires, focus groups.

By themselves, audits cannot mobilize people into action. Audits can only come up with recommendations. Indeed, in some of the classic failures like Barings, audit recommendations were not implemented. The way senior managers enforce audit recommendations is hence key to sound operational risk management.

A key pillar of Basle II is market discipline which is facilitated by detailed and honest disclosures. The Satyam scam of 2008 has raised major concerns about the quality of disclosures in emerging markets and the role of auditors who certify these disclosures. Many high profile and respected companies in India seem to be resorting to "aggressive" accounting. The independence of auditors, who certify the financial statements is being widely questioned. After all, they are appointed by and paid for by clients. The main watchdog for financial disclosures, The Institute of Chartered Accountants of India (ICAI) is owned, managed and controlled by accountants and auditors. So it has limited scope to discipline and punish offending auditors. In the past, suggestions made by ICAI

for rotation of auditors have been rejected on the grounds of client confidentiality. This has led to what many independent observers believe "cosy" relationships. The ICAI has some 150,000 members. Yet, its disciplinary committee has barred only three license holders for life in the last three years. One solution being proposed is for listed companies to pool in money and give it to the stock exchanges who can then appoint auditors.

Conclusion

Operational risks abound in today's business environment. The whole process of measuring, managing, and allocating operational risk is still in its infancy. As time goes by and data is accumulated, more precise procedures are likely to emerge. Operational risk capital allocation aims at ensuring that business units become more sensitive to the need for managing operational risk.

Case Illustration: The Collapse of Barings

Introduction

The collapse of Barings Bank in 1995 was one of the most astounding events ever in the history of investment banking. Barings went broke when it could not meet the huge obligations piled up by its trader Nick Leeson. At the time of its bankruptcy, Barings had huge outstanding futures positions of $27 billion on Japanese equity and interest rates; $7 billion on the Nikkei 225 equity contract and $20 billion on Japanese government bond and euro yen contracts. The risk taken by Leeson was huge when we consider that Barings' capital was only about $615 million. Leeson was particularly aggressive after the Kobe earthquake on January 17, 1995. His bet was that the Nikkei would continue to trade in the range 19,000 - 20,000. Unfortunately for him, the Nikkei started falling after the Kobe earthquake. Leeson made some desperate moves and single handedly tried to reverse the sentiments on the Osaka Stock Exchange but this had little impact. Barings' total losses exceeded $1 billion. The bank went into receivership in February, 1995.

Background Note

Barings Bank, founded in London by Francis Baring in 1763, was the first merchant bank in the world. It provided finance and advice to its clients and also traded on its own account. When it was set up, Barings operated in the London-based commodities markets, selling and buying wood, wool, copper and diamonds. During the Napoleonic wars, the bank helped the British treasury by supplying gold ingots to Britain's allies.

In 1818, Barings' influence was such that the French prime minister of the day, the Duc de Richelieu, declared, "Barings has become the sixth great power in Europe, after England, France, Austria, Prussia and Russia." It was a party to nearly all the major deals at that time.

In 1890, the rapidly growing bank made massive losses in Argentina and had to be bailed out by the Bank of England. In the 19th century, Barings spread across the globe, creating a global network that remained its main source of competitive advantage until the 1990s. By the beginning of the 20th century, Barings had become the British royal family's banker and received five separate peerages as rewards for its services to banking. In 1995, the star of Barings with 55 offices in 25 countries, was clearly on the ascendant.

Nick Leeson and the Singapore Operations

Nick Leeson started his career as a settlement clerk in 1985, with one of England's prominent bankers, Coutts & Company. In June 1987, Leeson joined Morgan Stanley as a trainee in the Settlement Division for Futures and Options. He quickly realized that dealers held the most remunerative jobs. Driven by ambition, Leeson resigned from Morgan Stanley and joined Barings in July 1989 again as a clerk in the Settlement Division for Futures and Options. He was transferred to Jakarta where he streamlined the

settlement of bearer bonds and reduced Barings' exposure from £100 million to £10 million. By the time he returned to London in 1991, he had grown in stature and was looking for more challenging assignments.

Barings had acquired a seat on the Singapore International Monetary Exchange (SIMEX) but had not activated it. The Barings subsidiary in Singapore bought and sold shares, researched the local markets and offered fund management and banking facilities. But it was not able to deal in futures. As all the requested transactions were routed through another trader, Barings could not charge commission. Leeson felt Barings should activate the seat to take advantage of the growing business and expressed his willingness to be involved in the Singapore operations.

Soon after arriving in Singapore, Leeson passed an examination conducted by SIMEX and started his trading activities. Shortly thereafter, Leeson was named General Manager and head trader of the local branch. Initially, Leeson dealt only in arbitrage trades[97] based on the Nikkei index, where the profit margins were small.

At first, SIMEX was a very small exchange, handling only 4,000 trades a day. Most of the big dealers dealt in the Nikkei index at the much bigger Osaka exchange in Japan. During the summer of 1992, the Osaka exchange imposed stringent regulations on futures and options dealers. The dealers were asked to pay much higher margins on which no interest was paid and a minimum commission was also stipulated. As a result of these restrictions, many dealers shifted to the SIMEX. The number of trades increased from 4,000 to 20,000 a day. Leeson captured a large share of this increase in trading volumes.

Leeson's modus operandi

Barings booked trading errors in a separate computerised account known as the 'error account'. Essentially, error accounts accommodated trades that could not be settled immediately. (In securities trading jargon, these are called breaks). A compliance officer normally investigated the trade and examined how it affected the firm's market risk and profit and loss. When Leeson had started the operations, he had an error account numbered '99905', where all the errors were booked before they were transferred to London. After receiving instructions from London, Leeson started a new error account, which was numbered '88888'. Leeson conducted a number of unauthorised trades using this account and asked a colleague to remove this account from the daily reports which Barings Singapore sent to London.

▪ Between 1992 and 1995, the Barings management had little idea of Leeson's true profit and loss performance. The details of account 88888 were never reported to Treasury officials in the London headquarters.

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[97] Arbitrage trades take advantage of the price differential of an instrument or a commodity in two markets. They involve buying in a lower-priced market and selling in the higher-priced one.

- In September 1992, the London headquarters set up an error account 99002. Instead of shifting to this account, Leeson kept error account 88888 active to hide his trading losses and unauthorised trades.

- Leeson made it look as though he was maintaining a flat book exposure. Actually, he maintained huge long and short positions which carried risk way beyond he was authorized to take or for that matter, even Barings as a bank could afford to take. Leeson was allowed to make unhedged trades on up to 200 Nikkei 225 futures, 100 Japanese Government Bonds and 500 euroyen futures contracts. Leeson's positions greatly exceeded these authorized limits. Leeson also engaged in the uanuthorised sale of Nikkei 225 put and call options. He did this to earn premiums that could be used to meet margin calls.

- Initially, Leeson's proprietary trading involved arbitrage in Nikkei-225 stock index futures and 10-year Japanese Government Bond (JGB) futures between the SIMEX and the Osaka Securities Exchanges (OSE). However, Leeson soon embarked upon a much riskier trading strategy. He began placing bets on the direction of price movements on the Tokyo stock exchange. Initially, Leeson was very successful. His reported trading profits, were spectacular and accounted for a significant share of Barings' total profits. The bank's senior management regarded Leeson as a star performer and did not think it necessary to drill deeper into his activities.

- Far from making profits, Leeson was in reality making losses. Leeson needed funds to meet his margin calls and support the losses that were piling up. But he succeeded in persuading the London office to release funds. From 1992 till the collapse of Barings, Leeson was able to get funds to meet margin calls on unauthorized trades with little security whatsoever.

- Leeson used his position running the back office to hide the true picture from his bosses. In September 1992, he debited a Barings receivable account at Citibank Singapore and credited the funds to error account 88888. This transfer helped Leeson to hide his trading losses. Lesson also forged a fax from the London based risk manager to the effect that the error account 88888 had an insignificant balance.

- Leeson sold straddles on the Nikkei 225, hoping that the Nikkei index would be trading in the range 19000-19500. The money he collected as premium could be booked as profits when the options expired worthless. But following the Kobe earthquake of January 17, 1995, the Nikkei dropped to 18,950. As the Nikkei fell, Leeson lost money on the put options. Leeson responded by buying March 1995 futures contracts. On January 23, the Nikkei dropped to 17,950. The long positions and the puts both began to register heavy losses. Though Leeson had started off by arbitraging between prices on the same futures contracts in Osaka and Singapore, by the time Barings collapsed, he was long on both these exchanges. Not surprisingly, during January and February 1995, Barings made huge losses.

The Crisis

Just a few months after he had begun trading, Leeson had accumulated a loss of ₤2 million. The loss remained hidden and unchanged until October 1993. Then it began to

rise sharply. Leeson lost another £21 million in 1993 and £185 million in 1994. Total cumulative losses at the end of 1994 stood at £208 million. That amount was slightly larger than the £205 million profit (before accounting for taxes and for £102 million in scheduled bonuses) reported by the Barings Group as a whole. After the Kobe earthquake, the Nikkei crashed making Leeson's open position worse. By February 1995, Barings had gone into receivership. Leeson tried to escape but was later jailed. Barings was taken over by the Dutch group, ING.

Once the Singapore and Osaka exchanges understood that Barings would not be able to meet its margin calls, they took control of all the bank's open positions. The Nikkei index fell precipitiously when market participants learnt that the exchanges would be liquidating such large positions. The situation became more complicated when SIMEX announced that it would double the margin requirements on its Nikkei stock index futures contract from February 28. Several clearing members feared that their margin money might be used to pay for Barings' losses and threatened to withhold payment of the additional margin. To complicate matters further, regulators in Japan and Singapore were slow to inform market participants of the steps they were taking, to ensure the financial integrity of the exchange clearing houses. This lack of communication aggravated the fears of market participants. Later, following an assurance given by Monetary Authority of Singapore, SIMEX's margin calls were met and a potential crisis was avoided.

This was not the end of the matter for Barings' customers. Barings was one of the largest clearing members on SIMEX. It handled clearing and settlement for 16 U.S. firms and held approximately $480 million in margin funds on their behalf when it went bankrupt. U.S. futures exchanges typically arranged for the immediate transfer of all customer accounts of a financially troubled clearing member to other firms. Laws in the U.S. facilitated such transfers because they provided for strict segregation of customer accounts. This prevented the creditors of a broker or clearing member firm from attaching the assets of customers. But Japanese laws contained no such provisions. And this was not well known before the collapse of Barings. Although laws in Singapore recognized the segregation of accounts, SIMEX had never before dealt with the insolvency of a clearing member firm. Since most of Barings' customer accounts had been booked through Barings Securities in London, SIMEX did not have detailed information on individual customer positions. It had records pertaining to only a single aggregated account for Barings Securities. Moreover, the information that Leeson had provided to the exchange, was largely incorrect. So the task of sorting out the positions of individual customers became extremely difficult.

During the next week, Barings' U.S. customers scrambled to reproduce documentation of their transactions with the bank and supplied this information to SIMEX and The Osaka Exchange. This information enabled the exchanges to identify customer positions. At the same time, Barings' bankruptcy administrator in London asked the exchanges to block access to all Barings' margin deposits. The administrator also raised questions about the U.K. laws on the segregation of customer accounts.

It was not until ING took over Barings on March 9 that the bank's customers were assured of access to their funds. Even then, access was delayed in many cases. Some major clients waited for more than three weeks before their funds were returned.

The Bank of England Report on Barings

Following the Barings failure, the Bank of England identified various lessons from the disaster.

- *Management teams have a duty to understand fully the businesses they manage.* Top management at Barings did not have a good understanding of Leeson's business though it was creating huge profits for the bank.
- *Responsibility for each business activity must be clearly established.* Barings was using a "matrix" reporting system (by region and product) that left ambiguities in the reporting lines for Nick Leeson.
- *Clear segregation of duties is fundamental to any effective risk control system.* Leeson had control over both the front and back offices. The Barings affair demonstrated a compelling need for independent risk management.

Source: Philippe Jorion, "Value at Risk – The new benchmark for managing financial risk," McGraw Hill, 2007.

Concluding Notes

Looking back, it is clear that the Barings management failed to institute adequate managerial, financial and operational control systems. Checks and balances failed at lower as well as senior levels resulting in Leeson's free run. On paper, Leeson had many supervisors but no one really exercised any control.

Barings broke a very important rule of any trading operation i.e., separation of the dealing desk and the back office. The back office, which recorded, confirmed and settled trades transacted by the front office, should have provided the necessary checks to prevent unauthorised trading, fraud and embezzlement. But by putting himself in charge of the back office, Leeson relayed false information to Barings' London headquarters. Market risk reports submitted by Leeson were later found to be manipulated and inaccurate. Before the crisis, an internal audit team had concluded that Leeson's dual responsibility for both the front and back office was an excessive concentration of powers. It had recommended that Leeson be relieved of four responsibilities, back office supervision, cheque signing, signing SIMEX reconciliations and bank reconciliations. This recommendation was not implemented.

Barings' senior management did not invest adequate time and effort in understanding the use of derivatives. While they were very enthusiastic and happy about the substantial trading profits earned by the Singapore office, they did not make any serious effort to analyse the way profits had been booked. Investigations later revealed that Leeson had conducted unauthorised trades almost from the time he started trading in Singapore. He made losses on many of these trades.

One of the techniques used by Leeson to deceive his bosses in the UK was cross trade, a transaction in which the same member of the exchange was both buyer and seller. If a

member had matching buy and sell orders from two different customer accounts for the same contract and at the same price, he could execute the transaction by matching the two client accounts. However, he could do this only after declaring the bid and offer price in the pit. Also, a cross trade had to be done at the market price. Leeson, did not follow these guidelines. He broke down the total number of contracts into several different trades and changed the trade prices to manipulate profits. Leeson also recorded some fictitious transactions to jack up profits. Leeson also did not separate the proprietary and client trades.

Meanwhile, Barings also did not have a system to reconcile the funds Leeson requested from time to time with his reported positions. By 1995, Leeson had requested and received almost $1.2 billion. The management continued to fund Leeson's activities, thinking they were paying margins on hedged positions. Actually, losses were being incurred on outright positions on the Tokyo stock market. There was no system in place to reconcile the funds, Leeson had requested for his reported positions and the clients' positions. Only later did the management realize that Barings was exposed to significant market risk due to the naked positions.

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Chapter - 8
Integrated Risk Management

"Economic theory tells us that market and credit risk are intrinsically related to each other and more importantly, they are not separable. It the market value of the firm's assets unexpectedly changes, this affects the probability of default. Conversely, if the probability of default unexpectedly changes, this affects the market value of the firm."

- *Robert Jarrow, Stuart Turnbull[98]*

Introduction

Integrated risk management also popularly called Enterprisewide Risk Management (ERM), looks at various kinds of risk - market risk, credit risk, liquidity risk, operational risk and business risk in a holistic fashion. An integrated view generates a better picture of the risk climate of the organization and also helps in making the risk management process more efficient and effective. Considerable cost savings can be achieved by aggregating and netting out positions. A firmwide approach can reveal natural hedges and guide the firm's strategy towards activities that are less risky when considered as a whole. ERM also acts as a check on risk migration, i.e., movement towards other types of risk that are less visible but may be more dangerous. Last but not the least, by providing an aggregate measure of risk, ERM helps companies to decide what is the optimal level of capital they must hold. *Too little capital means the company is taking risks which it cannot afford to take. Too much capital means the company is being too conservative and may fail to generate adequate returns for shareholders*.

While the integration of market and credit risk in banks has made impressive strides in recent years, the same cannot be said about the integration of business and financial risks in non banking corporations. Traditionally, the two kinds of risk have been handled in two different silos by two types of people, the business managers and the finance managers respectively. Business people bring in a strong intuitive dimension to risk management but often lack the tools to quantify risk. The finance people are data driven and swear by quantification. But often they do not understand the business adequately enough to bring in the necessary element of intuition and judgment. ERM can help bridge the silos by striking the right balance between intuition and quantification. In this chapter, the focus will be on the integration of different types of financial risk.

Business Risks

Business risks refer to the risks a company willingly assumes to create a competitive advantage and add value for shareholders. These are the risks which arise in the design, development, production and marketing of products. In other words, business risk refers to the uncertainty about the demand for a company's products and services. Some of these risks may arise due to internal factors while others may be due to the environment.

Risks arising due to internal factors include:
- Product development choices

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[98] "The inter section of market and credit risk," Journal of Banking and Finance, Vol 24, 2000.

- ▪ Marketing strategies
- ▪ Organizational structure

Risks emanating from external factors include:
- ▪ Macro economic risk
- ▪ Competition risk
- ▪ Technological risk

Financial risks

Under financial risk, we normally include three kinds of risk: market, credit, operational. These risks have already been dealt with in detail in separate chapters. We will not spend much time here on these risks. But this is a good time to examine liquidity risk which is often clubbed under market risk. A good understanding of liquidity risk becomes critical when viewed in the backdrop of the sub prime crisis. Indeed, many banks and regulators have singled out liquidity risk for special attention in recent months. The right way to handle liquidity risk is to build it into measures of market risk and credit risk. After examining liquidity risk right away, we shall briefly examine some other risks not so far covered in the book. Then we look at the key principles of integrated risk management. The last part of this chapter is a case study about a bank that has done exceptionally well during the recent financial melt down.

Exhibit 8.1
A high level view of Integrated Risk Management[99]
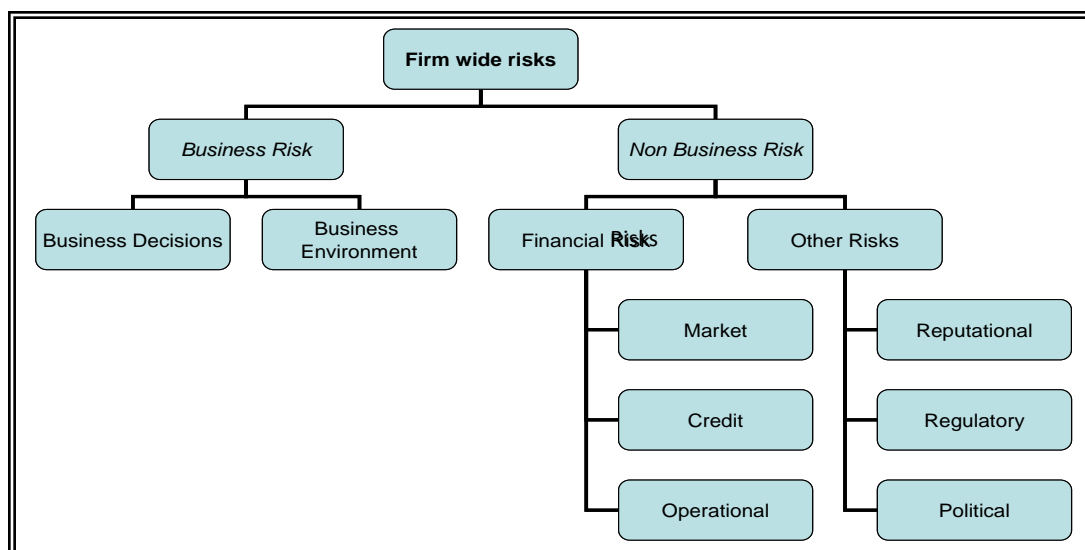
Understanding liquidity risk

Liquidity risk and other financial risks go together. For example, market risk is the possibility of losses due to fluctuations in interest rates, commodities, stocks and currencies. Credit risk refers to the possibility of losses arising due to excessive exposure to a counterparty. Managing market or credit risk calls for ongoing adjustments of the

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[99] Philippe Jorion, "Value at Risk – The new benchmark for managing financial risk," McGraw Hill, 2007.

exposure depending on the performance of the portfolio. But this adjustment is possible only when a liquid market exists where assets can be bought and sold easily.

Liquidity risk emanates from the liability side when creditors or investors demand their money back. This usually happens after the institution has incurred or is thought to have incurred losses that could threaten its solvency. Problems arise on the asset side when the forced liquidation of assets at distress prices causes substantial losses.

Liquidity risk is more complex than we think. Understanding liquidity risk involves knowledge of market microstructure, which is the study of market clearing mechanisms; optimal trade execution (e.g., minimising trading costs) and asset liability management (matching the values of assets and liabilities on the balance sheet).

Liquidity is crucially dependent on the market conditions and the prevailing sentiments. As Paul McCulley[100] mentions, "Liquidity is the result of the appetite of investors to underwrite risk and the appetite of savers to provide leverage to investors who want to underwrite risk. The greater the risk appetite, the greater the liquidity and vice versa. Put another way, liquidity is the joining or separating of two states of mind – a leveraged investor who want to underwrite risk and an unleveraged saver who does not want to take risk and who is the source of liquidity to the leveraged investor. The alignment or misalignment of the two investors determines the abundance or shortage of liquidity."

In his very insightful book, "The Partnership," Charles Ellis has given an excellent example of liquidity by quoting Bob Mnuchin, a senior leader of Goldman Sachs: "When you can get out a stock that you're long at a small loss and buy back a stock you're short at a small loss, that's an easy decision. It is painful when there isn't an apparent opportunity to unwind a position or the price moves farther and faster away. Then you hesitate. Then you pray."

Types of liquidity risk
At this point, it makes sense to draw a distinction between two types of liquidity risk.

Asset liquidity risk is the risk that the liquidation value of the assets may differ significantly from the current mark-to-market values. When unwinding a large position or when the market circumstances are adverse, the liquidation value may fall well below the fair or intrinsic value.

Asset liquidity is low when it is difficult to raise money by selling the asset. This typically happens when selling the asset depresses the sale price. Asset liquidity depends on the relative ease of finding somebody who takes on the other side of the trade. When it is difficult to find such counterparties, liquidity is low. There are three forms of asset liquidity:

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[100] CFA Institute Reading 53, "The Liquidity Conundrum."

- the bid–ask spread, which measures how much traders lose if they sell one unit of an asset and then buy it back right away;
- market depth, which shows how many units traders can sell or buy at the current bid or ask price without moving the price;
- market resiliency, which tells us how long it will take for prices that have temporarily fallen to bounce back. While a single trader might move the price a bit, large price swings occur when "crowded trades" are unwound—that is, when a number of traders attempt to exit from identical positions together.

Funding liquidity risk refers to the inability to meet payment obligations to creditors or investors. Funding liquidity risk can thus take three forms:
- rollover risk, or the risk that it will be more costly or impossible to roll over short-term borrowing;
- margin/haircut funding risk, or the risk that margins and haircuts will change;
- redemption risk.

Most financial institutions fund long term assets with short term sources of funds. This maturity mismatch can lead to problems if depositors/investors start withdrawing their money simultaneously.

Funding liquidity problems also arise because most trading positions are leveraged. Traders post collateral in exchange for cash from a broker. The value of the collateral is constantly marked to market. If this value falls, the market participant may be asked to deposit some additional payment called the variation margin to keep the total amount above the loan value. Without adequate liquidity to make these margin payments, market participants can find themselves in trouble.

Typically, when a trader purchases an asset, the trader uses the purchased asset as collateral and borrows (short term) against it. However, the trader cannot borrow the entire price. The difference between the security's price and collateral value is called the margin or haircut. The haircut must be financed by the trader's own equity capital. Haircuts are adjusted to market conditions on a daily basis. Since traders are leveraged and carry little capital in relation to their assets, increasing the haircut may force them to sell part of their assets when liquidity dries up in the market.

Financial institutions that rely substantially on short-term (commercial) paper or repo contracts have to roll over their debt. An inability to roll over this debt is equivalent to margins increasing to 100 percent, because the firm becomes unable to use the asset as a basis for raising funds. Similarly, withdrawals of demand deposits from an investment fund have the same effect as an increase in margins. When the time is due for redemption or if investors want to make premature withdrawals, banks can find themselves in serious trouble if they do not have adequate liquidity.

Conceptually, as Markus Brunnermeier[101] has explained, asset liquidity refers to the transfer of the asset with its entire cash flow. On the other hand, funding liquidity is like

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[101] "Deciphering the liquidity and credit crunch 2007-08," Journal of Economic Perspectives, Winter 2009.

issuing debt against a cash flow generated by an asset. Liquidity can suddenly evaporate through the interaction of asset liquidity and funding liquidity. Thus the failure to roll over a loan may lead to the need to sell a part of the asset. If this is simultaneously done by various traders, asset prices will fall. This will lead to a margin call and add to funding liquidity risk. The result can be a vicious circle in which liquidity rapidly dries up.

Let us understand how different types of market participants are affected by liquidity risk. Much of the risk of a bank run can be attributed to the nature of funding. Demand deposit contracts, usually operate on a first come first served basis. During a bank run, people well ahead in the queue will get back their money. Those standing behind will not. Thus when a few people line up outside a bank during a run, even investors who do not really need the money start to panic. As the run develops, the demand for bank deposit withdrawals grows. Even an otherwise safe bank can be pushed into insolvency if too many people start demanding back their money simultaneously and the bank finds it difficult to meet the temporary surge in liquidity needs.

It is precisely to deal with bank runs that regulators have put in place two mechanisms – Deposit insurance and Discount window. Thanks to deposit insurance, deposit holders are assured of getting their money back, upto a prespecified amount, in the event of bank runs. This ensures that all the small depositors are taken care of. In the US, this amount is currently $250,000. Under the discount window, the central bank stands ready to provide liquidity to a bank in trouble. This "lender of last resort" role can come in handy during a bank run.

It is not just depository institutions but also investment funds that could run into a liquidity crisis. Investment funds collect money from investors and park the money in various market instruments. Most mutual funds are of the open end type. That means, they must stand ready to buy back previously issued shares from investors at a price called the net asset value. Investment funds could face dramatic liquidity runs if investors begin to develop doubts about the net asset value and start demanding their money back simultaneously. During the sub prime crisis, this is exactly what happened with the large money market mutual fund, Reserve Primary.

But there is a significant difference between investment funds and banks. In the case of a bank, the depositors get back their money on first come first served basis. In the case of investment funds, on liquidation, the assets are distributed to the shareholders on a pro rata basis. So there is less incentive for fund shareholders to engage in bank runs. But even then, during a crisis, sentiments can take over, leading to big withdrawals.

Hedge funds can be done in by a liquidity crisis, as the example of Long Term Capital Management (LTCM) vividly demonstrates. Using its sophisticated mathematical models, LTCM had found a pricing discrepancy between the US treasury markets and other bond markets. The hedge fund sold US treasuries betting that prices would fall and bought other bonds hoping their prices would go up. But the Russian rouble crisis of mid-1998 prompted investors to retreat to safety. As the rouble fell, money started

moving out of various emerging markets into US treasuries. So T bill prices started going up while other bond markets started to plunge. So instead of a convergence, what happened was a divergence of yields.

LTCM soon experienced huge losses on its positions. Under the terms of its collateralization and margin agreements, LTCM had to make substantial payments. The fund did not have the necessary liquidity. When it tried to liquidate some assets, it found liquidity had dried up. And fresh capital from panicky investors, could hardly be expected in the situation. No wonder, the Federal Reserve, fearing the ability of the financial system to cope with a possible failure of LTCM and the asset liquidation that would follow, had to put together a $3.5 billion bail out plan.

Managing liquidity risk[102]

Sourcing

The first aspect of liquidity risk management is sourcing. Liquidity broadly speaking can be sourced in two ways:

- **Purchase** – Liquidity can be purchased in various ways: from the central bank, the repo market and the inter bank market. Liquidity can also be accessed by floating certificates of deposit, notes and bonds. This method's principal drawback is that the interest outflows on the purchased liquidity may exceed the inflows on the bank's assets. Another problem is that the availability of such liquidity becomes a question mark if the bank runs into solvency problems.

- **Storage** – The bank can 'store' liquidity by keeping appropriate assets on the balance sheet. The bank can then liquidate some of its assets to meet a liquidity crunch. Many banks maintain cash reserves with the central bank. Of course, when cash is kept to address future liquidity needs, there is an opportunity cost of being unable to invest the money in loans and other higher interest earning assets.

Banks usually use a combination of stored and purchased liquidity management to address their liquidity needs.

Planning

The next aspect of liquidity risk management is planning. Liquidity risk is a highly underrated risk. Only when it is encountered, managers start to tear their hair in frustration. Liquidity planning can enable banks to make key decisions before liquidity problems arise.
- The bank should have clearly defined responsibilities for senior managers should a liquidity crisis occur.
- The bank should also be clear about the market participants who may withdraw funding support in the event of a crisis.

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[102] This part draws heavily from "Financial Institutions Management: A risk management approach," by Anthony Saunders and Marcia Millon Cornett, Mc Graw Hill, 2008.

- The bank must have a visibility on how deposit/fund withdrawals may happen over time.
- The bank must plan the sequencing of assets for disposals.
- Last but not the least, the bank must develop relationships with strategic investors such as sovereign wealth funds who can be requested to step in during a crisis.

Measuring

The third aspect of liquidity risk management is measurement. While dealing with liquidity risk, it helps to put together some numbers and figures. Liquidity risk can be measured/assessed in various ways:

- Net liquidity statement: The bank can list the sources and uses of liquidity and thus assess the liquidity position.

- Financing gap: The financing gap is the difference between the bank's average loans and average deposits. The larger the financing gap, the more the bank needs to borrow in the money markets and the greater the liquidity problems during a crisis.

- Maturity ladder: A maturity ladder model facilitates a comparison of cash inflows and outflows on a day-to-day basis and over specific time periods. The ladder thus helps in determining daily and cumulative net funding requirements.

- Ratio analysis: The bank can closely monitor its key liquidity ratios: loans to deposits, borrowed funds to total assets, lending commitments to assets. These ratios will indicate whether the bank needs to mobilize more deposits or plan for exigencies arising out of unexpected drawdowns from existing loan commitments.

- Liquidity index: This index measures the potential losses the institution could suffer from a sudden or fire sale disposal of assets compared with the amount it would receive under normal market conditions when the disposal can be done in an unhurried way. The index can be calculated as:

$$I = \sum_{i=1}^{n} \frac{w_i p_i}{p_i^*}$$

  p_i is the immediate distress sale price
  p_i^* is the fair market price
  w_i is the weight of the asset in the portfolio.

Containing liquidity risks: Recommendations of the UK Financial Services Authority

- The UK Financial Services Authority has recently come out with detailed guidelines for managing liquidity risk.

Key considerations in liquidity risk management.
- Liquidity risk has inherently systemic characteristics. The simultaneous attempt by multiple banks to improve their liquidity position can contribute to a generalised collapse of liquidity.

- Liquidity management has become increasingly complex over time. There is increased reliance on 'liquidity through marketability' alongside traditional liquidity through funding access. This makes it difficult to base good liquidity regulation primarily on one or a few standard ratios.

- There is a tradeoff to be struck. Increased maturity transformation delivers benefits to the non bank sectors of the economy and is favourable to long-term investment. But the greater the aggregate degree of maturity transformation, the more the systemic risks and the more difficult for central banks to address liquidity crises.

Recommendations to deal with liquidity risk:
- There is a need for greater such as detailed maturity ladders, analysis of the assumed liquidity of trading assets, and analysis of off-balance sheet positions with liquidity implications.

- Individual Liquidity Adequacy Assessments must be carried out for different assets.

- A liquid assets buffer must be maintained.

- Firms must quantify and reflect in internal costing systems the liquidity risk created by participation in different categories of activity.

- Regulators must specify some stress tests, rather than leave it entirely to bank internal decisions. Stress tests must consider market-wide events as well as firm specific events.

- There must be a strong focus on the analysis of cross-system liquidity trends, with the publication of a periodic system-wide report.

A new regime

There can be considerable risk both for individual banks and for the system as a whole, if rapid asset growth is funded through increased reliance on potentially unstable funding sources. In the UK, between 2002 and 2007, growth of bank balance sheets was significantly correlated with the percentage of funding derived from short-term wholesale deposits. The new liquidity regime, should ideally result in:

- less reliance on short term wholesale funding,
- greater emphasis on retail time deposits;
- a higher amount and quality of stocks of liquid assets, including a greater proportion of those assets held in the form of government debt;
- a check on the unsustainable expansion of bank lending during favourable economic times.
- These measures will naturally involve a trade off between a cost to the economy during 'normal times' and the benefits of the reduced probability of extreme adverse events. But such a trade-off is justified in order to safeguard future financial stability.

A 'core funding ratio' as a prudential and macro-prudential tool.
The FSA has proposed a core funding ratio.

Factoring liquidity risk into VAR

As mentioned earlier, instead of considering liquidity risk separately, it often makes sense to integrate it with market and credit risk. In simple terms, adverse market movements can lead to liquidity problems in terms of funding. If this triggers off asset sales, it leads to asset liquidity problems. Similarly, a lowering of the credit rating may result in the need to deposit more collateral or margin. This in turn may lead to funding liquidity problems. So liquidity risk must be integrated into VAR models so that risk measures pay sufficient attention to liquidity. A simple way to do this is by looking at bid-ask spreads.

High spreads often mean the markets are shallow and liquidity is lacking.

Liquidity adjusted VAR[103] can be calculated by adding $s\alpha/2$ for each position in the book, where α is the dollar value of the position and s is defined as (offer price − bid price) / mid-price.

If there are multiple positions,

Liquidity adjusted VAR = VAR + $\displaystyle\sum_{i=1}^{n} \frac{s_i \alpha_i}{2}$

where n is the number of positions and i denotes the ith position.
If the spread is volatile and keeps fluctuating, the equation can be modified as:

Liquidity adjusted VAR = VAR + $\displaystyle\sum_{i=1}^{n} (\mu_i + \lambda\sigma_i)\frac{\alpha_i}{2}$

μ is the average spread while σ is the standard deviation of the spread.

λ is related to the confidence level. Thus, assuming a normal distribution, for a confidence level of 95%, $\lambda = 1.65$.

Liquidity risk can also be factored into VAR measures by ensuring that the time horizon is at least greater than an orderly liquidation period. Generally, the same time horizon is applied to all asset classes, even though some assets may be less liquid than others. Increasing the time horizon leads to an increase in risk capital. Thanks to more capital, a financial institution will be better placed to deal with a severe liquidity crisis. Sometimes, longer liquidation periods for some assets are taken into account by artificially increasing the volatility. This again leads to a higher capital buffer.

Liquidity Black Holes

The most severe liquidity crises occur when we have "liquidity black holes". In a normal market, when prices fall, some people will want to buy. During a serious crisis, many people may want to sell simultaneously. A liquidity black hole results when virtually everyone wants to sell in a falling market.

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[103] John. C. Hull, "Risk Management and Financial Institutions," Pearson Education, 2007.

The crash of October 1987, on the New York Stock Exchange is a good example. Many traders followed a strategy of selling immediately after a price decline and buying back immediately after a price increase. As a result of this strategy called *portfolio insurance,* the initial decline in prices fuelled off further rounds of price declines and the market plunged sharply. In fact, the market declined so fast and the stock exchange systems were so overloaded that many portfolio insurers were unable to execute the trades generated by their models.

Herd behaviour, which lies at the heart of liquidity black holes, can cause the market to move completely to one side. Hull[104] has listed some of the reasons for herd behaviour:

- Different traders use similar computer models and as a result pursue the same strategy. This can create tremendous selling pressure at the same time.
- Because they are regulated in the same way, banks respond to changes in volatilities and correlations in the same way.
- People start imitating other traders thinking there "must be something in it."

Let us understand briefly how a uniform regulatory environment, i.e., similar rules for all market participants, may accentuate a liquidity crisis. When volatility increases, value-at-risk (VaR) will increase. Consequently, all banks will be forced to increase their capital. Alternatively, they will have to reduce their exposure in which case many banks will try to do similar sell trades. In both situations, liquidity needs will suddenly shoot up and a liquidity black hole may result.

For black holes not to happen, at least some of the market participants should pursue contrarian strategies. Investors can often do well by selling assets when most people are buying and by buying assets when most people are selling. One reason for Goldman Sachs' seemingly smart recovery from the sub prime crisis in the early part of 2009, seems to be this kind of an approach.

Volatilities and correlations may increase but over time, they get pulled back to the long term average. As such, there is no need for long term investors to adjust their positions based on short term market fluctuations. One way forward is for regulators to apply different rules to asset managers and hedge funds. If regulations are different, there will be diversity in the thinking and strategies of different market participants. Consequently, there is less likelihood of black holes developing.

The Sub prime crisis and Liquidity Risk

The sub prime crisis was as much about liquidity as about insolvency. Many banks suffered during the sub prime crisis because their capital structure relied too heavily on debt.

Markus Brunnermeier[105] has pointed out that a *loss spiral* arises for leveraged investors because a decline in the value of assets erodes the investors' net worth much faster than

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[104] Risk management and Financial Institutions, Pearson Education, 2007.

their gross worth. The amount that they can borrow falls sharply. For example, consider an investor with a leverage ratio of 1:10, who buys $100 million worth of assets on 10 percent margin. This investor finances only $10 million with his own capital and borrows $90 million to build the position. Say the value of the acquired asset declines temporarily to $95 million. The investor, who started out with $10 million in capital, now has lost $5 million. So there is only $5 million of capital remaining. To prevent the leverage ratio from going up, this investor must reduce the overall position to $50 million. In other words, $45 million of assets must be sold. And this sale will happen exactly when the price is low. This sale will depress the price further, inducing more selling and so on. This loss spiral will get aggravated if some other potential buyers with expertise may face similar constraints at the same time. The spiral will also get amplified if potential buyers find it more profitable to wait out the loss spiral before reentering the market. Indeed, traders might even engage in "predatory trading," deliberately forcing others to liquidate their positions at fire-sale prices.

The *margin/haircut spiral* reinforces the loss spiral. As margins or haircuts rise, the investor has to sell assets to reduce the leverage ratio. Margins and haircuts spike in times of large price drops, leading to a general tightening of lending. A vicious cycle emerges, where higher margins and haircuts force de-leveraging and more sales, which increase margins further and force more sales.

A perceived increase in counterparty credit risk can create additional funding needs and potential systemic risk. Brunnermeir has illustrated this with an example related to the Bear Stearns crisis in March 2008. Imagine a hedge fund that had a swap agreement with Goldman Sachs. Say the hedge fund offset its obligation through another swap with Bear Stearns. In the absence of counterparty credit risk, the two swap agreements would together be viewed essentially as a single one between Goldman and Bear Stearns. Goldman would hesitate to renew the contract if it feared that Bear might default on its commitment. Goldman was asked to increase its direct exposure to Bear after the trading hours on March 11, 2008 when Bear was approaching bankruptcy. Goldman did renew the contract in the morning of March 12. But the delay in response was mistakenly interpreted as a hesitation on Goldman's behalf and fear that Bear Stearns might be in trouble. This misinterpretation was leaked to the media and seems to have contributed to the run on Bear Stearns.

Indeed, when individual institutions manage risk separately, an increase in perceived counterparty credit risk can be self-fulfilling and create additional funding needs. Suppose A has an offsetting swap agreement with B which in turn has offset its exposure with C. All parties, taken together, are fully hedged. However, each party is aware only of its own contractual agreements. So it may not know the full situation and therefore become concerned about counterparty credit risk. So the parties may have to either put up additional liquidity, or insure each other against counterparty credit risk by buying credit default swaps. This happened in the week after Lehman's bankruptcy. All major investment banks were worried that their counterparties might default. So they bought

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[105] "Deciphering the liquidity and credit crunch 2007-2008" *Journal of Economic Perspectives,* Winter 2009, pp. 77-100.

credit default swap (CDS) protection against each other. The already high prices on CDS of the major investment banks almost doubled. The price of CDS for AIG was hit the worst. It more than doubled within two trading days. Such problems are more easily overcome if there is a central clearinghouse which knows who owes what to whom. Indeed, many economists have argued strongly in favour of moving away from OTC to central clearing arrangements for most if not all derivatives. We will discuss this topic in more detail elsewhere in the book.

It is a good idea now to take stock of what banks are doing to manage liquidity in the aftermath of the subprime crisis.

Liquidity and funding risk management framework at UBS[106]
UBS was one of the banks hit hard by the subprime crisis. A new liquidity and funding risk management framework was approved by the Board of Directors (BoD) of UBS in 2008. Some of the key features of this new framework are:

- UBS allocates the real costs of funding to the business that generates the funding requirement. The bank has announced, after the sub prime fall out that there will be no more cross-subsidization of one business division by another.

- UBS will limit the size of its balance sheet, fund illiquid assets long-term and reduce its reliance on short-term unsecured funding.

UBS makes an assessment of all material, known and expected cash flows and the level of high-grade collateral that could be used to raise additional funding. It entails both careful monitoring and control of the daily liquidity position, and regular liquidity stress testing. Limits are set at Group level by the BoD risk committee. The Executive Committee of the Group Executive Board (GEB) is responsible for the allocation of resources to the business divisions and sets limits for each of the business divisions.

The liquidity position and asset and liability profile are continuously tracked. This involves monitoring the contractual and behavioral maturity profiles and projecting and modeling the liquidity exposures of the firm under a variety of potential scenarios – encompassing both normal and stressed market conditions.

The liquidity and funding process is undertaken jointly by Group Treasury and the foreign exchange and money market (FX&MM) unit within the Investment Bank's fixed income, currencies and commodities (FICC) business area. Group Treasury establishes a comprehensive control framework, while FX&MM undertakes operational cash and collateral management within the established parameters.

This centralization permits close control of both UBS's global cash position and its stock of highly liquid securities. The central treasury process also ensures that the firm's general access to wholesale cash markets is concentrated in FX&MM. Funds raised externally are largely channeled into FX&MM including the proceeds of debt securities

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[106] This part draws heavily from UBS Annual Report, 2008.

issued by UBS. FX&MM in turn meets all internal demands for funding by channeling funds from units generating surplus cash to those requiring finance. In this way, UBS reduces its external borrowing and use of available credit lines, and presents one face to the market.

When it comes to liquidity modeling and contingency planning, UBS employs the following main measures:

- A cash ladder, which shows the daily liquidity position – the net cumulative funding requirement for a specific day – projected for each business day from the current day forward six months.

- A contractual maturity gap analysis of UBS's assets and liabilities.

- A behavioral maturity gap analysis under an assumed severe liquidity crisis scenario.

- A cash capital model which measures the amount of stable funding in relation to the amount and composition of its assets.

- UBS also uses stress testing & scenario analysis. Scenarios include large drawdowns on otherwise stable client deposits, an inability to renew or replace maturing unsecured wholesale funding and limited capacity to generate liquidity from trading assets.

Since a liquidity crisis could have various causes, UBS focuses on a scenario that encompasses all potential stress effects across all markets, currencies and products. The assessment includes the likelihood of maturing assets and liabilities being rolled over in a UBS-specific crisis within an otherwise stressed market environment, and gauges the extent to which the need for liquidity can be covered by available funding. UBS applies crisis-level discounts to the value of the assets. It assumes that it would be generally unable to renew any of the Group's wholesale unsecured debt, including all its maturing money market paper (outstanding volume CHF 112 billion on 31 December 2008) and that no contingency funding could be raised on an unsecured basis. UBS regularly monitors undrawn committed credit facilities and other latent liquidity risks and factors these potential liquidity outflows into the scenario analysis. Particular emphasis is placed on potential drawdowns of committed credit lines.

UBS has developed detailed contingency plans for liquidity crisis management. Implementation falls under the responsibility of a core crisis team with representatives from Group Treasury, FX&MM and related areas. Should a crisis require contingency funding measures, Group Treasury takes responsibility for coordinating liquidity generation together with representatives from FX&MM and the relevant business areas.

Global Core Excess at Goldman Sachs[107]

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[107] Draws heavily from Goldman Sachs Annual Report, 2008.

The global investment bank, Goldman Sachs has put in place a comprehensive set of liquidity and funding policies:

- *Excess Liquidity* — Goldman maintains substantial excess liquidity to deal with various potential cash outflows in an adverse environment.

- *Asset-Liability Management* — Goldman seeks to maintain secured and unsecured funding sources that are sufficiently long-term in order to withstand a prolonged or severe liquidity-stressed environment without having to sell assets.

- *Conservative Liability Structure* — Goldman attempts to access funding across a diverse range of markets, products and counterparties. The bank emphasizes less credit-sensitive sources of funding.

- *Crisis Planning* — Goldman bases its liquidity and funding management on stress-scenario planning and maintains a crisis plan to respond effectively to a liquidity-threatening event.

To deal with a liquidity crisis, Goldman maintains excess liquidity in the form of unencumbered, highly liquid securities that may be sold or pledged to provide immediate liquidity. This "Global Core Excess" is intended to allow the bank to meet immediate obligations without needing to sell other assets or depend on additional funding from credit-sensitive markets. The Global Core Excess reflects the following principles:

- The first days or weeks of a liquidity crisis are the most critical for survival.

- The focus must be on all potential cash and collateral outflows, not just disruptions to financing flows.

- During a liquidity crisis, credit-sensitive funding, including unsecured debt and some types of secured financing agreements, may be unavailable, and the terms or availability of other types of secured financing may change.

The size of the Global Core Excess is based on an internal liquidity model together with a qualitative assessment of the condition of the financial markets and of the bank. The liquidity model identifies and estimates cash and collateral outflows over a short-term horizon in a liquidity crisis, including:

- upcoming maturities of unsecured debt and letters of credit;
- potential buybacks of outstanding negotiable unsecured debt;
- potential withdrawals of client deposits;
- adverse changes in the terms or availability of secured funding;
- derivatives and other margin and collateral outflows;
- additional collateral to be posted in the event of a two notch downgrade in the bank's credit ratings;
- upcoming cash outflows, such as tax and other large payments.

The following table gives the average loan value (the estimated amount of cash that would be advanced by counterparties against these securities), as well as overnight cash deposits, of the Global Core Excess:

Exhibit 8.2
Global Core Excess at Goldman Sachs

(in millions)	Year Ended November	
	2008	**2007**
U.S. dollar-denominated	$78,048	$52,115
Non-U.S. dollar-denominated	18,677	11,928
Total Global Core Excess[108]	$96,725	$64,043

The Global Core Excess is limited to a narrowly defined list of highly liquid securities and cash. The U.S. dollar-denominated excess consists of only unencumbered U.S. government securities, U.S. agency securities and highly liquid U.S. agency mortgage-backed securities, all of which are eligible as collateral in Federal Reserve open market operations, as well as overnight cash deposits. The non-U.S. dollar-denominated excess is comprised of only unencumbered French, German, United Kingdom and Japanese government bonds and overnight cash deposits in highly liquid currencies.

In addition to Global Core Excess, Goldman has a significant amount of other unencumbered securities. These assets, which are located in the U.S., Europe and Asia, include other government bonds, high grade money market securities, corporate bonds and marginable equities.

The Global Core Excess and other unencumbered assets, if pledged or sold, would provide the funds necessary to replace at least 110% of Goldman's unsecured obligations that are scheduled to mature within the next 12 months. The estimated aggregate loan value of Global Core Excess, as well as overnight cash deposits, and other unencumbered assets averaged $163.41 billion and $156.74 billion for the fiscal years ended November 2008 and November 2007, respectively.

Other risks
We now examine briefly some of the other risks faced by organizations, especially banks.

Legal risk is the risk of losses owing to fines and penalties on account of lawsuits.

The various sources of legal risk can be summarized as follows:
- Failure in sub contracting i.e., improper authorization or execution
- Failure in contract documentation i.e., mistakes in documentation
- Changes in laws and regulations.

Certain basic precautions can help to reduce legal risk:

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[108] Beginning in 2008, the Global Core Excess as presented includes the Global Core Excess of GS Bank USA and GS Bank Europe. The 2007 amounts include $3.48 billion of Global Core Excess at GS Bank USA.

Authority*:* It is important to check that counterparties have the legal authority to engage in trades.

Insanity*:* There is always a possibility that clients may claim that the contracts were unsuitable to their needs or level of expertise. Losing parties can claim financial insanity; i.e., they were temporarily unable to judge financial contracts. So, standardised contracts such as master netting agreement, must be used to reduce the risk.

Interrelationships*:* Legal risks often become intermingled with market and credit risks. Counterparties who lose money on account of market risk often resort to legal action to recover their losses. For example, P&G sued Bankers Trust in a well documented case study.

Reputational risk can be viewed as the negative impact on the ongoing business due to a damaged reputation. Reputation is particularly important for financial institutions, as the nature of their business requires maintaining the confidence of the market participants and regulators. If reputation gets eroded, there will be a run on the bank. In the case of some Swiss banks, the negative impact on reputation following the sub prime crisis has led to substantial withdrawals of money by wealth management clients.

Regulatory risks are the result of changes in regulations or interpretation of existing regulations. When regulations change, business models and strategies also must change. A change in regulations can be a threat to the current business model and effectiveness of the existing business strategy. Banking regulation is poised to undergo significant changes in the aftermath of the sub prime crisis.

Political risks arise from actions taken by policy makers that significantly affect the way an organization runs its business.   Usually, political risk tends to be higher in underdeveloped and emerging markets. In such markets, government policies tend to be personality centric. As such, the business climate is often characterized by a higher degree of uncertainty. In emerging markets, political risk can take the form of nationalization or imposition of various controls that put restrictions on the way business can be conducted. But even in developed countries, political risk should not be underestimated. A good example is the current controversy involving the US Internal Revenue Service (IRS) and the Swiss banks. The IRS has applied a lot of pressure on these banks to disclose sensitive client information. The controversy has risen on account of how to interpret banking secrecy laws. The Swiss make a distinction between tax evasion and tax fraud. But for the US, any person not paying taxes as per the laws of the land is liable to be persecuted. There is, however, little doubt that the current political climate (The Democrats are in charge in the U.S.)and the general anger against bankers has considerably aggravated the issue. In general, in developed countries, financial crises/losses often lead to calls for legislative action. This is clearly the case today as legislators have threatened to impose various restrictions on the way bankers are compensated.

Towards integrated risk management: the three ways of managing risk

In a world of risk, it is important not only for banks but also for non banking corporations to manage risks strategically and holistically. Integrated risk management is all about the identification and assessment of the risks faced by a company as a whole, followed by the formulation and implementation of a companywide strategy to manage them. According to Lisa Melbroek[109], companies must learn to use the best combination of three complementary approaches to risk management.

- The first is to modify the company's operations suitably.
- The second is to reduce debt in the capital structure.
- The third is to use insurance or financial instruments like derivatives to transfer the risk.

Take the case of the environmental risk that a heavy chemicals manufacturer faces. Modifying the company's operations could mean installation of sophisticated pollution control equipment. The company could also reduce debt and keep plenty of capital to deal with any contingencies arising out of environmental mishaps. The company can also achieve risk transfer by buying an insurance policy that would protect it in case an accident occurs.

An oil company needs a steady supply of petroleum crude to feed its refinery. Oil prices can fluctuate, owing to various social, economic and political factors. Indeed, they have done so in recent years. The company can set up, or at least tie up, with a large number of oilfields all over the world to insulate itself from volatility. This would limit the damage due to Opec actions, terrorist strikes or instability in Islamic countries. In case of a long recession, the best bet for a company would be to keep minimum debt and maintain huge cash reserves. The company may also resort to buying oil futures contracts that guarantee the supply of crude at predetermined prices.

A company like Walt Disney, which operates theme parks, is exposed to weather risks. If the weather is not sunny, people will not turn up. So, Disney took a decision to set up its second theme park in Florida. Today, the company can buy weather derivatives or an insurance policy to hedge the risks arising from inclement weather.

A similar argument may well apply to the Board of Control for Cricket in India (BCCI). These days, with big money involved, especially in the form of television rights, cricket matches are scheduled all through the year. So the threat of rain is real. If a match is washed off, the losses will be heavy. BCCI has two options. It can stick to the cities where there is little rain. In the long run, it can even explore the possibility of indoor stadia. This is the operational solution. Alternatively, BCCI can take insurance cover. This is the risk transfer approach.

The software giant, Microsoft, operates in an industry where technology risks are high. The company manages risk by maintaining low overheads and zero debt. But Microsoft also has organisational mechanisms to deal with risk. The capacity of a software

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[109] "Integrated Risk Management for the firm: A senior Manager's Guide," Working Paper, Harvard Business School, 2002.

company is effectively the number of software engineers on its payroll. Excess capacity can create serious problems during a downturn. Right from the beginning, Microsoft's founder, Bill Gates was particular about not employing more persons than required. So, Microsoft has always maintained lean staffing, depending on temporary workers to deal with surges in workload from time to time. This not only reduces the risk associated with economic slowdowns but also results in greater job security for its core group of most talented workers.   In contrast, many Indian software services companies have traditionally maintained a huge "bench." This became a major liability during the recent downturn fuelled by the financial crisis.

India's well known software services company, Infosys maintains plenty of cash. Infosys believes cash gives a lot of comfort in a volatile industry, characterised by swift changes in technology, and shifts in client spending patterns. To sustain operations under adverse conditions, and make investments in marketing and R&D, Infosys depends heavily on equity and keeps little debt on its balance sheet.

Airlines can manage their exposure to fluctuating oil prices by taking operational measures to cut fuel consumption. This might involve better maintenance of the air craft or purchase of more fuel-efficient engines. Another option is to buy financial instruments such as futures to hedge this risk. This is the risk transfer approach.

The Collapse of Bankers Trust[110]

Bankers Trust is a good example of the failure to approach risks in an integrated way. Under the leadership of Charles Sanford, Bankers Trust was transformed from a sleepy commercial bank into a financial powerhouse using risk management as a competitive tool. In 1994, however, the bank became entangled in a high-profile lawsuit with Procter & Gamble that badly damaged the bank's name. Many customers shied way from the bank after the bad publicity. In an attempt to restore its reputation, the bank brought in a new chief executive, Frank Newman, in 1996. Newman, quickly reached an out-of-court settlement with P&G. The bank's trading activities were scaled down. Bankers Trust also recognized that its profit-driven culture often placed the bank's profit before the client's interest. Various changes were implemented in the bank's compensation schemes to reward salespeople for improving relationships with customers.

The new plan failed to take hold, however. By October 1998, the bank's stock price was back at its level of early 1996, underperforming its peer group. In November 1998, Bankers Trust was acquired by Deutsche Bank.

Various factors determine the choice of the approach to handling risk. Often a combination of these approaches makes sense. The choice between a financial and organisational solution varies from risk to risk. As we briefly mentioned earlier, strategic risks, which are core to the business and are critical to the generation of shareholder value have to be retained. So they invariably need organisational solutions. Where suitable financial instruments do not exist for risk transfer, organizational solutions may be unavoidable. In the case of some risks, organisational solutions may be too complicated, too expensive or may conflict with the company's strategic goals. In such situations, risk

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[110] Philippe Jorion, "Value at Risk: The New Benchmark for Managing Financial Risk," McGraw Hill, 2007.

transfer solutions such as derivatives or insurance may be more efficient than organisational solutions.

The ultimate strategy for the rainy day is to keep overheads and debt low and hold plenty of cash to tide over uncertainties about which managers have little idea today. Indeed, equity is an all-purpose risk cushion. The larger the amount of risk that cannot be identified, accurately measured or quantified, the more the equity component should be. It is no surprise that technology companies like Microsoft and Infosys keep little or no debt on the balance-sheet. Of course, equity is a more expensive source of funds. Equity holders expect a much higher rate of return, compared to debt providers. But that might well be a small price to pay in a volatile business environment. During a severe downturn, a comfortable capital position can give a company a major competitive advantage by allowing it to pursue an acquisition or a major investment that might well have had to be postponed otherwise.

Lessons from past crises

A failure to understand the inter-relationships between different risks and deal with them in a holistic manner can lead to serious problems. For example, the practice of mark-to-market in a derivatives trade reduces credit risk but at the expense of more frequent collateral payments. This cash requirement creates liquidity risk, as we have seen, earlier in the Chapter. Moreover, there is an increase in operational risk as mark-to-market involves additional transactions. Contracts need to be valued on a regular basis and cash exchanged with the counterparty.

Long Term Capital Management (LTCM), controlled its market risk by pursuing what are called convergence trades in bond markets. LTCM would go long in one set of financial instruments and short in another related set. The yields would, under normal circumstances, converge with time, enabling LTCM to book profits.

Unfortunately, in 1998, the market conditions became abnormal. The assumptions behind the hedge fund's sophisticated models became unrealistic. Yields started diverging instead of converging, following worries among investors about the stability of emerging markets in the aftermath of the Asian currency crisis and the plunge of the Rouble in Russia. LTCM's positions were fundamentally sound but the fund did not have the liquidity to hold on till the situation improved. As it suffered losses on its positions, LTCM had to meet margin calls. When it tried to raise capital, there were few takers. With insufficient liquidity, LTCM went bankrupt and had to be bailed out under a Federal Reserve sponsored plan. What actually happened was that market risk became liquidity risk.

In the 1980s, many American banks gave dollar-denominated floating rate loans to countries like Mexico and Brazil to eliminate market risk or more specifically exchange rate and interest rate risk. When interest rates in the US sky-rocketed during the tenure of Federal Reserve chairman Paul Volcker (who was fighting a fierce battle against inflation then) and the dollar appreciated, there were major defaults. In short, market risk was transformed into credit risk.

The well known investment bank, Barings collapsed because of poor operational risk management. Since then operational risk has become a senior management concern particularly in banks. Operational risk deserves a separate treatment but cannot be completely delinked from market and credit risk. Indeed, operational risk losses are often contingent on market movements. In the case of Barings, if the market had moved in Nick Leeson's favor, there would have been no loss. The fraud and breakdown in the bank's control system would probably never have come to light. Indeed, if the market movement had been favourable, Leeson would not have resorted to the kind of malpractices he adopted to conceal his losses.

Operational risks may also interact with credit risk. For example, when mistakes are made in a loan's documentation, it is usually the case that losses result if and only if the counterparty defaults.

A fundamental understanding of the business context of market participants and their motivation is the starting point in integrated risk management. During the Asian currency crisis of 1997, many Asian Institutions had borrowed in US dollars to take advantage of low US interest rates and decided to invest in local currencies such as the Thai Baht with high interest rates. These currencies had been by and large pegged to the dollar. But on account of worries about the growing trade deficits in some of these countries, speculators began to sell their currencies. As the currencies fell, the loan repayment burden increased and so did the defaults. The scale of defaults was much higher because counterparties were using the swaps to speculate, not to hedge. More generally, when a counterparty uses the trade as a hedge, a loss on the trade would be offset by an operating gain on the underlying asset. So a market gain for the bank or loss for the counterparty does not increase the probability of default. In contrast, when the counterparty uses the trade to speculate, a default is more likely in the event of a market loss.

Business units must not be considered in silos while managing risk. Consider a mortgage company. Loan origination generates revenues from new mortgage loans. This business performs well when interest rates are falling. Not only are new customers attracted but also many existing home owners may decide to refinance their loans. But this business suffers when rates increase. On the other hand, the loan servicing business typically generates revenues from the monthly loan payments. When interest rates increase, the life of the loans is extended because home owners refinance less. In short, the two business lines have negative correlation. By appreciating this correlation, the bank can have a better grip on the risks facing the organization as a whole and minimise over/under hedging.

Economic Capital and Risk Adjusted Return on Capital

Economic capital refers to an organization's estimate of the capital it needs for the risk it is taking. The time horizon for measuring economic capital is usually one year while the confidence level would depend on the specific context. Economic capital is needed to take care of unexpected losses. Economic capital provides a robust platform for integrated risk management. The loss distributions for different types of risk across

business units are aggregated. The final aggregation gives the probability distribution of total losses for the financial institution or organization as the case may be.

Exhibit 8.3
Deutsche Bank: Economic capital usage

Economic capital usage in € m.	Dec 31, 2008	Dec 31, 2007
Credit risk[1]	8,986	7,043
Market risk[1]	8,794	4,944
Trading market risk	5,547	3,227
Nontrading market risk	3,247	1,718
Operational risk	4,147	3,974
Diversification benefit across credit, market and operational risk	(3,134)	(2,651)
Sub-total credit, market and operational risk	18,793	13,310
Business risk	513	301
Total economic capital usage	**19,306**	**13,611**

1 Traded default risk is reported under trading market risk beginning in 2008. It was reported previously under credit risk. Amounts above for 2007 have been restated.

Exhibit 8.4
Deutsche Bank: Economic capital across businesses

The table below shows the economic capital usage of our business segments as of December 31, 2008.

Dec 31, 2008 in € m.	Corporate and Investment Bank			Private Clients and Asset Management			Corporate Invest-ments	Total DB Group[2]
	Corporate Banking & Securities[1]	Global Trans-action Banking	Total	Asset and Wealth Manage-ment	Private & Business Clients	Total		
Total economic capital usage	14,361	590	14,951	1,456	2,341	3,797	550	19,306

1 Central Areas & Support items allocated to CB&S.
2 Including € 8 million of Consolidation & Adjustments.

A related concept that has become popular in recent years and will undoubtedly become even more widely applied in the coming years is risk adjusted performance measurement (RAPM). One way to measure RAPM is to divide the profits earned by Value-at-Risk. Another way to do so is to calculate the risk adjusted return on capital, RAROC. This is defined as:

RAROC = [Revenues − Costs − Expected losses] / Economic capital

RAROC is a powerful management fool for comparing the performance of different divisions. RAROC can also be used to decide where more investments should be made and where less.

The best economic capital allocation schemes take into account the incremental impact of the business unit on the total economic capital. The amount of capital allocated to a business unit should also take into account the diversification benefits.

Conclusion

The Counterparty Risk Management Policy Group (CRMPG) was formed to strengthen risk management practices after the collapse of LTCM in 1998. The group recommended that financial institutions should apply an integrated framework to evaluate market, credit and liquidity risk. Institutions must stress test their market and credit exposure, taking into account concentration risk to counterparties and also the impact of liquidation of

large positions on the markets. Many institutions started to integrate the credit and market risk functions after the LTCM crisis. That trend seems to have accelerated following the sub prime crisis. Banks are realizing that liquidity risk must be integrated with market and credit risk. And as we saw a little earlier, even operational risk cannot be completely delinked from market and credit risk. The same argument applies to legal risks.

Integrated risk management has the potential to create significant value for shareholders. By treating their risks as part of a single portfolio, organisations can have a better understanding of their risk situation. They do not need to take separate insurance cover against each type of risk. Transaction costs can be reduced if the hedging problem is viewed on a companywide basis. Efforts to limit one kind of risk often lead to an increase of another kind. The only way to prevent this is by taking an integrated, holistic approach.

Case Illustration: Nurturing a risk culture at Goldman Sachs[111]

Introduction

As we mentioned right at the start of the book, businesses cannot survive in the long run without taking risk. At the same time, the risks an organization takes must be understood carefully and managed effectively. All global banks invest heavily in risk management models. But what distinguishes the successful banks from the others is the way risk management is embedded in the fabric of the organization. No organization symbolizes this better than Goldman Sachs. While many banks have been mauled and bruised by the sub prime crisis, Goldman has actually thrived and made money. So much so that it has become the target of attack for many politicians in the US.

Background Note

Goldman's ability to handle risk is the outcome of a culture that has been shaped and nurtured by its senior leaders starting from Sidney Weinberg (who for all practical purposes founded the organization) to the current CEO, Lloyd Blankfein, a lawyer by training but who understands financial markets better than most people in the world. All these leaders have had a deep appreciation of risk management and struck the right balance between excessive caution and too much aggression.

Weinberg, as Richard Ellis, mentions in "The Partnership," knew the markets first hand and had a feel for both numbers and people. Weinberg shaped a culture of meritocracy in Goldman. To foster a long term orientation among managers, he kept payouts to partners low, forcing them to build equity in the firm. This policy played a crucial role in shaping the risk culture at the firm. As a partner remarked, "It was good for the firm because it made everyone focus always on what was best for Goldman Sachs as a whole firm."

Weinberg's successor, Gus Levy, a man of action, built on the foundation laid by Weinberg. On decisions where he was involved, Levy expected short and crisp recommendations. He detested ambivalence and uncertainty. Levy could operate at both ends of the spectrum. He delegated various issues and yet became completely hands on in others. Levy was also a persistent learner. As he once mentioned (*The Partnership)*, "Don't tell me where we're good. We can't do much about that. Tell us where we're weak, where we can improve, because that is what we are determined to do."

Under Levy, Goldman built the block trading business. Block trading meant transactions involving hundreds of thousands of shares. A risky but lucrative business, Goldman put in place a framework to control the risks involved. Goldman decided to buy blocks only from institutional traders who would treat the firm fairly and who would make up by doing extra business later if Goldman made losses on a transaction. The second risk

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[111] This case draws heavily from the book, "The Partnership - A History of Goldman Sachs," by Charles D Ellis.

imperative was the ability to sell blocks quickly so that the inventory "turned over" and there was no "warehousing." To facilitate swift reselling, Goldman built up a superb market information network and close contacts with clients at major institutions. By putting up capital, Goldman successfully ramped up a business that was "priced as a risk taking principal trade but then executed quickly as a no risk agency trade."

John Whitehead, along with John Weinberg, Sidney Weinberg's son took over the leadership mantle from Levy. Whitehead articulated the core values of Goldman. One of the values for which Goldman has developed a stellar reputation is teamwork. Whitehead wrote: "We stress teamwork in everything we do. While individual creativity is always encouraged, we have found that team effort often produces the best results. We have no room for those who put their personal interests ahead of the interests of the firm and its clients."

Steve Friedman and Robert Rubin, the next line of leaders initiated bold steps to take Goldman forward. The traditional customer oriented agency business did not look promising in the long run. Big profits could be made only by committing money to proprietary trading. At that point of time, Goldman trailed way behind in the fixed income business, compared to players like Salomon Brothers and First Boston. In 1985, Rubin and Friedman recruited several experienced bond dealers from Salomon Brothers to change the culture of the fixed income division and introduce a "bold, risk embracing, capital intensive proprietary business model."

Rubin made a very important move, when on the advice of Robert Merton, he brought Fischer Black, a young MIT professor and well known for the Black Scholes model, to Goldman. Rubin's brief to Black was to develop rigorous analytical models that could be profitably used by traders. As a senior Goldman executive mentioned[112], "Bob had the vision to appreciate how the guys with the academic theories and quantitative models could work with traders and add substantial value. " Together, Black and Rubin launched an "intellectual revolution" in the firm. As the news spread, many other talented quants joined Goldman.

Recent developments

Hank Paulson, who became a celebrity worldwide, as the US Treasury Secretary, (for both the right and wrong reasons) at the height of the sub prime crisis, decentralized decision making at Goldman even as he increased the coordination of the different operating units through centralized disciplines: risk controls, business planning, performance measurement. Paulson once mentioned[113], "The things that make a good leader are being open minded, having a willingness to really ask for and accept advice, showing a sense of humility and putting the right people in the right seats." Paulson strategically repositioned the firm and announced that Goldman would be both principal and agent.

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[112] "The Partnership - A History of Goldman Sachs," Charles D Ellis.
[113] ibid

Lloyd Blankfein who succeeded Paulson maintained the momentum that pushed Goldman more and more into proprietary trading. The firm began to integrate the roles of advisor, financier and investor. It not only advised clients but also committed capital. With clients expecting investment banks to help finance the transactions they recommended, Blankfein believed Goldman had to be more willing to use its capital on behalf of clients and on its own account. The strategic choice was not agency or principal but actually both. But proprietary trading involves risks of a different order. In particular, valuation of assets can be a problem when the markets are not very liquid. During the sub prime crisis, when traders found it difficult to price their portfolios, Blankfein asked them to sell 10% of their portfolio to arrive a realistic price for the purpose of valuation.

Learning from mistakes

Like most successful organizations, Goldman too has had its share of luck. In 1970, the bank found itself facing a major crisis after Penn Central, the US rail road company declared bankruptcy. Goldman had been selling the company's commercial paper aggressively. Many clients filed lawsuits. The judge ruled that Goldman had failed to disclose material information. Goldman lost $30 million over several years. Though the financial losses were heavy, there was a silver lining on the cloud as a senior Goldman executive mentioned[114], "Some real good came out of it. All the partners pulled together to work through a life threatening situation. There were no recriminations and no fault finding…. Humbled and chastened by Penn Central, Goldman Sachs avoided the disease of arrogance that did long term harm to other firms on Wall Street." Goldman moved quickly to increase controls and define a clear division of responsibilities between credit approvals and client service.

In the early 1990s, Goldman faced another crisis on account of the publishing tycoon, Robert Maxwell. Maxwell had been a high profile Goldman customer. In fact Goldman was described as Maxwell's "principal financial enabler" in his later years. Unable to bear his financial commitments. Maxwell committed suicide in 1991. By that time he had piled up unpayable bank loans amounting to about $2.8 billion and plundered about $500 million from two public companies and the pensions of some 33,000 British workers. Eventually, Goldman had to pay $254 million to settle the issue.

Looking back, the partners realized that the Maxwell episode was the result of lax supervision and inadequate checks and balances. A small trading relationship became large and unacceptable over time. Following the fiasco, Goldman imposed much stronger and rigorous risk controls on the organization.

Goldman seems to have learnt its lessons from past failures, well. That explains why it came out with flying colours from the sub prime crisis. At the right time, partly due to foresight, partly due to luck, Goldman decided to cancel underwriting any pending CDO issues and sold all the inventory it could. The bank made major bets against the ABX index, a proxy for the prices of credit default swaps. Goldman managed to exit the

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[114] "The Partnership - A History of Goldman Sachs," Charles D Ellis.

market at the right time. Later, as many global banks like UBS completely withdrew from fixed income, Goldman continued to maintain its presence. As a result, it made record profits in 2008. Goldman's stock has been doing very well indeed as we approach the fall of 2009. This is a clear reflection that the markets see Goldman emerging as a clear winner from the sub prime crisis.

Conclusion

What are the lessons from Goldman Sachs?

- The firm's culture embraces rather than avoids risk. This is a mindset that is remarkably different from the typical corporate approach. Goldman makes money by being willing to risk losing it.

- Goldman ensures that its managers are familiar and comfortable with risk, can debate it freely without fear of sanctions, and are willing to make decisions quickly when necessary. The company's aggressive hedging in 2007 in markets related to subprime mortgages was a striking example of this.

- Unlike many other banks, the top management of Goldman have a deep appreciation of mathematical modeling. Beginning in the early 1980s, Goldman recruited experts in mathematical modeling. These quants provided the quantitative and intellectual rigor needed to support Goldman's complex trading and derivatives businesses.

- Goldman takes a firm wide, integrated approach to risk management. Under the leadership of Jon Corzine, Goldman revamped risk management by establishing the Firm-wide Risk Committee to oversee market and credit risk worldwide. The committee, which meets weekly, attempts to ensure that certain risk-return standards are applied consistently across the firm. Individual committees get into details in specific areas. Operational and reputational risks are addressed by the Business Practices Committee Loan and underwriting risks are addressed by the Capital and Commitments committees. Liquidity risk is managed by the Finance Committee.

- Goldman has invested heavily in measuring risk. This facilitates effective risk control. Daily risk reports detail the firm's exposure, showing the potential impact of changes in various macro risk factors. Stress tests indicate potential losses under a variety of scenarios, such as a widening of credit spreads.

- Goldman's partnership culture has stood it in good stead over the years. From its earliest days in 1869 to its IPO in 1999, Goldman was funded largely by its own partners. Goldman's partners usually left as much as 80% of their after-tax earnings in the firm. They withdrew substantial amounts of capital only after retirement. The partners were careful stewards of the firm's capital because it was their own. Goldman's most senior executives maintain this tradition.

- All banks articulate the importance of protecting their reputation. But none take this more seriously than Goldman. The bank demonstrates the importance of reputation in various ways. New hires are taught the importance of safeguarding the firm's reputation. They are encouraged to solicit independent views from risk, compliance, legal, and other powerful control functions when they face ethical dilemmas.

Unilateral decisions that put the reputation of the firm at risk are severely looked down upon.

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Chapter - 9
Regulating Risk: Some Strategic Perspectives

"The difficult issues regulators must address include the appropriate degree of protection for financial institutions, the regulation of non bank entities (such as hedge funds) and the determination of adequate capital levels. Brave – even radical changes may be necessary."

- *Patrick Butter[115]*

Introduction

Banks are fundamentally different from other corporations in other industries. Banks lie at the heart of the economy. A large section of the population keeps their money with them. Many businessmen and small entrepreneurs depend heavily on these institutions for their capital requirements. Banks create and sustain markets for financial instruments and help in channelising savings into productive investments. They also facilitate payment flows among customers. It is difficult to conceive of a modern economy working without banks.

When a bank fails, the consequences are serious. And when a number of banks fail, the impact can be disruptive for the economy. For example during a banking crisis, investors may retreat to safe government securities, due to lack of confidence in the financial system. This may lead to a sharp decline in investment spending. Consumers may also postpone purchases. As a result, recessionary pressures will gather strength. Several percentage points of GDP growth may be lost in the process. This is exactly what happened during the recent financial crisis.

In this chapter, we examine briefly the current state of banking regulation and then discuss the kind of changes that can be expected in the coming years.

The fragility of banks

Banks are inherently fragile as they use a small amount of capital and leverage it to build huge asset positions. Banks assume that all depositors will not demand their money back at the same time. From time to time, banking crises have been witnessed as panicky depositors have tried to withdraw money in droves.

Since banks are inherently fragile, most countries have a system of deposit insurance, which protects small investors in the event of a bank failure. This guarantee of a "bailout" for small investors helps in maintaining customer confidence and consequently preventing a run on the bank. But deposit insurance can lead to a moral hazard problem. Banks may end up taking more risk than they can handle. Also, because they are protected by insurance, depositors may have little incentive to monitor banks. This is where a strong regulatory framework comes in. Regulation aims at providing a robust risk management framework for financial institutions and checking whether enough capital has been set aside to deal with various risks.

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[115] "Learning from financial regulation's mistakes," McKinsey Quarterly, 2009, Issue 3.

In short, the following are the reasons given to justify the existence of banking regulation:

- A bank's depositors are too small to monitor the performance of the bank.
- Banks facilitate payment against and settlement of transactions. If payment and settlement systems break down, there will be chaos.
- The failure of a bank can have systemic effects because of interlinkages with other financial institutions. The systemic risk must be managed carefully. Otherwise, there will be a crisis in the financial markets.
- The collapse of a major financial institution can affect industrial investment in the region. Other banks may not be able to step in with substitute offers as they may not have enough information on the clients.

A brief overview of the regulatory framework across the world

Financial institutions can be broadly divided into three categories: Commercial banks, Securities houses and Insurance companies. We leave out insurance as it is outside the scope of this book. Commercial banks and Securities houses must be considered together as most commercial banks (except the small regional players in each country) often have investment banking activities and vice versa.

The regulatory framework applicable to financial institutions, varies across the world. The Basle Committee has played the pivotal role in shaping regulation for banks in the past 20 years. In some countries, regulation is unified while in others, multiple regulators exist. The UK is a good example of unified regulation while the US has several regulators.

In the US, there are three main agencies to regulate commercial banks. These are the Federal Reserve, Office of the Comptroller of the Currency and the Federal Deposit Insurance Corporation. The main regulatory authority for securities houses is the Securities and Exchange Commission (SEC).

The UK has only one regulator, the Financial Services Authority (FSA) whose jurisdiction extends across banks, securities markets and insurance companies. The FSA was set up in October 1997.

In Japan, the Financial Services Agency was established in July 2000, to supervise banks, securities houses and insurance companies. The Agency shares responsibility with the Bank of Japan for monitoring financial institutions.

Regulation of securities houses differs substantially from that applied to banks. The aim of capital in case of securities houses is to ensure an orderly liquidation of positions if things go wrong. This is unlike banks where capital is measured on an ongoing basis. The International Organization of Securities Commissions (IOSCO) based in Montreal, addresses regulatory problems related to international securities transactions. The IOSCO and Basle Committee collaborate on common regulatory issues. Moreover, the distinction between commercial and investment banks has thinned down considerably in recent years.

In the last 80 years, the regulatory framework has evolved steadily. The real momentum of course has come only in the past 20 years, with the Basle framework shaping the agenda. Basle I which began with a focus on credit risk has given way to a more comprehensive Basle II. Today, the Basle framework covers credit, market and operational risk. And even Basle II is likely to undergo a major revamp in the light of the subprime crisis, and the stated intentions of the national regulators in countries like the US, the UK and Switzerland to introduce significant changes in the regulatory framework. It will take some more time, as we approach the fall of 2009, for the air to clear and for us to have a complete grip on where regulation is headed. Nevertheless, we will examine the limitations of Basle II and some of the possible changes which may be introduced, later in the chapter.

Background

The US is pretty much the global leader in financial services. So much of the discussion will revolve around the US. Two watershed events, the crisis of 1907 and the Great Depression, have had a major influence on the regulatory framework in the US. The crisis of 1907 led to the establishment of the Federal Reserve (The Fed). The Great Depression of the late 1920s and early 1930s led to extensive structural reforms of the American financial system. Various steps were taken by the US administration to restore confidence in the banking system. These included deposit insurance and the separation of investment banking from commercial banking, through the Glass Steagall Act of 1933. The Federal Deposit Insurance Corporation (FDIC) was set up in 1933 to offer unconditional guarantees to most depositors of American banks.

Over time, a system of multiple regulators evolved in the US. For example, the Securities Exchange Commission (SEC) began to regulate securities trading firms. The National Association of Insurance Commissioners laid down the guidelines for insurance companies. Various regulatory authorities were created at the state level. The Commodity Futures Trading Commission (CFTC) began to regulate the futures markets.

Meanwhile, in many European countries such as France, the response to the Depression was much stronger. The banking sector began to be controlled both through extensive regulation and public ownership.

All these reforms in the developed countries, succeeded in containing banking crises. But in the process, risk taking and competition were so tightly controlled that the basic function of the financial system, to allocate financial resources efficiently, was defeated. Over time, pressures soon started to mount for the liberalization of the financial system. And liberalization quickly became the theme for many governments. Indeed, liberalisation proceeded with great gusto in different countries across the world in the subsequent three decades. The Financial Services Modernisation Act of 1999 (Gramm Leach Bliley Act) repealed the major provisions of Glass Steagall. Banks could expand significantly their range of financial services in any type of business including brokerage and insurance.

From time to time, in the past five decades, there have been financial crises. But there has been nothing on the scale of the recent global meltdown, which marks another watershed event in the history of banking regulation. The fundamental tenets of regulation have been challenged, following the sub prime crisis.

Even as the regulatory framework evolves in the aftermath of the subprime crisis, there is demand for standardization of banking regulation across the world. Banking activities do vary from country to country. So a one size-fits all approach may be neither practical nor desirable. Yet the general consensus is that some degree of global standardization of banking regulations is desirable. Otherwise, there would be regulatory arbitrage with banks shifting their activities to regions which are lightly regulated.

The Basle accord

The Basle Committee[116] on Banking and Supervision was established in 1974 by the governors of the G-10 central banks. The need to set up this committee was felt in the aftermath of various crises on the foreign exchange markets, and in particular, the Herstatt Bank[117] crisis of 1974. The committee began to formulate broad supervisory standards that it hoped would be embraced by national regulators.

Before 1988, regulators across the world looked at the leverage ratio or the ratio of capital to total assets as the key parameter to monitor. But the definition of capital and the ratio chosen varied across the world. This led to the pursuit of regulatory arbitrage. Banks tried to expand activities in regions with less capital requirements. At the same time, the kinds of transactions undertaken by banks became increasingly sophisticated. Many derivative positions were held off balance sheet and consequently did not need to be backed by capital. It became increasingly clear to the authorities in the developed countries that the system had major lacunae.

The period until the mid-1990s was characterized by a rather rigid and standardized regulatory approach. Since the mid-1990s, market discipline and recourse to internal models have been emphasized. Basle II represents an intermediary step. It encourages internal models and self discipline. But only those banks which meet specified criteria, can use internal models.

Basel I

The supervisory authorities of Belgium, Canada, France, Germany, Italy, Japan, Luxembourg, the Netherlands, Sweden, Switzerland, the UK and the US came together in Basle to form the Basle committee on banking supervision. They met under the patronage of the Bank for International Settlements, BIS. In 1988, they came up with a framework to set international risk based standards for capital adequacy. The accord

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[116] For various documents published by the Basle Committee, visit www.bis.org

[117] The Herstatt Bank crisis is a landmark event in the field of Credit Risk Management. Herstatt Bank had received foreign currency payments but collapsed before making its US dollar payments. As a result, many counterparties incurred heavy losses. CLS (Continuous Linked Settlement) Bank, set up in 2002 allows members and clients to settle payment instructions related to foreign exchange deals in real time. This eliminates time zone differences, payment delays and consequently settlement risk.

which came to be popularly known as Basle I, created greater awareness about the risks in banking and encouraged banks to devote more resources to understanding, measuring and managing risks. The primary objective of Basle I was to promote the safety and soundness of the global financial system and to create a level playing field for internationally active banks.

Initially, Basle I covered only credit risk. Basle I prescribed two minimum standards – assets to capital ratio of at most 20 and a Cooke ratio of 8%. The Cooke ratio was defined as the capital divided by the total of risk weighted assets. Each balance sheet item was allotted a risk weight. For example, cash and securities issued by OECD governments were given a risk weight of zero. On the other hand, loans to corporations had a risk weight of 100%. Loans to OECD banks and government agencies had a risk weight of 20%.

The total capital (minimum of 8% of risk weighted assets) had two components. Tier I capital consisted of "permanent" items such as equity. This component had to be at least 4% of risk weighted assets. (The Basle capital adequacy norms certainly look small when we consider that in the late 19th century, a typical American/British bank held core capital equal to 15-25% of its assets. And even in the 1960s, British banks held about 25% of the assets in the form of low risk, liquid government bonds and cash. Going into the sub prime crisis, the core capital for some banks was less than 3% of assets. Merrill Lynch would have needed an estimated core capital ratio of 23% before the sub prime crisis to avoid going below the 4% minimum level as the crisis began. For UBS, that figure would have been about 17%.) Tier 2 capital, also called supplementary capital included other items such as long term subordinated debt. See details below:

Tier I capital or core capital included:

- *Equity capital or shareholder's funds*. These included common stock and non redeemable, non cumulative preference shares.
- *Disclosed reserves*. These included share premiums, retained profits and general reserves.

Tier II capital included:

- *Undisclosed reserves:* These were reserves that had passed through the earnings statement but remained unpublished.
- *Asset revaluation reserves:* These were the result of revaluation of assets like long term holdings of equity securities.
- *General provisions/Loan loss reserves:* These were held against future unidentified losses.
- *Hybrid debt capital instruments:* They were somewhere between equity and debt. eg., is cumulative preference shares.
- *Subordinated term debt:* This needed to have a minimum original maturity of five years.

Tier 3 capital consisted of *short term subordinated debt* with a maturity of at least two years. This component could only be used to cover market risk. The amount of Tier 3 capital was limited to 250% of Tier I capital that supported market risks.

Some items were deducted from the Capital base. These included goodwill and investments in financial entities.

G-30 Policy recommendations[118]

In 1993, an influential group of market participants, dealers, academics, accountants and lawyers active in derivatives markets published various risk management recommendations. Of these, 20 were targeted at dealers and four at legislators, regulators and supervisors. Some of the key recommendations of the group were:

- Derivatives positions should be marked to market at least once a day.
- Market risk must be measured using a consistent measure such as value-at-risk.
- The risk management function should be independent of the trading operation.
- People responsible for setting credit limits should be independent of those involved in trading.
- There should be adequate systems in place for capturing and processing data, settlement and preparing reports.
- There should be consistency in income recognition treatment between hedging instruments and the risks being managed.

The 1996 amendment

Efforts to amend Basle I began in 1995 and were implemented in 1998. The Amendment officially recognized market risks. A distinction was drawn between the *banking book* and the *trading book*. The banking book consisted primarily of loans and was generally not marked to market. These *held-to-maturity* assets were valued on historical cost basis. The trading book consisted of various instruments including derivatives and was typically marked to market daily. These instruments were *held for sale*.

The amendment added a capital charge for the market risk of trading books and the currency and commodity risk of the banking book. But the credit risk charge excluded debt and equity securities in the trading book and positions in commodities and foreign exchange. There was a market risk capital charge for all items in the trading book whether they were on or off balance sheet.

The amendment outlined a standardized approach for measuring the capital charge for market risk. Capital was assigned separately to different categories of instruments without considering the correlation that existed among them. The more sophisticated banks were allowed to calculate value-at-risk (VaR) using their internal model, with a 99% confidence level and a 10 day horizon.

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[118] http://group30.org

Using internal models, the market risk capital was calculated as:

(k) (VaR) + SRC

k being a multiplicative factor > 3 and SRC, the specific risk charge being the capital charge for risks particular to the company.

Total capital was arrived at using the formula:

Total Capital = (.08) (credit risk risk weighted assets + market risk risk weighted assets).

Basle II

Basle I had some limitations. For example, it was not granular enough. Loans to two corporations with different risk ratings were treated in the same way. Default correlations were not considered. In June 1999, the Basle committee proposed new rules. Based on different studies and recommendations, Basle II was launched. Though it is mandatory only in Europe, many regulators and banks all over the world have accepted Basle II as a voluntary step towards the improvement of the banking system. The fine tuning and implementation of Basle II has been a long drawn out process. Indeed, in many banks, implementation of Basle II was in an advanced stage, when the sub prime crisis struck.

Basle II is based on three pillars:
- Minimum capital requirements
- Supervisory review
- Market discipline

Minimum capital requirements
Capital is the ultimate risk buffer for banks. Without adequate capital, banks will find it difficult to cope with tough market conditions. The *minimum capital requirement* takes into account not only credit and market risk but also operational risk. The total capital remains 8% of total risk weighted assets. But this figure is being intensely debated and is likely to go up to double digits in the coming years. We shall cover the approaches for calculating risk capital, later in the chapter. The table below covers the different approaches at a glance.

The average level of losses a bank considers as reasonable, given the nature of its business is called *expected loss*. This is effectively the cost of doing business. Such a loss must be provisioned and built into the prices of the products/services being offered.

On the other hand, losses above the expected level have to be dealt with differently. Such losses cannot be anticipated in terms of timing or severity. The market will not support product prices that will cover all *unexpected losses*. So to cover such losses, banks need capital.

Exhibit 9.1
Computing Risk Capital Under Basle II

Credit Risk	▪ Standardised
	▪ Foundation Internal Ratings Based
	▪ Advanced Internal Ratings Based
Market Risk	▪ Standardised
	▪ Internal Models Based
Operational Risk	▪ Basic Indicator
	▪ Standardised
	▪ Advanced Measurement Based

Excess capital provides the bank a cushion but raises the cost of doing business. Reducing capital frees up economic resources. So an appropriate balance has to be maintained. It was the general view before the sub prime crisis that an amount of capital equal to 8% of risk weighted assets was adequate. But following the turmoil in the global financial markets since mid-2007, a consensus seems to be emerging that 12-15%[119] may be a better bet. Moreover, as mentioned earlier, capital consists of various components, Tier I, Tier II, and Tier III. The focus is now more on Tier I (the most permanent component) rather than the total capital. Regulators are also beginning to give greater importance to leverage ratio, i.e., the ratio of total assets to equity.

A report in the *Economist*[120] indicated that 19 major financial firms in the US, based on stress tests conducted by the US treasury, needed to hold a minimum core capital of $313 billion. During the sub prime crisis and its aftermath, these banks will consume about $317 billion of capital to cover losses. That means at the start of the crisis, the banks would have needed to keep $630 billion of capital or about 8.1% of their current risk weighted assets. At the end of 2007, the financial systems in western countries held about 6% capital. And Basle rules allowed the core capital ratios to go as low as 2%. Looking back, it seems a peak core capital ratio of 10% might have been needed for the big American banks to cope effectively with the sub prime crisis. At the same time, it would be too simplistic to argue that raising capital requirements will solve all problems facing the banking system today. To take an example, Lehman Brothers had a Tier I capital ratio of 11%, a few days before it went bankrupt.

Supervisory review
Supervisors need to ensure that:
▪ Banks have in place a process for assessing capital in relation to risk.
▪ Banks operate above minimum regulatory capital.
▪ Corrective action is taken as soon as problems develop.

The *supervisory process* allows regulators some discretion in how rules are applied. At the same time, Basle II attempts to achieve consistency in the way rules are applied. The

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[119] As I am finishing this book, an article by Peter Boone and Simon Johnson, "A bank levy will not stop the doomsday cycle," Financial Times, January 19, 2010 argued in favour of at least $20 - 25$ percent of assets in core capital.
[120] July 11, 2009

new accord places more emphasis on early intervention when problems arise. Supervisors are expected to be proactive and encourage banks to develop and use better risk management techniques.

Supervisors must also attempt to identify risks that are not covered by Pillar I. They are expected to engage in an active dialogue with the banks and deal with gaps and deficiencies when identified. Supervisors must act early to prevent capital from falling below the minimum levels required to support the risk exposure. They must insist on immediate corrective measures if capital falls below the minimum level required. The Basle framework also emphasizes transparency and accountability in the procedures used by bank supervisors.

Market discipline

Market discipline implies more detailed disclosures about risk and allocation of capital. If shareholders are furnished more information, there will be added pressure on banks to improve the quality of risk management. Banks are expected to provide information relating to:

- the structure of the risk management function and how it operates
- methods used to identify and measure different kinds of risk
- amounts of Tier 1, Tier 2 and Tier 3 capital

Banks that fail to meet disclosure requirements cannot use internal models. In other words, the trade off for greater reliance on a bank's own models is greater transparency.

Credit Risk

Basle II provides for three different ways of calculating the credit risk charge:

- Standardized approach
- Foundation Internal Ratings Based approach
- Advanced Internal Ratings Based approach

Standardized approach

The Standardized approach is based on risk assessments by external credit rating agencies. Risk weights have been prescribed for different categories of banks, sovereigns and corporates. These risk weights can be used to calculate the capital charge.

Exhibit 9.2
Claims on Sovereigns

Credit Assessment	AAA to AA⁻	A⁺ to A⁻	BBB⁺ to BBB⁻	BB⁺ to B⁻	Below B⁻	Unrated
Risk Weight	0	20%	50%	100%	150%	100%

Exhibit 9.3
Claims on Corporates

Credit Assessment	AAA to AA⁻	A⁺ to A⁻	BBB⁺ to BB⁻	Below BB⁻	Unrated
Risk Weight	20%	50%	100%	150%	100%

For sovereign exposures, the credit assessments may include those developed by OECD export credit agencies, as well as those published by private rating agencies.

Internal Ratings Based approach

Banks using IRB approach must classify their exposures into the following:

- *Corporate* – Project finance, object finance, commodities finance, income producing real estate, high volatility commercial real estate.
- *Retail* - Exposure to individuals, residential mortgage loans, loans extended to small businesses.
- *Sovereign* –
- *Bank* -
- *Equity* -

In the *Foundation Internal Ratings Based (IRB)* approach, banks can use their internal model to estimate the probability of default but other inputs are obtained as in the standardized approach.

In the *Advanced IRB* approach, banks have much greater latitude. They can use internal models to arrive at the probability of default (PD), exposure at default (EAD) and loss given default (LGD). PD and LGD for all applicable exposures are mapped into regulatory risk weights. The capital charge is obtained by multiplying the risk weight by EAD by .08. The Advanced IRB approach applies to sovereign bank and corporate exposures. It does not apply to retail portfolios.

Basle II takes into account the impact of various credit risk mitigation techniques such as collateralization, third party guarantees, credit derivatives and netting. Where collateral is posted, the risk of the collateral can at least partially substitute the risk of the counterparty. However, the volatility of the collateral must be taken into account while reducing the capital charge. In case of guarantees and credit derivatives, capital relief is granted only if there is no uncertainty as to the quality of the guarantee. When the credit protection is direct, explicit, irrevocable and unconditional, the principle of substitution can be applied. Say Bank A buys credit protection against default by company B from Bank C. Then A can substitute C's credit for B's credit. For a credit loss to occur, both B and C must default. The likelihood of such a simultaneous default is very low. This can be taken into account while estimating capital needs.

Basle II also deals with securitization. A bank can remove assets from its balance sheet if certain conditions are satisfied. Significant credit risk must be transferred to third parties. The seller must not have control over the assets. The securities are no longer an

obligation of the seller. When the required conditions are met, assets can be removed from the balance sheet and new risk weights can be applied for securitization tranches.

Market Risk

The capital charge for market risk can be computed using the following approaches:
- Standardized method
- Internal Models approach.

Standardised method

In the standardised method, market risk is computed for portfolios exposed to interest rate risk, equity risk, currency risk and commodity risk using specific guidelines. The bank's total risk is the sum of these risks. This method is simple but unsophisticated. Different underlying assets are equated without taking into account their differences in volatility. Since the risk charges are added, the effects of diversification are not taken into account.

Internal Models method

In the Internal Models approach, banks can use their own risk management systems. To be able to use their own models, banks must meet the criteria laid down by regulators. The bank's risk model should incorporate a sufficient number of risk factors. A ten day horizon, 99% confidence interval and one year of historical data (six months if a non-equal weighting scheme is used) are recommended for calculating VAR. Quarterly updating must be done if prices are subject to material changes.

The general market risk charge is set at the higher of the previous day's VAR or the average VAR over the last 60 business days, multiplied by a factor, K. The floor for K is 3. A penalty component can be added to K if the validation of VAR forecasts reveals that the bank is systematically underestimating its risk.

After arriving at VAR, banks add the specific risk charge. This represents a buffer against idiosyncratic factors including default and event risk, related to individual bond and equity issuers.

To be able to use internal models, banks must satisfy qualitative requirements and have in place a rigorous back testing process.

The qualitative standards include:
- Existence of independent risk control limit
- A regular back testing program
- Involvement of senior management and board members
- Integration of risk model with day-to-day management.
- Regular stress tests
- Compliance with a documented set of policies
- Independent review of trading units and risk control unit.

In addition, the model should incorporate a sufficient number of risk factors. For example, in case of material exposures to interest rates, there must be at least six factors for yield curve risk plus separate factors to model spread risk.

Operational risk

A key improvement in Basle II is the explicit recognition of the importance of operational risk. In 2001, the Basel committee defined operational risk as the risk of loss arising from inadequate or failed internal processes, people and systems, or from external events.

The Basle committee has identified seven categories of operational risk:
- Internal fraud, eg., misreporting of positions
- External fraud, eg., computer hacking
- Employment practices and workplace safety
- Clients, products and business practices - eg., misuse of client information
- Damage to physical assets
- Business disruption and system failures, eg., hardware failure
- Execution, delivery and process management, eg., data entry errors.

Three different methods have been prescribed to deal with operational risk:
- The Basic Indicator approach
- The Standardized approach
- The Advanced Measurement approach.

Basic indicator approach

The basic indicator approach is based on an aggregate measure of business activity. The capital charge is arrived at by multiplying the gross income by the *alpha factor*. Banks must hold capital for operational risk equal to the average over the three previous years of a fixed percentage (α) of positive annual gross income figures. Any year for which gross income is negative or zero should be excluded.   Gross income is defined as the net interest income plus the net non interest income. This measure should be gross of any provisions and operating expenses, including fees paid to outsourcing service providers. But it must exclude realized profits/losses from sale of securities on the banking book extraordinary or irregular items and income derived from insurance. α is typically set at 15%. This method is simple and transparent, but clearly lacks in sophistication.

Standardised approach

In the standardized approach, the bank's activities are divided into eight business lines. Within each business line, the gross income is a broad indicator that serves as a proxy for the scale of business operations and thus the likely scale of operational risk exposure. Within each business line, the capital charge is arrived at by multiplying the gross income by the *beta factor*. Each business line has a different beta. These capital charges can then be summed up. The total capital charge is calculated as an average for three years. The values of Beta for different business lines are given in the table below:

Exhibit 9.4

Business Line	Beta Factor
Corporate Finance	18%
Trading & Sales	18%
Retail banking	12%
Commercial banking	15%
Payment & Settlement	18%
Agency services	15%
Asset management	12%
Retail brokerage	12%

In order to be able the use the standardized approach, a bank must be able to satisfy its supervisor that:

- the board and senior management are actively involved in the process
- the operational risk management system is conceptually sound and implemented with integrity.
- it has enough resources to use the approach in different business lines as well as the control and audit areas.
- clear responsibilities are assigned to the operational risk management function.
- the bank is systematically tracking relevant operational risk data including material losses by business line.
- there is regular reporting of operational risk exposures and material losses.
- there is adequate documentation of the operational risk management system.
- the risk management processes are subject to validation and regular independent review and also the review of external auditors.

Advanced measurement approach

In the Advanced measurement approach (AMA), banks use their internal models to estimate the required capital. This approach is allowed only if the bank demonstrates the effective management and control of operational risk. This means that the bank must satisfy the regulator about the following:

- Its board of directors and senior management are actively involved in the oversight of the operational risk management framework.
- It has an operational risk management system that is conceptually sound and is implemented with integrity.
- It has sufficient resources in the use of the approach in the major business lines as well as the control and the audit areas.
- Independent operational risk management function exists for the design and implementation of polices, methodologies and strategies to identify, measure and control operational risk.
- The operational risk measurement system is closely integrated with the bank's day-to-day risk management processes. The output of the system plays a significant role in risk reporting, management reporting, internal capital allocation and risk analysis.
- There is regular reporting of operational risk exposures and loss experience to business unit management, senior management and board of directors.

- Internal policies, controls and procedures are clearly documented. There is a routine for enforcing compliance.
- Systems and processes are regularly reviewed.
- Data flows and processes associated with the risk measurement system are transparent and accessible.

Various quantitative criteria have also been prescribed:

- The operational risk approach captures potentially severe tail loss events.
- There are rigorous procedures for model development and independent validation.
- The bank calculates the regulatory capital requirement as the sum of the expected loss and unexpected loss, unless the bank can credibly demonstrate that the expected loss is captured in its internal business practices.
- The risk measurement system is sufficiently granular.
- While aggregating operational risk measures, correlations are used only if the robustness of the process for establishing correlations is demonstrated.
- There is a credible, transparent, well documented and verifiable approach for including and weighing internal data, relevant external data, scenario analysis and factors reflecting the business environment and internal control systems.
- The bank tracks internal loss data systematically. When the bank first moves to AMA, a three year historical data window is acceptable. Otherwise, a five year observation period is recommended. Apart from information on gross loss amounts, the bank should collect information about the date of the event, any recoveries of gross loss amounts as well as some descriptive information about the drivers or causes of the loss event.
- Operational risk losses that are related to credit risk and have historically been included in the credit risk database, will be treated as credit risk. Such losses will not be subjected to operational risk capital charge.
- Operational risk losses that are related to market risk are treated as operational risk and are subject to operational risk capital charge.
- Relevant external data is used when there is reason to believe that the bank is exposed to infrequent, yet potentially severe losses. The actual loss amounts, information on the scale of business operations when the event occurred and information on the causes and circumstances of the loss event must be ascertained to judge the relevance of the risk to the bank.
- For high severity events, scenario analysis is used.
- Key business environment and internal control factors that can change the operational risk profile of the bank are carefully considered.

Banks using the IRB approach for credit risk and the AMA for operational risk must compare the floor with the calculated value. The floor is based on the 1988 Accord. It is derived by applying an adjustment factor (80% in 2008) to 8% of risk weighted assets plus Tier I and Tier II deductions less the amount of general provisions that may be recognized in Tier 2. The bank must also calculate 8% of total risk weighted assets less the difference between total provisions and expected loss amount and other Tier I/Tier II

deductions. If the floor amount is larger, banks have to add 12.5 times the difference to the risk weighted assets.

Backtesting
Basle II prescribes various backtesting procedures to ensure that the internal models are working fine. Upto 4 exceptions during the last year are acceptable. This defines a *green zone*. If the number of exceptions are 5 or more, the bank moves into a *yellow zone*. It moves into a *red zone* if the number is 10 or more. The multiplicative factor can be increased from 3 to 4 when the number of exceptions crosses 4. Within the yellow zone, the supervisor has the discretion to apply a penalty. If the basic integrity of the model is in doubt or the model is found to be seriously deficient in some respects, a penalty may be applied. If the exceptions occur because the markets are volatile or correlations have changed suddenly, the penalty may not be applied. In the red zone, an automatic non discretionary penalty is applicable.

In case of credit risk, a bank using a VAR model will have to backtest its output using a sample of 20 counterparties of which 10 should be the largest. The remaining can be selected at random. Depending on the number of exceptions for the 20 counterparties over the most recent 250 days, the output of the VAR model can be scaled by using a multiplier as provided in the table below.

Exhibit 9.5

Zone	No. of exceptions	Multiplier
Green	0 – 99	1
Yellow	100 – 119	1.13
	120 – 139	1.17
	140 – 159	1.22
	160 – 179	1.25
	180 – 199	1.28
Red	> 200	1.33

The shadow banking system and new regulatory challenges
A remarkable feature of the global economy in the last two decades has been the rapid growth of the non regulated part of the financial system. As Jamie Dimon, CEO mentioned in JP Morgan's 2008 Annual Report, "The role of banks in the capital markets has changed considerably…. Traditional banks now provide only 20% of the total lending in the economy. Right after World War II, that number was almost 60%. The other lending has been provided by what many call the shadow banking system."

More importantly, the formal and the shadow banking system are too closely interlinked. Indeed, authorities across the world are realizing that the financial system cannot be managed by dividing it into two segments – core banking institutions that need to be tightly regulated and others such as hedge funds, brokers and structured investment vehicles that can be left to operate on their own since they do not use public money. The "core" and the "shadow banking" segments have become far too interconnected. It is estimated that by the summer of 2007, the assets of the six largest US commercial banks were about $6 trillion while the shadow banking system controlled assets worth $4

trillion. The two systems have become so closely intertwined that the collapse of a shadow banking entity can send ripples across the formally regulated banking world.

The shadow banking system is increasingly coming under scrutiny from regulators across the world. Many European politicians are pressing for curbs on offshore tax centers and hedge funds. The ECB president, Jean Claude Trichet mentioned a few months ago that reforms need to be holistic and regulation must be extended to all important markets that pose fundamental risks to financial stability. The proposals by the US Treasury in May 2009 seem to echo this sentiment.

But we cannot be too sure whether such an approach will solve all the problems. Curbs on the shadow banking system may allow a new breed of institutions to form at the periphery. Moreover, the financial system has always been good at finding loopholes in the existing legal and regulatory framework and moving into segments that bypass regulation. Besides, for a well functioning and liquid market, different participants must have different views towards holding and transferring risk. If all entities try to manage risk and liquidity in the same way, the dynamism of the market will be threatened. The current cyclicality bias in the regulatory system may then be further amplified.

In the following section, we capture some of the current thinking on regulatory issues by eminent scholars and experts. Annexures at the end of the chapter summarise the views of some important regulatory authorities.

Emerging ideas on regulation
Despite its sophisticated approach and the various ways in which it is superior to Basle I, Basle II does have some limitations.

- It does not take into account liquidity risk sufficiently.
- It depends heavily on rating agencies.
- It is pro cyclical with respect to capital requirements for assets.
- It takes too long to implement.
- It responds slowly to market changes.
- It is unevenly applied across countries.

Not surprisingly in the wake of the sub prime crisis, experts have been discussing various ways of dealing with loopholes in the existing regulatory framework.

One of the main drawbacks in the current regulatory regime is the inherent cyclicality bias. Injecting counter cyclicality is not a new theme. Back in 2004, in an interesting paper, Anil Kashyap and Jeremy Stein[121] mentioned that during a downturn, not only will there be more loan losses but also the credit rating of existing non defaulting borrowers may plunge. This would result in the need for more capital. As capital is not easy to mobilize during a downturn, banks might cut back on their lending activities, thereby aggravating the initial downturn.

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[121] "Cyclical implications of the Basle II capital standards," Economic Perspectives, Federal Reserve Bank of Chicago, Q1, 2004.

Kashyap and Stein argued that banking regulation must aim at a balance between protecting the system against the costs of bank default and encouraging banks to invest in value creating projects. In the pre-occupation with controlling risk, the second goal is often forgotten. Excessive capital requirement will reduce expected default costs but also reduce bank lending thereby leading to under investment. In this context, the key parameter to monitor is the shadow value of bank capital, i.e., scarcity of bank capital relative to positive Net Present Value (NPV) lending opportunities. A higher shadow value means greater relative scarcity and more severe underinvestment. For a fixed confidence level, the shadow value of bank capital will rise during a recession.

Exhibit 9.6
Key issues in banking regulation

▪ Increasing capital requirements
▪ Dealing with counter cyclicality
▪ Facilitating orderly closure of troubled institutions
▪ Preventing asset bubbles
▪ Reducing moral hazard in securitisation
▪ Ensuring transparency of risk in structured products
▪ Aligning bankers' compensation with larger interests of banks

Kashyap and Stein argued that instead of using a single risk curve that maps the probability of default into the capital charge, what was needed was a family of curves, with each curve corresponding to a different shadow value of bank capital, for different macroeconomic conditions. One could use a high confidence level in good times when bank capital was relatively plentiful and hence had a low shadow value. During a recession, the confidence level and consequently capital charge could be reduced. The required capital adequacy ratio could adjust to movements in the shadow value of the banking capital. Alternatively, the risk weights could be adjusted.

The lack of counter cyclicality in the Basle II framework has received considerable attention from many other economists and practitioners in recent months. Indeed, except for the emergency actions of the government, there has been little to offer by way of counter cyclicality during the recent crisis.

Jamie Dimon, CEO of JP Morgan has made three specific suggestions for improving counter cyclicality in the bank's 2008 annual report.
- Loan loss reserves can be arrived at, based on the estimation of credit losses over the life of the loan portfolio. Banks can increase reserves when losses are low and run down the reserves when losses are high.
- If a bank lends very aggressively, the central bank can either impose higher capital costs or reduce the amount it lends to the bank.
- Procedures must be streamlined to accelerate the process of raising capital during a downturn. Banks should be able to make a rights issue in days rather than weeks.

A complex financial system combined with a buoyant economy is a dangerous combination. In a booming economy, there is tremendous demand for capital. So financial institutions are prepared to take more risk than is warranted. When an

economic shock hits the system, optimism gives way to pessimism, leading to a self reinforcing downward spiral. As Robert Bruner and Sean Carr mention[122], the boom part of the credit cycle erodes the shock absorbers that cushion the financial system in the slump. When an external shock occurs, banks realize they do not have enough capital in relation to the risks they have taken. They reduce lending. This in turn triggers off a liquidity crisis. So buffers must be built during the good times to be drawn down during recessions.

Raghuram Rajan[123] mentions that, faith in draconian regulation is strongest at the bottom of the cycle. But that is the time, when there is little need for market participants to be regulated. At the same time, the misconception that markets will take care of themselves is most widespread at the top of the cycle. Incidentally, that is the point when there is maximum danger and a compelling case for tightening regulation exists.

How can regulators inject counter cyclicality in the system? In boom times, the market demands very low levels of capital from banks as the general euphoria makes losses seem remote. Should regulators impose higher capital requirements on banks? We know from past experience, especially the sub prime crisis, that when regulated financial intermediaries are forced to hold more costly capital than the market requires, they try to shift activity to unregulated intermediaries. Even if regulations are strengthened to detect and prevent this shift in activity, banks can always find loopholes that get around capital requirements. At the same time, during a downturn, risk-averse banks will hold much more capital than regulators require. No amount of prodding will bring back the credit expansion that is critical for an economy in a serious recession.

In short, it is not so simple to deal with the cyclicality inherent in the current regulatory framework. Rajan argues that new regulations should be comprehensive, contingent, and cost effective.

Regulations should be comprehensive so that they are less likely to encourage the drift of activities from heavily regulated to lightly regulated institutions over the boom. Regulations should also be contingent. They must have the maximum impact when the danger to the system is most potent. This will make regulations more cost effective, and less prone to arbitrage or dilution. For example, instead of raising *permanent* capital, banks can be asked to arrange contingent capital for troubled times. These "contingent capital" arrangements will be contracted in good times. So they will be relatively cheap compared with raising new capital in a crisis and thus easier to enforce. Because the capital infusion occurs in bad times when capital is really needed, it protects the system and the taxpayer at the right time. Post crisis measures like bailouts can be avoided. Rather than depending on their discretion, banks could be asked to issue debt that would automatically convert to equity when two conditions are met: first, when the system is in crisis, and second, when the bank's capital ratio falls below a certain value.

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[122] "Lessons from the Financial Crisis of 1907," Journal of Applied Corporate Finance, Fall 2007.
[123] Federal Reserve Bank Of St. Louis *Review* September/October, Part 1 2009. Pp. 397-402.

Calomiris[124] argues that at a bank level, the two key challenges are finding ways to measure the value and the riskiness of different assets accurately, and ensuring speedy intervention to prevent losses from growing once a bank has become severely under capitalized.

The current system of measuring asset values and risks depends on bank reporting, supervisors' observations, and rating agencies' opinions. None of these parties has a strong interest in the correct and timely measurement of asset value and risk. So objective information must be brought from the market into the regulatory process. Market sources of discipline in debt markets must be brought to bear in penalizing bank risk-taking.

THE TURNER REVIEW: Summary of key recommendations[125]

Capital adequacy, accounting and liquidity
- The quality and quantity of overall capital in banks should be significantly enhanced.
- Capital required against trading book activities should be increased significantly.
- A counter-cyclical capital adequacy regime should be introduced.
- A maximum gross leverage ratio should be introduced to act as a check on excessive growth in absolute balance sheet size.
- Liquidity regulation and supervision should be treated on par with capital regulation.
- More intense and dedicated supervision of individual banks' liquidity positions should be introduced.
- A 'core funding ratio' must be introduced to ensure sustainable funding of balance sheet growth.

Institutional and geographic coverage of regulation
- Regulatory and supervisory coverage should follow the principle of economic substance, not legal form.
- Authorities should have the power to gather information on all significant unregulated financial institutions to allow assessment of overall system-wide risks.
- Regulators should have the power to extend prudential regulation of capital and liquidity or impose other restrictions if any institution develops bank-like features that threaten financial stability.
- Offshore financial centres should be covered by global agreements on regulatory standards.

Deposit insurance
- Retail deposit insurance should be sufficiently generous to ensure that the vast majority of retail depositors are protected against the impact of bank failure.
- Retail depositors must be made to understand the extent of deposit insurance cover.

Bank Resolution
- A resolution regime which facilitates the orderly wind down of failed banks should be in place.

Credit rating agencies
- Credit rating agencies should be subject to registration and supervision.
- Credit ratings must only be applied to securities for which a consistent rating is possible.
- Rating agencies and regulators should communicate to investors that the ratings are designed to carry inference for credit risk, not liquidity or market price.
- There should be a fundamental review of the use of structured finance ratings in the Basel II framework.

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[124] "Financial Innovation, Regulation, and Reform," *Cato Journal,* Vol. 29, No. 1 (Winter 2009).

[125] See more detailed account of the Turner review at the end of the chapter. Also see website, www.fsa.gov.uk/pages/library/corporate/turner/index.shtml

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Remuneration
- Remuneration policies should be designed to avoid incentives for undue risk taking.
- Risk management considerations should be closely integrated into remuneration decisions.

Credit Default Swap (CDS) market infrastructure
- Clearing and central counterparty systems should be developed to cover the standardised contracts which account for the majority of CDS trading.

Macro-prudential analysis
- Central banks and other regulatory authorities should be extensively and collaboratively involved in macro-prudential analysis and the identification of policy measures. Measures such as countercyclical capital and liquidity requirements should be used to offset these risks.
- Institutions such as IMF must have the resources and robust independence to do high quality macro-prudential analysis and if necessary to challenge conventional wisdom and national policies.

Global cross-border banks
- International coordination of bank supervision should be enhanced by the establishment and effective operation of colleges of supervisors for the largest complex and cross-border financial institutions.
- There must be pre-emptive development of crisis coordination mechanisms and contingency plans between supervisors, central banks and finance ministries.

One way to do this is to ask banks to issue some form of uninsured debt. That would give banks a strong incentive to satisfy market concerns about the value and riskiness of their assets. The interest rates paid on risky debts would provide valuable information about market perceptions of bank risk. These perceptions are not vulnerable to manipulation by bankers, supervisors, regulators, or politicians.

Calomiris adds that "Contingent capital certificates" (CCC)—debts that converts to equity when banks suffer sufficient portfolio losses— may be better than straight subordinated debt for this purpose. CCC are likely to work better than subordinated debt as a source of information about risk and a form of market discipline.

Lloyds of Britain issued contingent convertible (CoCo) bonds in 2008 to the extent of 1.6% of risk adjusted assets. The instrument pays a coupon like any other bond. But if the bank's core capital falls below 5% of risk adjusted assets, the bond gets converted to equity. The coupon rate paid by Lloyds is high, at about 10 – 11%. One concern with such an instrument is that it may not behave as it is intended to, in a crisis. Thus, if the bond gets converted to equity, alarm bells may start ringing, prompting a run on the bank. Another worry is that if these bonds are packaged and repackaged and the risks sliced and diced, the entire nightmare of CDOs and CDSs which precipitated the sub prime crisis, might be repeated.

Whatever be the method chosen, there is no doubt, as Rajan mentions that the idea of infusing counter cyclicality in the regulatory framework can no longer be postponed. During a crisis, the temptation on the part of regulators will be to over regulate. Once the recovery takes hold, deregulation will begin and add so much economic value that the deregulatory camp will be strongly empowered. Eventually, deregulation will swing to the other extreme and eliminate regulatory muscle rather than fat. That is, some of the important checks and balances will go away. Instead of swinging wildly between too much and too little regulation, cycle proof regulation might be a better approach.

One major problem with the banking system today is that many of the institutions are so large that it is difficult to imagine they can be allowed to fail by governments and regulators. That is why the collapse of Lehman was an epochal event in modern finance. Rajan argues that the right way to deal with the "too big to fail" syndrome is not to impose regulations that limit the size and activities of institutions. A better approach is to make it easier to close down these institutions. Systemically important financial institutions must be required to develop a plan that would enable them to be wound down in a matter of days. Such arrangements have been called "living wills", "assisted euthanasia," or "shelf bankruptcy" plans by different writers. Banks would need to track, and document, their exposures much more carefully and in a timely manner. The plan would require periodic stress testing by regulators and the support of enabling legislation— such as facilitating an orderly transfer of a troubled institution's swap books to precommitted partners. The requirement to develop resolution plans would give financial institutions a strong incentive to reduce unnecessary complexity and improve management. Such an arrangement might also force management to be better prepared to deal with unexpected worst case scenarios.

As Calomiris mentions, living wills can create benefits for the financial system both prior to and during a crisis. Before a crisis, large complex banks would be more careful in managing their affairs. If the institutions are forced to plan their resolutions credibly in advance, and if this planning process is very costly, then there is a strong incentive to be less complex and smaller. After a crisis, because of the element of planning, changes in the control over distressed banks would occur with minimal disruption to other financial firms.

Another big theme in the current debate on changes in the regulatory framework is the need to prevent asset bubbles. While Greenspan & Co seemed to have successfully controlled inflation in the 2000s, they did not pay as much importance to the rising real estate prices. Identifying and preempting asset bubbles can go a long way in preventing shocks to the economy. Since the financial system plays a critical role in the formation of bubbles, appropriate macro level regulation is needed.

Calomiris mentions that prudential regulations can succeed in reducing the supply of credit by tightening capital, liquidity, and provisioning requirements. This is the most direct and promising approach to attacking the problem of a building asset price bubble, assuming that one can be identified. Greenspan used to argue that it was difficult to identify asset bubbles. And the costs associated with tackling "imaginary" asset bubbles would be high. Calomiris accepts that there are economic costs associated with adopting macro prudential triggers to combat asset bubbles. Credit slowdowns and capital raising by banks may happen during periods identified as bubbles that are in fact not bubbles. These costs, however, are likely to be small. If a bank believes that its extraordinary growth is based on fundamentals rather than a bubble, then it can easily raise capital to support loan expansion. The cost to banks of raising a bit more capital during a boom is relatively small. Most importantly, macro prudential triggers would promote procyclical equity ratios for banks, which would mitigate the agency and moral-hazard problems that

encourage banks to increase leverage during booms. As we all know, during the subprime boom, commercial banks and investment banks substantially raised their leverage.

Indeed, we can learn from history in this context. There have been occasions in the past when banks behaved more prudently and wisely. During the boom era of the 1920s, New York city banks expanded their lending dramatically. Their loan-to-asset ratios also rose as the banks participated actively in promoting the growth in economic activity and stock prices during the 1920s. But recognizing the rising risk of their assets, the banks made adjustments accordingly and substantially raised their equity capital. New York banks went to the equity market frequently in the 1920s, and on average increased their market ratios of equity to assets from 14 percent in 1920 to 28 percent in 1928. Virtually no New York city bank failed during the Depression.

David Mcllroy[126] argues that regulation failed during the recent financial meltdown because of the development of faulty market practices. Owing to the self interest of market participants, the systematic risk rose to unacceptable levels. Besides cyclicality bias, (which has already been adequately covered) Mcllroy has argued for reform in the following areas:

- Reducing the moral hazard involved in the "originate and distribute" model of securitization where the bank originating a product becomes completely separated from the risks in the originated products.
- Ensuring transparency of risk in financial products. Only those derivatives must be permitted to be traded where the risk can be identified and accurately quantified.

Mcllroy mentions that the originators of securitised products must be forced to retain a substantial interest in the instrument even after it is 'distributed'. Otherwise there is little incentive for the originator to be transparent about the risks involved and to be prudent taking risk. Moreover, *financial products must be transparent and well understood before they are marketed aggressively.*

On improving the transparency of financial products, many suggestions have been put forth by academics, regulators and bankers. Calomiris mentions there are two separate issues that need to be addressed by regulators. Banks should be encouraged to move from OTC to central clearing arrangements to deal with the systematic consequences of opacity in counterparty risk. The clearinghouse, would effectively stand in the middle of all transactions as counterparty and thereby eliminate the problem of measuring counterparty risk. Clearinghouses are quite good at dealing with counterparty risk. But they may not be practical for highly customized OTC contracts. A regulatory cost can be imposed on OTC contracts that do not go through the clearinghouse (in the form of a higher capital or liquidity requirement) to encourage, but not compel, clearinghouse clearing. For contracts where the social benefits of customization are high, banks' fees will compensate them for the higher regulatory costs of bilateral clearing.

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[126] "Regulating risk: A measured response to the banking crisis," Journal of Banking Regulation, Vol 9, 4, pp. 284-292.

The second issue, Calomiris mentions is the problem of monitoring and controlling the net risk positions of individual banks and the systemic consequences of those positions. Requiring that all derivatives positions be publicly disclosed in a timely manner may not be practical. Disclosure of their derivatives positions could place banks at a competitive disadvantage with respect to other market participatns. This might even reduce aggregate market liquidity. For example, if Bank A had to announce that it had just undertaken a large long position in a currency contract, other participants might expect that it would be laying off that risk in the future. This could lead to a decline in the supply of long positions in the market and a marked change in the price that would clear the market. A better approach to enhancing disclosure, therefore, would be to require timely disclosure of positions only to the regulator, and public disclosures of net positions with a lag.

Another important issue on the regulatory report agenda is a major overhaul of the current compensation regime for investment bankers. In their greed to earn huge bonuses, many bankers threw caution to the winds and pursued risky trading strategies. They also took advantage of their financial models and accounting rules to book profits immediately but allow losses to pile up later. There has been public outrage at the way bankers swelled their pockets even as the banks they worked for, were being put to huge risk. Various suggestions have been put forward by governments, including a cap on banker compensation and high taxes for variable pay exceeding a certain sum. The partnership model where partners had unlimited liabilities was more effective in aligning the incentives to the management with the interests of the bank. Among the large investment banks, the partnership model came to an end in 1999 when Goldman Sachs made its I.P.O. Clearly, the partnership model is not appropriate today when banks have huge capital requirements, far more than individual partners can together provide. But as Neil Record[127] suggests, bankers can indeed be made personally liable to the extent of the cumulative bonuses they have earned. It can take a long period of time to be certain whether the risks taken by a bank have led to profits or losses. So the personal liability can exist for a period of say, 10 years. This liability will be triggered either by a government bail out or a private sector rescue or liquidation. The bankers would be relieved of their liability over time. But with every new bonus payment, they would assume a new liability.

Bank of England: Some key recommendations[128]

Stronger market discipline
Market discipline should be strengthened significantly:
- There must be richer, more consistent and more timely disclosures by banks.
- The threat of closure/wind-down credible for all financial firms via resolution regimes must be real.
- There should be improved cross-border crisis management arrangements.
- A risk-based, pre-funded deposit insurance system must be established.

Greater self-insurance
Financial institutions' own resources should be the first line of defence against financial pressures. There should be:

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[127] Financial Times, January 7, 2010.
[128] www.bankofengland.co.uk

- higher levels of bank capital, consisting of common equity;
- build up of bank reserves in periods of strong earnings to absorb losses in times of stress;
- larger liquidity buffers, comprising government bonds;
- contingent plans for accessing capital in times of stress;
- contingent funding plans;
- contingent plans for restructuring or wind-down in the event of failure;

Improved management of risks arising from interactions
Regulatory authorities need better information and means to manage the interconnections between financial institutions and between the financial system and the real economy. There must be:
- improved information on connections between financial institutions, including flow of funds, data;
- common stress tests that factor in feedback effects from financial institutions' response to shocks;
- capital and liquidity buffers gauged to firms' systemic importance;
- expanded use of central counterparties for clearing financial contracts;
- more trading of key financial instruments on exchanges/open trading platforms.

Banks should not be too big or complex
The size and structure of financial systems need to be compatible with maintaining financial stability.
- Simpler, more transparent, legal structures are necessary that are capable of being supervised and resolved;
- Potential changes are needed to the structure or size of banks to ensure they can be effectively supervised and wound up. Banks should not become "too-big-to-fail."

Clear principles for public safety nets
Where self-protection fails, a safety net is needed that encourages prudent behaviour and contains risks to the public finances. Clear principles guiding lender of last resort interventions are necessary.

Conclusion

The global financial meltdown has come as a rude shock to regulators. Regulation has clearly failed to keep pace with complexity. Many of the institutions guiding the financial system in the west, especially in the US were fashioned during the Great Depression. In the past seven decades, the financial system has become considerably complicated and interlinked but regulation has not kept pace. Hank Paulson the former US treasury secretary admitted in an interview with the *Financial Times*[129]: "We're dealing with something that is really historic and we haven't had a playbook. The reason it has been difficult is first of all, these excesses have been building up for many, many years. Secondly, we had a hopelessly outdated global architecture and regulatory authorities... in the US."

It is clear that multiple regulators in the US aggravated the sub prime meltdown. The Fed, Office of the Comptroller of the Currency (OCC), the Federal Deposit Insurance Corporation (FDIC), the Office of Thrift Supervision (OTS) and the National Credit Union Association (NCVA) were all involved in mortgage regulation. As Mark Zandy[130] has mentioned, "… with so many diverse groups involved, it was difficult to get a working quorum for decision making. At a time when oversight was most desperately needed on mortgages, half the nation's lenders were regulated at the federal level and half

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[129] December 31, 2008

[130] Financial Shock: A 360^0 look at the subprime mortgage implosion and how to avoid the next financial crisis." Financial Times Press, 2009.

by the states… Understaffed state regulators lacked resources to monitor a rapidly growing and increasingly sophisticated mortgage industry." Jamie Dimon CEO, has echoed similar sentiments in JP Morgan's 2008 annual report, "Overlapping responsibilities have led to a diffusion of responsibility and an unproductive competition among regulators which probably accelerated a race to the bottom." Many regulators also lacked the appropriate statutory authority to deal with some of the problems they were about to face during the financial meltdown.

The emerging regulatory framework is likely to emphasise a more long term approach towards capital management. Banks may be   asked to build a buffer during the good times that they can draw down during a recession. A key challenge for regulators is to estimate the amount of capital that can act as a reasonable safety buffer to cope with a downturn. As mentioned earlier, the figure of 8% of risk weighted assets is being challenged. Indeed, many global banks have started to maintain capital amounts much larger that this figure. The quantum of capital should change dynamically with the needs of the system. As Bruner and Carr point out[131], "The question of adequate sufficiency must be tested relative to the size of the available assets and the size of the shocks the buffer is meant to absorb. Over time, the size and complexity of the economy will outgrow the sophistication of static financial safety buffers." We mentioned earlier in the chapter that core capital as a percentage of assets has gone down steadily for Western banks in the past 150 years or so from 15 – 25% of assets to less than 4% during the onset of the sub prime crisis.

All the answers to the questions proposed by the sub prime crisis may not lie in better regulation. For, however, clever, regulators may be, bank failures will still happen. Regulators need to figure out the best way to minimize the burden on the tax payers if and when a bank does go bankrupt.

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[131] "Lessons from the financial crisis of 1907," Journal of Applied Corporate Finance, Fall 2007.

Annexure 9.1
BIS Proposals - December 2009[132]

A. Strengthening the resilience of the banking sector -

The Basel Committee on Banking Supervision has issued for consultation a package of proposals to strengthen global capital and liquidity regulations to strengthen the resilence of the banking system.

One of the main reasons for the severity of the sub prime crisis was excessive on- and off-balance sheet leverage, accompanied by a gradual erosion of the level and quality of the capital base and insufficient liquidity buffers. The banking system could not absorb the resulting systemic trading and credit losses nor could it cope with the reintermediation of large off-balance sheet exposures that had built up in the shadow banking system. The crisis was further amplified by a procyclical deleveraging process and by the interconnectedness of systemic institutions. During the most severe phase of the crisis, the market lost confidence in the solvency and liquidity of many banking institutions. The weaknesses in the banking sector were transmitted to the rest of the financial system and the real economy, resulting in a massive contraction of liquidity and credit availability. Ultimately governments and central banks had to intervene with unprecedented injections of liquidity, capital support and guarantees, exposing the taxpayer to large losses.

To address the market failures revealed by the crisis, the Committee is proposing a number of reforms to strengthen bank-level and macroprudential regulation.

- First, the quality, consistency, and transparency of the capital base will be raised. Under the current Basel Committee standard, banks could hold as little as 2% common equity to risk-based assets, before the application of key regulatory adjustments.
- Second, the risk coverage of the capital framework will be strengthened. In addition to the trading book and securitisation reforms announced in July 2009, the Committee wants to strengthen the capital requirements for counterparty credit risk exposures arising from derivatives, repos, and securities financing activities. The strengthened counterparty capital requirements will increase incentives to move OTC derivative exposures to central counterparties and exchanges.
- Third, the Committee will introduce a leverage ratio as a supplementary measure to the Basel II risk-based framework. This will help contain the build up of excessive leverage in the banking system, introduce additional safeguards against attempts to game the risk based requirements, and help address model risk.
- Fourth, the Committee is introducing various measures to encourage the build up of capital buffers in good times that can be drawn upon in periods of stress. The Committee has also proposed more forward looking provisioning based on expected

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[132] See www.bis.org for more details.

losses, which captures actual losses more transparently and is also less procyclical than the current "incurred loss" provisioning model.

- Fifth, the Committee is introducing a global minimum liquidity standard for internationally active banks that includes a 30-day liquidity coverage ratio requirement underpinned by a longer-term structural liquidity ratio. The framework also includes a common set of monitoring metrics to assist supervisors in identifying and analysing liquidity risk trends at both the bank and system wide level.

B. International framework for liquidity risk measurement, standards and monitoring

The Basel Committee has proposed various measures to strengthen global capital and liquidity regulations.

The sub prime crisis was preceded by several years of ample liquidity in the financial system, during which liquidity risk and its management did not receive the same level of scrutiny and priority as other risk areas. The crisis illustrated how quickly and severely liquidity risks can crystallise and certain sources of funding can evaporate.

To improve liquidity risk management and control their liquidity risk exposures, the Basel Committee issued *Principles for Sound Liquidity Risk Management and Supervision* in September 2008. These sound principles provide consistent supervisory expectations on the key elements of a robust framework for liquidity risk management at banking organisations. Such elements include:

- board and senior management oversight;
- the establishment of policies and risk tolerance;
- the use of liquidity risk management tools such as comprehensive cash flow forecasting, limits and liquidity scenario stress testing;
- the development of robust and multifaceted contingency funding plans; and
- the maintenance of a sufficient cushion of high quality liquid assets to meet contingent liquidity needs.

The Committee has developed two internationally consistent regulatory standards for liquidity risk supervision. Banks are expected to meet these standards as well as adhere to all the principles set out in the September 2008 Sound Principles document. National authorities are free to adopt arrangements that set higher levels of minimum liquidity.

To further strengthen and promote consistency in international liquidity risk supervision, the Committee has also developed a minimum set of monitoring tools to be used in the ongoing monitoring of the liquidity risk exposures of cross-border institutions and in communicating these exposures among home and host supervisors.

Annexure 9.2: The Turner Review on Reforms in banking regulation

This write up only provides a flavour of the celebrated Turner review. (Lord Adair Adair Turner the author of the report is the chairman of the UK Financial Services Authority). To get a full understanding, people, must read the complete report, which is available on the web[133].

According to the Turner review, five key features of the global financial system played a crucial role in increasing systemic risk that led to the meldown.

The growth of the financial sector.
The disproportionate growth of financial sector debt, driven by securitisation led to an explosion of claims within the financial system, among commercial banks, investment banks and hedge funds. This growth of the relative size of the financial sector, magnified the impact of the financial crisis on the real economy.

Increasing leverage
From about 2003 onwards, there were significant increases in the leverage of many commercial and investment banks. But 'risk adjusted' measures of leverage (e.g. Value at Risk (VAR) relative to equity) showed no such rise. This was because capital requirements against trading books, where the asset growth was concentrated, were extremely light compared with those for banking books. VAR measures suggested that risk relative to the gross market value of positions had declined. Clearly, these measures were faulty and the required trading book capital was inadequate.

The build up to the crisis saw the rapid growth of highly leveraged off-balance sheet vehicles – structured investment vehicles (SIVs) and conduits. The off-balance sheet nature of these vehicles resulted in a misrepresentation of true economic risk. When liquidity dried up, many banks were forced to take the assets back on their balance sheets, resulting in a significant increase in measured leverage. Moreover, the embedded leverage of products like CDOs, was not properly understood. Their vulnerability to shifts in confidence and liquidity was grossly underestimated.

Changing forms of maturity transformation.
One of the key functions of the banking system is maturity transformation, i.e., converting short term liabilities into long term assets. In recent years, much of the aggregate maturity transformation has been occurring not on the banking books of regulated banks, but in other forms of 'shadow banking - SIVs, conduits, investment banks. During a crisis, it may be difficult to roll over positions and manage this asset liability maturity mismatch. This can contribute to systemic liquidity strains.

Many institutions assumed they could fund their long term assets by short-term liabilities on the grounds that the assets could be sold rapidly in liquid markets if needed. This assumption was valid during the benign economic conditions that prevailed before the

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[133] www.fsa.gov.uk/pages/library/corporate/turner/index.shtml

sub prime crisis, but became rapidly invalid during the crisis, as many firms attempted to liquidate their positions simultaneously.

A misplaced reliance on sophisticated maths.
There was a general belief that that the increased complexity of structured products had been matched by the evolution of mathematically sophisticated and effective techniques for measuring and managing the resulting risks. At the same time, top management and boards found it difficult to understand the complex maths and to assess and exercise judgement over the risks being taken. Mathematical sophistication led to a false sense of complacence and other visible indicators of increasing risk (e.g. rapid credit extension and balance sheet growth) were ignored.

Hard-wired procyclicality.
The marketability of various assets, with no track record, depended on credit ratings. These ratings proved misleading predictors of risk. Senior notes of SIVs, for instance, were often awarded high credit ratings on the grounds that if the asset value fell below defined triggers, the SIV would be wound up before senior note holders were at risk. At the system level, however, this resulted in attempted simultaneous asset sales by multiple SIVs and liquidity rapidly disappeared. In case of some derivative contracts, the level of collateral depended on the credit ratings of counterparties. Credit default swaps (CDS) and other OTC derivative contracts entered into by AIG, for instance, required it to post more collateral if its own credit rating fell. When this occurred in September 2008, increased liquidity stress and falling perceived credit worthiness fed each other.

The Turner review has proposed seven key measures with respect to capital adequacy, accounting and liquidity policies.

Increasing the quantity and quality of bank capital
The quality of capital is as important as the quantity. The required capital ratios for banks should be expressed entirely in terms of high quality capital, i.e., Core Tier 1 and Tier 1 definitions – and should not count dated subordinated debt. The current international rules effectively result in an absolute minimum of 2% Core Tier 1 relative to risk weighted assets, 4% Tier 1 and 8% total capital (including dated subordinated debt). The Turner review calls for a future regime in which the minimum Core Tier 1 ratio throughout the cycle is 4% and the Tier 1 ratio 8%. This will ensure the generation of an additional buffer equivalent to 2-3% of Core Tier 1 capital at the top of the cycle. Supervisors can insist on a further discretionary buffer above this.

Significant increases in trading book capital
The current capital regime, requires only very light levels of capital against trading books. The risks are considered low because of the assumption that assets can be rapidly sold and positions rapidly unwound. The Turner Review calls for major changes to trading book capital, and a fundamental review of the whole methodology of assessing trading book risk.

Avoiding procyclicality in Basel 2 implementation.
The way in which capital requirements and the actual level of capital vary through-the-cycle is as important as the absolute minimum level. Counter-cyclicality must be injected into the capital regime.

Creating counter-cyclical capital buffers
Capital must increase in good years when loan losses are low, creating buffers which can be drawn down in recession years as losses increase. The growth of bank lending would slow down in the upswing and during a downswing there would be less need for banks to cut back on lending.

Offsetting procyclicality in published accounts
This countercyclical element of capital anticipating future losses should be reflected in published account figures as well as in calculations of required or actual capital.

A gross leverage ratio backstop
A gross leverage ratio must back risk weighted capital as a control measure.

Containing liquidity risks in individual banks and at the systemic level
Regulation relating to liquidity risk management should reflect three considerations:
- Liquidity risk has inherently systemic characteristics. The reaction of one bank to a liquidity crisis can cause a chain effect.
- Liquidity management has become increasingly complex over time. Today, liquidity largely depends on instruments being marketable and liquid. So liquidity regulation cannot be based on one or a few standard ratios comparable to the capital adequacy ratio used to regulate solvency.
- Regulators and policy makers should be aware of the tradeoff involved. Increased maturity transformation delivers benefits to the non bank sectors of the economy and produces term structures of interest rates more favourable to long-term investment. But the greater the aggregate degree of maturity transformation, the more the systemic risks.

The Turner Review has also examined a few other important issues in banking regulation.

Uutility Banking and Investment Banking
One issue being extensively debated, is whether there should be a greater institutional separation between traditional, plain vanilla banking services ('narrow' banking or 'utility' banking) and risky proprietary trading activities ('investment banking'). Indeed, the Glass Steagall Act of 1933, was introduced in the US to draw a clear regulatory distinction between these activities. The Act survived until it was dismantled through legislative changes in the 1980s and 1990s.

Several commentators have argued that banks which perform classic retail and commercial banking functions, and which enjoy the benefits of retail deposit insurance and access to lender of last resort (LOLR) facilities, should not be allowed to conduct risky trading activities. On the other hand, banks significantly involved in risky trading

activities must be clearly excluded from access to retail deposit insurance and from LOLR facilities. They would face the market discipline of going bankrupt if they ran into difficulties.

But the Turner report mentions that it would be difficult for any one country to pursue a clear separation of utility banking and investment banking activities while other countries do not. Moreover, such an approach may not be practical in today's complex global economy. Today's complex globally interconnected economy, requires the existence of large complex banking institutions. Many activities which before the lifting of Glass-Steagall were in the US conducted by investment banks – such as the underwriting of corporate bond issues – are today core elements of an integrated banking service to corporate customers.

Securitisation has been considered the villain of the piece. But the fact is securitization, if more effectively regulated and supervised, can lower cost and reduce risk for banks. Banks might take excessive risk if they make high risk loans and then hold them on their own banking book balance sheet. The optimal financial system for the future probably will include a significant role for securitised credit. So some banks will have to be engaged in activities somewhat distinct from those envisaged in the pure 'utility banking' model.

The notion that risky trading activities can be allowed to grow in an unregulated fashion and be subject only to market discipline is simplistic. Bear Stearns was not involved in any significant way in utility banking activities. But when it was on the verge of failure, the US authorities rightly identified it as systemically important. During a crisis, even those institutions not defined as narrow banks, tend to become eligible to receive LOLR support.

There is also nothing to suggest that 'narrow banks' focusing almost entirely on classic commercial and retail banking activities are immune to risk. Northern Rock, Washington Mutual and IndyMac were all 'narrow banks'.

In short, the complete institutional separation of 'utility banks' from 'investment banks' is difficult to achieve. Large complex banks spanning a wide range of activities are likely to remain a feature of the world's financial system.

Today, large commercial banks enjoy the benefits arising from retail deposit insurance, LOLR access, and an implicitly understood 'too big to fail' status. These benefits can be used to support proprietary trading activities which create risks for both the institution and the system. The Turner review calls for regulatory changes to prevent this:

- Significantly increased capital requirements for the trading book, along with a gross leverage ratio rule that puts a limit on the total balance sheet size.

- A major variation in capital requirements between different types of trading activity, based on a distinction between market making for clients and proprietary position taking.

- A more intense supervision of liquidity risks to check the tendency to hold potentially illiquid assets funded by short term liabilities. Internal pricing must reflect liquidity risk.

- Linking remuneration to risk adjusted profits.

Institutional and geographic coverage

Regulation should focus on economic substance, not legal form or geographical jurisdiction. The Turner review makes various recommendations in this context. Some of them are:

- Off-balance sheet vehicles must be treated as if on-balance sheet for regulatory purposes.
- Oversight of financial institutions should ideally be coordinated by integrated regulators who have responsibilities spanning banks, investment banks and insurance companies. This will minimise inconsistency and arbitrage between different authorities within one country.
- Hedge funds are different from banks in terms of their investment objectives and trading strategies. But their activities in aggregate can have an important procyclical systemic impact. For example, the simultaneous attempt by many hedge funds to deleverage may depress securities prices in a self fulfilling cycle. Regulators must apply appropriate capital and liquidity rules to hedge funds or any other category of investment intermediary, if at any time they judge that the activities have become bank-like in nature or systemic in importance.
- Many hedge funds are legally domiciled in offshore financial centres. Offshore centers did not directly contribute to the sub prime meltdown. But they must be brought within the ambit of internationally agreed financial regulation. Tighter effective controls in offshore centers may be needed to minimise the incentives for regulatory arbitrage.

Netting, clearing and central counterparty in derivatives trading.

There has been a huge growth in the value of OTC derivative contracts traded. A thorough revamp of the trading arrangements for such instruments has become necessary.

- In case of OTC instruments, the failure of one party can produce market disruption. Each exposure may be covered by collateral requirements, which in turn reflect the creditworthiness of the counterparties. As a result, changes in counterparty credit rating can produce disruptive procyclical effects.
- It is important to reduce unnecessary multiplication of gross exposures. The simplest way to achieve this is through 'compression', the netting out of offsetting bilateral positions. Achieving a reduction in net positions would also be greatly assisted by the development of clearing systems with central counterparties, allowing multilateral

netting and reducing economic exposures to those outstanding versus the central counter-party. The Turner review calls for robust and resilient central clearing house arrangements for CDS clearing.

- Clearing and central counterparty systems will only be feasible for the roughly 50-75% of the CDS market which is accounted for by standardised contracts. A large volume of customized contracts are likely to remain OTC. Such contracts must be backed by adequate risk capital.

Annexure 9.3: Recommendations of CRMPG III

The Counter Party Risk Management Policy Group (CRMPG) is an influential self regulatory authority that is concerned with the identification, measurement and control of counterparty risk. The group's August 2008 report provides valuable inputs on dealing with risk in an increasingly complex global financial system. The following summary outlines the high level approach to risk management, suggested by the CRMPG. To get a more comprehensive understanding, readers are advised to refer to the full report[134].

It is difficult for the senior management of large banks to fully grasp the scale and complexity of these control and risk effective management challenges. But a few fundamental principles can facilitate the effective management and supervision of large integrated financial intermediaries and ensure that risk controls are both robust and flexible over business cycles.

Precept I: The Basics of Corporate Governance
The culture of corporate governance at individual financial institutions can have a very large bearing on how they respond to unstable periods/crisis.

Instead of backward looking quantitative risk metrics, risk management must rely heavily on judgment, communication and coordination, spanning the organization and reaching to the highest levels of management.

Sound corporate governance can help to break down the silo mentality and ensure that critical information on risk profiles, institution-wide exposure and potential channels of contagion are regularly monitored at all levels.

Critical control personnel in such areas as risk monitoring, credit, operations, internal audit, compliance and controllers must be truly independent from front-line business unit personnel. Support and control functions must be equipped and empowered to impose necessary checks and balances across all risk- taking business units. High-potential individuals must be rotated between business units and support/control functions. Incentives must be designed to discourage short-run excesses in risk taking.

Precept II: The Basics of Risk Monitoring
Risk management models and metrics will be effective only if individual institutions are able to monitor all positions and risk exposures on a timely basis. All large integrated financial intermediaries must be able to monitor risk concentrations and exposures, to all institutional counterparties in a matter of hours. The operating staff must provide effective and coherent reports to senior management regarding such exposures to high-risk counterparties.

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[134] www.crmpolicygroup.org/index.html, August 6, 2008.

Precept III: The Basics of Estimating Risk Appetite
Estimating risk appetite and finding an adequate risk-reward balance must take into account both qualitative and quantitative factors. Stress tests and other quantitative tools are necessary, but not sufficient, tools for making judgments about risk appetite. Stress tests can never anticipate how future events will unfold unless such tests are so extreme as to postulate outcomes that no level of capital or liquidity will provide protection against potential failure. Risk appetite must also consider inherently judgmental factors such as compensation systems and the quality of the control environment.

The challenge for senior management, boards and prudential supervisors is to exercise the necessary judgments as to how factors such as incentives, the quality of the control environment, the point in the business cycle and other qualitative inputs will influence the appetite for risk.

Precept IV: Focusing on Contagion
The basic forces that give rise to contagion include:
- credit concentrations;
- broad-based maturity mismatches;
- excessive leverage
- the illusion of market liquidity.

All large financial institutions must regularly brainstorm to identify "hot spots" and analyze how such "hot spots" might play out in the future. Even if the "hot spots" do not materialize or even if unanticipated "hot spots" do materialize, the insights gained in the brainstorming exercise will be of considerable value in managing future sources of contagion risk.

Precept V: Enhanced Oversight

The board must provide appropriate oversight of the company consistent with the goal of maximizing shareholder value over time. It is difficult for outside independent directors to fully grasp all the risks associated with the day-today activities of large banks. But they can ask the right questions and insist on necessary information – properly presented so that they can effectively exercise their oversight responsibilities.

The highest-level officials from primary supervisory bodies should meet at least annually with the boards of directors of large integrated financial intermediaries. The supervisory authorities must share with the board and top management their views on the underlying stability of the institution and its capacity to absorb periods of adversity. The spokesperson from the supervisory body should be a true policy level executive or, preferably, a principal of the supervisory body. These high level exchanges of views should minimize the use of quantitative metrics and maximize the use of discussion and informed judgment.

These general recommendations may have to be adapted to the legal and cultural context of the nations and jurisdictions where they apply. The precise role of the board of

directors and supervisory bodies, will differ somewhat according to country laws and by jurisdiction. Where the board of directors is a pure oversight body, the supervisory authorities can communicate their conclusions to the full supervisory board through a written assessment. The supervisory authorities can meet, along with executive management, the committee of the board best equipped to participate knowledgeably in a discussion of the underlying stability of the institution.

The core precepts mentioned above are interrelated. No one institution can, by itself, accomplish all that needs to be done in restoring the credibility of the industry and limiting future financial stocks. There must be collective and concerted industrywide initiatives supported by progressive and enlightened prudential supervision. Greater financial discipline at individual private institutions must be reinforced by a renewed commitment to collective discipline. Individual institutions must be prepared under certain circumstances to put aside specific institutional interests for the common good.

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Chapter - 10
The Road Ahead for Risk Management

"The idea that economic crises, like the current financial and housing crisis are mainly caused by changing thought patterns goes against standard economic thinking. But the current crisis bears witness to the role of such changes in thinking. It was caused precisely by our changing confidence, temptations, envy, resentment and illusions and especially by changing stories about the nature of the economy,"

- *George A Akerlof, Robert J Shiller[135]*

Introduction

The overarching purpose of a sound financial system is to channelise effectively savings into productive investments. When the financial system is characterized by fear and panic, this function cannot be discharged. Investment spending falls and GDP shrinks. This more than anything else, is the real cost of a financial crisis.

Towards the end of 2008, as the crisis peaked, the markets for corporate bonds and commercial paper all but dried up. The spreads between risky and risk free instruments rose to phenomenal heights. Banks stopped lending and instead preferred to hoard cash. Economy after economy began to shrink in size with some countries showing double digit negative growth.

Since early 2009 however, things have improved remarkably. The markets seem to be recovering. And global trade is gaining momentum. As we approach the close of 2009, the worst seems to be over, though we still do not know whether the recovery that began in early 2009 will be sustained. During the peak of the crisis, the governments and central banks were the only source of liquidity. Unless this perception goes away completely, recovery will be muted and halting.

Whatever be the nature of the recovery, we do know that we are paying a huge cost for the sub prime crisis. The magnitude of the crisis is reflected in the scale of the government intervention. The value of sovereign credit and guarantees put in place during the crisis already exceeds $7 trillion. (Estimates of course vary.) There is hardly any major country in the world which has not announced a fiscal stimulus to boost spending and restore confidence. And obviously, central banks have been in the thick of things to provide liquidity to the financial system. The US Federal Reserve provided a bailout loan of $30 billion in case of Bear Stearns, a $85 billion credit facility for AIG and guaranteed $424bn of losses on bad assets in case of Citibank and Bank of America. As of June 2009, the Fed's total assets had risen to over $2 trillion compared with $852 billion in 2006. Only 29% of these assets were Treasury securities, compared with 91% in 2006.

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[135] "Animal Spirits – How human psychology drives the economy and why it matters for global capitalism," Princeton University Press, 2009.

Exhibit 10.1

IMF estimates of potential write-downs on US-originated assets, 2007-2010

US$trn   %

■ Securities
■ Loans
▲ Implied cumulative loss rate (RHS)
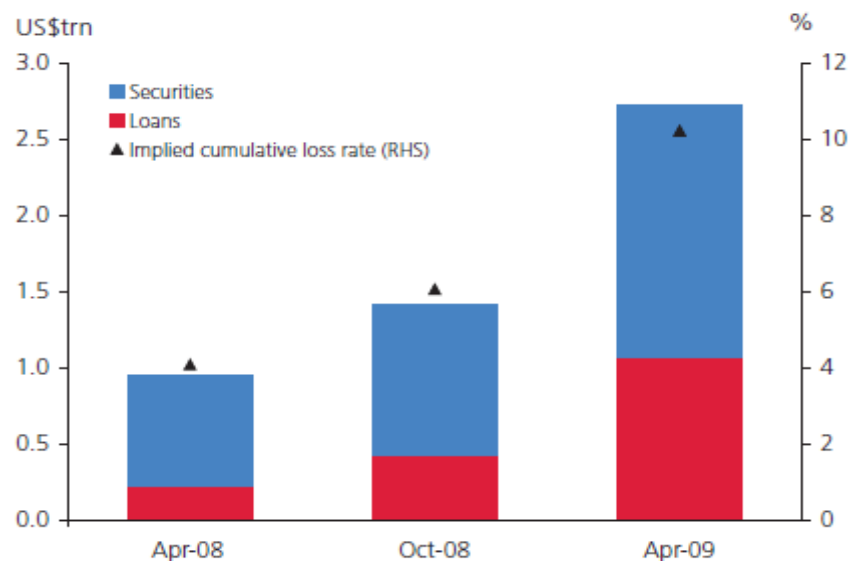
Source: IMF *Global Financial Stability Report* (*GFSR*).
Note: Implied cumulative loss rate is total potential write-downs divided by total outstanding loans and securities.

The future of society

The losses caused by the recent financial meltdown certainly look daunting and are indeed unprecedented. But the sub prime crisis should not distract our attention away from some major challenges faced by contemporary society. And these challenges cannot be addressed without a vibrant financial system. There is an energy crisis which has temporarily gone into the background but which can be expected to resurface again. The phenomenon of global warming can no longer be ignored. The energy crisis and global warming are interconnected. They call for major investments in clean technologies. How these investments should be funded was a major point of discussion in the Copenhagen summit of December 2009. A big demographic crisis in the developed world is not far away. Related to the demographic crisis is the health care challenge. As ageing picks up momentum, the cost of health care is bound to go up. Dealing with these crises will involve innovative approaches towards the mobilization and management of vast amounts of funding to facilitate the development and introduction of various new technologies. Clearly, the financial system needs to be restored to prime health quickly.

Retooling of the financial system will call for a lot of work from the various market participants, central banks, and the government, banking regulators, academics and opinion leaders. But before we look at some of these issues, let us first examine one of the specific challenges, the demographic crisis in more detail and understand the role of the financial system in dealing with this crisis. Here, we draw heavily from a brilliant

book on the subject – "Future-cast 2020 – A global vision of tomorrow" by Robert Shapiro[136].

Demographic trends have already started to have a huge impact on the developed countries. Indeed, ageing is the common thread running across societies in many western countries and Japan today. Ageing implies that relatively fewer and fewer income earning people will have to support more and more retired people in the coming years. In Germany, Italy and Japan, there are just two people in the age group 20-60, supporting one person above 60. The corresponding number for Sweden, France and Britain lies between 2.25 and 2.5. The US and Ireland are somewhat better off with figures of 3.33 and 4 respectively. But even in the US, things are not rosy. Some 12.4% of the paychecks of Americans go towards social security. The paycheck cuts are even higher in France (24%) and Italy (33%) to give just two examples. The burden of pay roll, income and value added taxes have increased to a point, where the scope for further increase in taxes, is very limited.

At the same time, many countries are running generous retirement systems which may be politically correct but are clearly not sustainable in the long term. In Italy, retired workers receive 90% of their pre retirement take-home monthly wages. The corresponding figure for Germany, France and Sweden lies between 68 and 72%. Where the retirement benefits are generous, the culture of building private savings is also weak. As a result, the pressure on government finances is increasing. By 2020, the European Union has estimated that public pension benefits will claim 15% of the GDP in France and Italy and 12.6% in Germany.

China too will face a demographic crisis in a couple of decades. The country does not have any semblance of retirement security today. Many people are trapped in subsistence living even as the Chinese economy powers ahead. The typical Chinese who retires today is destined to die in poverty unless help comes from family members. Even if China were to put in place a system that provides basic benefits to the retired, it would cost 10% of the country's GDP. This is a huge burden, even after considering that China is currently running a decent fiscal surplus. To meet this spending, China will have to cut back on other projects leading to slower growth. This is a situation which is clearly unappealing to the communist party.

Fresh and innovative approaches will be needed to deal with the demographic crisis. Finance will undoubtedly lie at the centre of these solutions. The financial system will have to encourage savings by citizens and ensure these savings are properly invested. For that to happen, the financial system will have to deepen and facilitate the launch of a wide range of instruments. These instruments must operate within a robust risk management framework. The risks involved, must be properly understood by ordinary, unsophisticated, retail investors who can then align themselves with the instruments most appropriate to them. At the same time, investors must be made to understand that shunning risks completely and having the state managing these risks on their behalf, is no longer a viable option. The traditional pay-as-you go, defined benefit pension plans (i.e.,

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[136] Profile Books, 2008.

guaranteed returns) run by governments in the past are simply not sustainable. As people become more comfortable with various financial instruments, they will start saving and investing. If over a period of time, they get decent returns, they can plan for retirement with less anxiety. The state funded pension systems will also be able to breathe a little easier. In other words, the financial system will have to retool itself by increasing risk awareness and by encouraging retail investors to take more risk about their future.

The future of the global economy

What is the outlook for the global economy? Will it bounce back to the pre sub prime crisis growth rate? Will it be a W shaped recovery, i.e., we will see another recession before recovery becomes sustained? Will the "new normal" imply a substantially lower growth rate than was the case before the sub prime crisis? No definite answers can be provided. But from the graphs and tables given below, it will be evident that many structural problems need to be resolved. Much of the recovery we have seen in recent months has been due to heavy government spending. This in turn has led to huge budget deficits in many developed countries. These deficits will have to come down in the coming years but any sudden reduction can arrest the recovery that seems to have begun. Meanwhile central banks continue to keep interest rates very low. There are concerns whether this will fuel another asset bubble.

While various reforms are being discussed in the financial system, the need of the hour is to restore the animal spirits. Experience tells us that animal spirits take time to come back after a bubble bursts. A brief recap of how the bubble burst is in order. As we mentioned in Chapter 2, at the heart of the recent crisis lay the huge macro economic imbalances in the global financial system. Excessive savings and huge trade surpluses of the emerging markets helped to keep interest rates low. In turn, low interest rates encouraged borrowing and consumption, especially in the US, as reflected in the huge trade deficits that the US ran for several years. The US was able to run huge trade deficits because the rest of the world was prepared to invest in US treasury instruments. Effectively, the savings of Asia and the middle east facilitated excess American consumption. China in particular built a high savings high investment economy and artificially suppressed consumption. With the steady flow of savings into the global financial markets, particularly the US, few imagined that liquidity would ever dry up.

But at the peak of sub prime, the situation swung to the other extreme. Banks stopped lending and began to hoard cash. The inter bank markets dried up as many market funds become hesitant to provide short term loans following the collapse of Lehman. Meanwhile, the repo market where banks lent out assets such as treasuries, mortgages and other bonds in return for cash was also in limbo. Funds withdrew from the commercial paper market, a key source of short term funding for companies.

Lending stopped because banks were not sure of how much capital they might need to deal with contingencies. There seemed to be a complete lack of trust in the financial system. At one point, the European Central Bank (ECB) even mooted the idea of a clearing house that would guarantee lending. Central banks started emerging as "default" counter parties in many financial market transactions. That is how the balance sheets of

central banks especially the Fed and the ECB started to grow dramatically. The Fed attempted to inject liquidity by purchasing commercial paper and the securities issued by Fannie Mac and Freddie Mac. The Fed purchased more than $313 bn of commercial paper between the end of October and the end of December, 2008.

Even as central banks tried to pump liquidity into the system, governments too became heavily involved in reviving the financial system. Indeed, fiscal policy went hand in hand with monetary policy as policy makers all over the world attempted to prevent deflation. The US Treasury took various steps to inject capital in banks and also help them to deal with the "toxic assets" on the balance sheet. The US government also stepped in to help sectors of the economy that were struggling badly. General Motors and Chrysler received liberal doses of help from the US government. Other governments in Europe and Asia also resorted to huge fiscal stimuli, though not on the same scale as the US.

All these measures – low interest rates, recapitalization, government guarantees and fiscal stimulus by no stretch of imagination, can guarantee a return of the animal spirits. As Sushil Wadhwani remarked in an insightful article[137], "The failure to incorporate the role of what Keynes described as 'animal spirits', might well have permitted the naïve belief that recapitalizing the banks would lead them to lend again. Once confidence has evaporated, banks will not lend, however well capitalized they may be. "

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[137] *Financial Times,* 17 December 2008.

Exhibit 10.2
Fiscal Balance (%GDP)
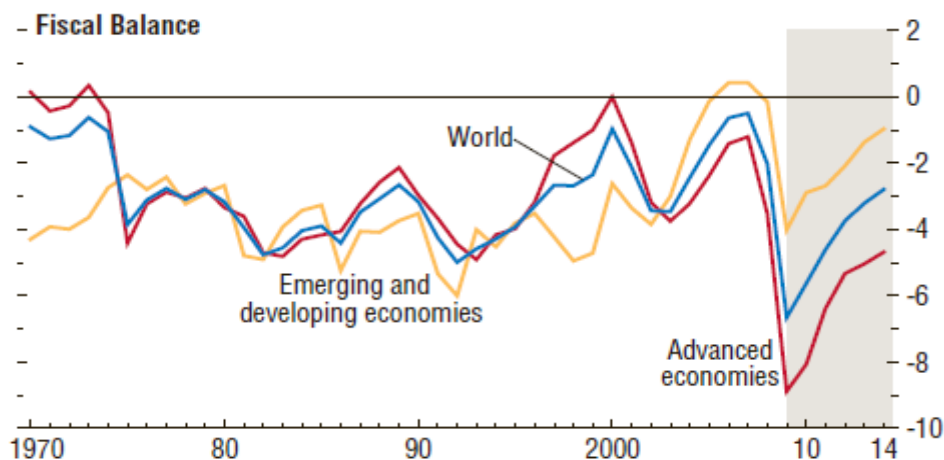
Ref: IMF World Economic Outlook, October 2009, www.imf.org

The future of financial innovation

"It is critical that we take the opportunity of the crisis to promote innovation enhancing financial deregulation and not let this be eclipsed by superficially popular issues[138]."

In the wake of the sub prime meltdown, the rapid pace of financial innovation in the past decade has been criticized. Innovation proceeded so fast that regulators were caught on the wrong foot. But the solution clearly does not lie in throttling innovation. No society can progress without innovation. Innovation creates new possibilities. And by their very nature, new things are risky. But that does not mean we go back to the past. Consider the following:

- Credit cards, if they are misused can cause considerable problems. Does it mean we must ban credit cards?
- Online payments can be very risky in a world where hackers abound. Does it mean we must stop online payments?
- High speed transport can result in major casualties if there is an accident. Does this mean we must go back to primitive modes of transport?
- Virtual collaboration tools are reducing the personal touch and leading to behavioural dysfunctions such as superficiality, multi tasking, inadequate concentration while doing a job and so on. Does it mean we must stop the use of email and social networking?
- Derivatives can be and have been used by some unscrupulous individuals. Does it mean we should ban their use and thereby take away an important means of transferring risk?

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[138] Robert Shiller, *Financial Times,* September 28, 2009, p. 9.

- Securitization was used ingeniously by banks to minimize capital requirements. Does it mean we should ban securitization and take away an effective means of making illiquid portfolios liquid?
- Speculators fuelled a housing boom. The boom was partly facilitated by innovative mortgage instruments. Does it mean we must put a blanket ban on these instruments and deny the aspirations of millions of people who want to own a home?

Having pointed out the benefits of innovation, we must pause for a while. If innovations pose risks, these risks must be addressed carefully. The experience of the sub prime crisis tells us that, we must encourage the "right" kind of financial innovations. In an interesting paper[139], Joseph R Mason points out that *only those financial innovations that facilitate diversification, market completion or capital deepening are useful to society in the long run*. Others end up creating more problems than solving them. And this is exactly what seems to have happened during the subprime crisis. Let us understand Mason's arguments in more detail.

Financial innovations that facilitate *diversification* are extremely important for investors. A good example is index funds, which allow small investors to hold a diversified portfolio that replicates the index without actually having the money needed to buy all the stocks that make up the index.

Market completion helps to make markets work more efficiently, by removing arbitrage opportunities and financial friction. For example, life settlement products allow life insurance policy holders to sell their policy for the expected present value of the insurance benefits. This value typically exceeds the policy surrender value and the net present value of the premiums contributed to date. If life settlement products succeed, the life insurance industry will have to pay much higher surrender values to compete with life settlement providers. This will remove a financial arbitraging opportunity.

Capital deepening means injecting liquidity by making assets more liquid. A good example is securitization, which enables illiquid loans to be sold. The proceeds of the sale can be used to make more loans. Thus more capital is available in the market.

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[139] "The summer of '07 and the short comings of financial innovation," Journal of Applied Finance, Spring/ Summer 2008.

Exhibit 10.3
OTC Derivative Volume by product type
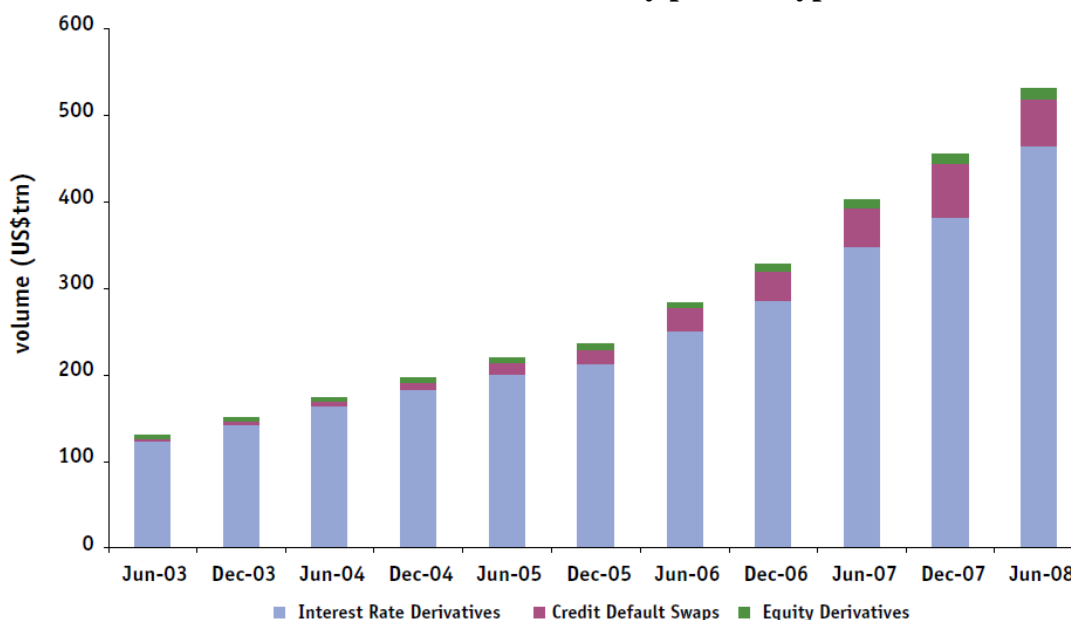
Source: ISDA

Ref: The Turner Review - A regulatory response to the global banking crisis, published by: UK Financial Services Authority, www.fsa.gov.uk/pubs/other/turner_review; March 2009.

Why did securitization, positioned as a capital deepening innovation, fail? Mason explains that the key to a capital deepening process is the effective distribution of risk and returns to a wider investor base. But during the sub prime crisis, the risk was either not distributed, i.e., it remained with the banks or was parceled off to unwitting investors without commensurate returns to justify the additional risk involved. Indeed, securitization, during the sub prime crisis became a risk "distillation" rather than a risk "distribution" process. While securitization pooled various loans and made them tradable, it also ended up creating a few very risky securities that ended up bearing all the expected losses in the pool. It was indeed this "toxic waste," which fuelled the sub prime meltdown.

Regulators must be proactive when it comes to financial innovation. Innovations, when first introduced, may be a black box to many. But as they become popular, they must become more transparent. The features of financial instruments must become standardized so that they can trade freely on OTC markets with adequate liquidity. Commoditized instruments can finally trade on organized exchanges where as we know, the counterparty risk is greatly minimized.

Adequate accounting rules, a proper regulatory framework and widespread understanding of product features are all necessary before an innovation can become broad based. Unfortunately, in the case of complex, opaque instruments like CDOs, the market expansion took off before participants had enough time to understand them and

appreciate the risks involved. As Mason sums up, "Recent experience should stand as a lesson that it is important to move financial innovations through those incipient stages of development before they grow large enough to substantially undermine economic performance, should a crisis arise."

In short, financial innovation must be encouraged within a controlled framework. Giving the financial sector complete freedom to operate in the name of encouraging innovations is a simplistic approach to say the least. Checks and balances are indeed necessary.

A small note on credit derivatives is in order here. At the heart of the recent financial crisis have been credit derivatives, especially Credit Default Swaps (CDS). The CDS market had grown to $62 trillion in notional value by early 2008. To put this figure in perspective, the size of the global economy in 2008 was approximately $55 trillion! It is because of the huge volumes of CDS transactions that insurance giant AIG had entered into, that the US Treasury had no option but to intervene and bail out the insurance giant. If AIG had collapsed resulting in the dishonor of many CDS contracts, these would have been mayhem all around. Similarly Bear Stearns was so deeply entangled in the CDS market that regulators feared its collapse would lead to chaos. That is why it was bailed out in early 2008.

Despite the problems arising out of the indiscriminate use of CDS, one can hardly imagine a world without derivatives. Just because a few players used derivatives indiscriminately is hardly a reason for banning the use of derivatives. Instead what we need are better mechanisms for reducing counterparty and settlement risk. To address the current concerns in the CDS market, some 17 large dealers have come together to launch a clearing house for credit derivatives. A central counterparty backed by a default fund would greatly reduce the probability of the system becoming unstable due to any one player's failure. Exchange based arrangements may also over time deal with other challenges such as a more precise definition of credit events. More recently, the US Treasury has come out with new guidelines that would call for better disclosure of derivative trades and capital backing and a shift from OTC trades to exchange trades wherever possible.

The future of investment banking

After all the mauling they received, what is the future of banking? Plain vanilla commercial banks can be expected to operate as before. They provide basic functions like mobilizing savings, providing fixed deposits, etc. In many cases, they also provide letters of credit and other forms of trade financing. These functions are well understood and are indispensable to the modern economy. Indeed, these "non glamorous functions," may regain their importance in the coming years.

But what about investment banks? A few like Goldman Sachs already seem to have recovered. But many others are still struggling. With the collapse of Bear Stearns and Lehman Brothers and the acquisition of Merrill Lynch by Bank of America, the air of invincibility about large financial institutions no longer exists.

Till recently, investment banks remained the dream employers for graduates of most leading Business Schools. The cowboy approach of the investment bankers received admiration and respect from society, even though of a grudging type. They came to be known as "Masters of the Universe." Under the guise of financial innovation and various quantitative models, the investment bankers succeeded in convincing regulators that they had found ingenious ways to package and disperse risk. But it is now clear that many of these strategies were undesirable from the systemic risk point of view.

Thanks to the sub prime melt down, investment banking will undoubtedly undergo some structural changes in the coming years. Many banks are examining their product lines to determine whether the returns generated justify the risks taken. Banks are also reducing leverage dramatically. Some such as UBS have cut down proprietary trading drastically. Others are moving away from trading to fee based advisory services.

Leverage has traditionally been an integral part of the business model of most investment banks. Indeed, investment banks thrived on leverage to generate adequate returns for shareholders. The leverage ratio (Total assets to equity) for Wall Street banks was in the range 25-30 before the bubble burst. The great thing about leverage is that even a small rise in the value of investments results in a phenomenal return on capital. But the downside is that a small drop in the value of investments can wipe out the equity and raise fundamental concerns about a bank's viability causing the stock price to plunge. That is why investment banks are reducing leverage. But as leverage reduces and capital goes up, the returns to shareholders are bound to reduce. So investment banks will have to get used to much lower returns on equity than they have been used to delivering in the past. In 2009, some banks such as Goldman have shown record profits. But that seems to be more due to government support. It is unlikely that these profits can be sustained in the long run.

Investment banks will also have to diversify their fund base. They will have to reduce their dependence on wholesale short term funding. During the sub prime crisis, when this funding dried up, it became difficult to roll over positions. That is how the Structured Investment Vehicles (SIVs) got into trouble. Liquidity dried up and many of the sub prime assets came back to the balance sheets of banks. In future, investment banks are likely to depend on "stickier," retail deposits for their funding needs.

What kind of shakeout can we expect in the investment banking industry? It is too early to make predictions but already there are some doubts about the future of bulge bracket investment banks. Advisory boutiques with a "partnership," culture that give clients good, independent advice, seem to be doing well after the meltdown. These boutiques also have less conflict of interest. For example, they are generally not involved in proprietary trading or market making. Meanwhile, regulatory authorities in the US are considering the imposition of size limits and curbs on proprietary trading, hedge fund and private equity activities. This is in line with the philosophy covered earlier in the book that financial institutions should no longer be too big to fail. Moreover, institutions that are involved in risky activities should not qualify for lender-of-last-resort support from the central bank.

The future of risk management

No society can thrive without taking risk. We should not respond to the sub prime crisis by swearing solemnly. "Never again shall we take risk." Rather, the efforts must be channelized towards plugging loopholes in the current risk management framework, and strengthening systems and processes. Such efforts will encourage companies to take risk once again and pave the way for the return of the animal spirits.

But before we gaze into the future, it is a good idea to look at the recent past. In the months before the crisis, many banks claimed to have put in place sophisticated risk management systems. Yet these systems failed to deliver and many a bank landed in a mess after the sub prime crisis started to unfold. Why did this happen?

Risks went out of control for various reasons. To start with, mechanical approaches were followed by many banks with human judgment and intuition being completely ignored. For example, credit ratings were used to justify heavy investments in the super senior tranches of CDOs. In some cases, the top management did not become sufficiently involved while dealing with risk. In the name of delegation, they abdicated their responsibility. Sometimes, the top management did raise the right questions. But they did not follow through with appropriate actions. In other cases, traders fooled risk managers into believing that all the rules were being followed. To a large extent, they were able to do this by hiding behind technical jargon and sophisticated quantitative models. Only banks like Goldman Sachs, JP Morgan and Toronto Dominion (of Canada) where the top management asked the right questions at the right time and took principled decisions, escaped relatively unscathed.

Exhibit 10.4
Key implications for risk management

▪ Piecemeal risk management must give way to an integrated, holistic approach.
▪ Balance sheet, capital and liquidity positions must be monitored together.
▪ Risk committees should include senior management, business managers and legal and compliance officers as equal partners.
▪ Complex and illiquid securities must be approached with caution.
▪ Liquidity and market risk management must be integrated.
▪ External credit ratings   must be complemented with internal credit quality assessment.
▪ Incentives must be linked to long term firm wide profitability.

Last year, the *Economist* magazine[140] carried a highly insightful article by a risk manager at a global bank. The senior structured tranches of CDOs, with AAA credit rating were considered risk free, on the basis of high credit ratings. So much sanctity was attached to external bond ratings that if the bank's risk department had ever assigned a lower rating, the judgment of the risk officers would have been immediately questioned.

Soon the bank's approach became increasingly mechanical and superficial and it became very comfortable with investment grade assets. Little capital was needed to support them. There was no liquidity charge and seemingly no default risk. The assets fetched easy profits thanks to a small "carry" between holding the assets and their financing in the liquid inter bank and repo market.

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[140] August 9, 2008.

Exhibit: 10.5
How to gain an advantage over competitors through superior risk management

Information	• Firms that take risk must invest in superior information networks. • Companies must be clear about the kind of information needed for decision making in a crisis and put in place necessary information systems. • Early warning information systems must trigger alerts and preset responses.
Speed	• The speed of response can be critical in a crisis. • Speed depends on the quality of information, and understanding the potential consequences and the interests of the stakeholders. • Organizational structure and culture also determine the speed of response.
Experience/Knowledge	• Having experienced similar crises in the past can give us an advantage. • Firms must invest in learning . • They can enter new and unfamiliar markets, expose themselves to risk and learn from mistakes. • They can acquire firms in unfamiliar markets . • They can form strategic alliances or poach people with the necessary expertise.
Resource	• Having the resources to deal with crisis can give a company a significant advantage over competitors.
Flexibility	• A flexible response to changing circumstances can be a generic advantage. • For some firms, flexibility may come from production facilities that can be modified at short notice to produce modified products that better fit customer demand • For others, flexibility may come from lower overheads/fixed costs. • Flexibility also mean the ability to get rid of past baggage, cannibalising existing product lines and having a "paranoid" culture.
Corporate governance	• Interests of decision makers must be aligned with those of the owners. • Both managers with too little wealth and too much wealth tied up in their business will not take risk. • The appropriate corporate governance structure for the risk taking firms would call for decision makers to be invested in the equity of the firm but also to be diversified.
People	• When facing a crisis, some people panic, others freeze but a few thrive and become better decision makers.
Reward/punishment mechanisms	• A good compensation system must consider both process and results.

Source: Aswath Damodaran, "Strategic Risk Taking: A Framework for Risk Management," Wharton School Publishing 2008.

Meanwhile, despite the fact that the risk department had a separate reporting line to the board, it became difficult to control the traders. To start with, the independent reporting hurt the relationship with the traders. At the same time, the traders looked down upon the

risk managers[141], who were not earning money for the bank, but had the power to block trades. When the risk managers looked at hugely profitable trades with suspicion, the traders perceived it as "non-commercial" and "unconstructive." With the business lines focused on getting the transaction approved rather than really worrying about the risks, meetings between the risk managers and business leaders rapidly became dysfunctional. To complicate matters, the risk managers did not score high on communication and persuasion skills. Finally, the traders won the day.

Risk managers were forced to make many compromises, as they faced resistance from traders. In the benign economic environment, that prevailed between 2003 and 2006, the focus was on the upside. And there was tremendous competitive pressure to maintain earnings. In these circumstances, the risk managers agreed to many transactions that led to the accumulation of a portfolio of highly rated, "very low risk" assets such as the super senior tranches of CDOs. But these assets eventually proved to be very risky. A small price movement finally led to large market-to-market losses. By focusing completely on eliminating non investment grade assets from the portfolio, the bank ended up with a huge pile of highly rated but potentially illiquid assets.

How can this classic tussle between traders and risk managers be handled more effectively? One pragmatic measure is to encourage more traders to become risk managers. Traders know the business well and if they became risk managers, they would be able to "connect" better with the businesses. This point makes sense when we consider that one reason for Goldman's relatively good performance during the subprime crisis has been the quants and trading background of top management. Whereas in many other banks, the top management played a "leadership role." Their lack of understanding of the business allowed traders at lower levels to take risks merrily and maintain the facade that everything was under control.

Financial crises happen from time to time. As mentioned earlier in the book, all crises have some unique features. But they also have some common underlying elements. It is important that we learn from these crises to put in place better systems and processes. The Asian currency crisis, the collapse of Barings and the LTCM crisis are some of the better known ones.

Risk management guru, John Hull[142] has summed up neatly the lessons companies and banks must learn from past crises. Here, we take a few of Hull's insights as a starting point and build upon them.

- Companies and banks must define clearly the limits to the financial risks that can be assumed.
- Violations of risk limits must be sternly dealt with.
- Even successful traders must be monitored carefully. Luck rather than superior trading skills often explain the success of traders. "Star" traders should not enjoy immunity from audit checks by risk managers.

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[141] "Confession of a risk manager," The Economist, August 9, 2008. pp. 72-74.
[142] Risk Management and Financial Institutions, Pearson Education, 2007.

- Diversification benefits should not be over estimated. Concentration risk must be managed carefully.
- Scenario analyses and stress testing must back risk measures such as value-at-risk. It is important to think outside the box and consider extreme situations. As Nicholas Nassem Taleb would say, just because we have never seen a black swan, it does not imply that one does not exist.
- Models should not be blindly trusted. If large profits result from relatively simple trading strategies, risk managers should become suspicious. Maybe, the profits are being measured in the wrong way.
- Getting too much trading business of one type warrants as much critical examination as getting too little of that type.
- Traders should not be allowed to book inception profits, i.e., profits at the start of a trade, by marking-to-model. By recognizing inception profits slowly, a longer term, more mature orientation can be inculcated among traders.
- Banks must sell clients products that are appropriate for them. Before the sub prime crisis, many wealth management clients seem to have been been sold complex products whose risks they did not fully appreciate.
- The possibility of liquidity black holes must not be underestimated. Liquidity problems can crop up more frequently than what models would seem to suggest. Less actively traded instruments will not always sell at close to the theoretical price, as predicted by models. When many market participants are following the same strategy, there might be big market moves leading to a liquidity crisis. So liquidity and market risks should be examined together.
- Top management should not approve a trading strategy that they do not fully understand. Otherwise, traders are quite likely to take advantage of the situation.
- Caution should be exercised before turning the treasury department of a company into a profit centre. The treasury can become a profit centre only by taking more risk. This implies that hedging will inevitably move towards speculation.

Concluding Notes

The subprime crisis seems to be behind us. A recovery does seem to be under way as we approach the end of 2009. But whether this recovery can be sustained will be known only with time.

The challenge facing many central banks across the world is how to make a smooth exit after such massive intervention in the financial markets over the past two years. And that is not going to be easy. History offers some useful lessons in this regard. In 1936-37, the Fed, fearing an uncontrolled, run away expansion of credit, decided to raise the reserve requirements. Banks responded by reducing lending and by building a liquidity buffer beyond the legal requirements. This led to a sharp contraction in credit and economic activity. The recovery, the economy had been making since 1933 was arrested. Today, the Fed faces a similar situation.

Confidence will take time to come back, after all the tumultuous events of the past 18 months. But it will come back one day. How bankers will behave during the next boom and how prepared regulators are with checks and balances will determine whether such a

serious crisis will ever be repeated. We mentioned earlier in the book that many experts have called for a counter cyclical approach to capital management to ensure that things do not go out of control. This means building up capital in the good times by raising the capital adequacy ratio and bringing the ratio down during a recession to encourage lending.

There is also a felt need for coordinating regulation across the world. Unfortunately, in a globalised economy, approaches to banking regulation remains far too fragmented. Coordination across nations, notwithstanding all the forums created for multilateral discussions, remains weak. Despite talks of global collaboration, countries are pretty much focused on their own individual interests. The heads of the Group of 20 (G-20) (formed in 1999 after the Asian currency crisis), met in Washington in mid – November 2008 in an event dubbed as the new Bretton woods. During the meeting, the leaders sketched out a grand plan for cooperation to support global growth and deal with the financial crisis. There was also a promise to refrain from protectionist measures. But Russia, Indonesia, Argentina, Brazil and India changed their position days after the meeting.

At their most recent meeting in September 2009 in Chicago, the G-20 sent out signals that it was ready to take over the economic leadership of the world from the G-8. The G-20 meeting suggested a three stage process. National leaders will agree on priorities for the global economy in annual G-20 summits. Countries will submit reports to indicate how their domestic policies are aligned with those priorities. The IMF will assess whether national plans taken together, will support global objectives. Peer pressure is expected to be the main disciplining mechanism for the group.

Among the specific measures on which the G-20 leaders came to a broad understanding, if not actual details, were deferred compensation for bankers, tougher capital requirements for banks, a leverage ratio to check capital adequacy and new liquidity requirements. The meet also called for the need to bring US and international accounting standards in line. The G-20 agreed on the need to avoid a premature withdrawal of the fiscal stimulus introduced at the peak of the crisis. The group indicated the need to plan and coordinate carefully the exit strategies.

Meanwhile, many economists, have raised another fundamental set of questions about the role of finance: Has the financial sector grown too big? Are all the activities of the financial sector useful for society? Should the focus not be on boosting productivity rather than on financial engineering? Even the chairman of the UK Financial Services Authority, the widely respected Lord Adair Turner has mentioned there is a need to limit the size of the financial sector in the UK.

But finance is an integral part of modern development. As *The Financial Times*[143] mentioned, "Finance and production are not alternatives but complements. The real economy relies on finance both for capital to invest and for consumers to be able to save, borrow and so shift their consumption in time. Finance regulators must act to address the

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[143] December 31, 2008.

clear and specific failures revealed this year. But that, not reining in finance for the sake of the 'real' should be their goal."

Similarly, *The Economist*[144] has argued in favour of a balanced, pragmatic approach: "….the aim should be neither to banish finance nor to punish it but to create a system that supports economic growth through the best mix of state – imposed stability and private initiative. Modern finance is flawed, unstable and prone to excess. But think of those boots and those wasted lives (in the erstwhile Soviet Union), planned markets are flawed, unstable and excessive too."

In his book, "The Sub Prime Solution," Robert Shiller mentions that, the recent crisis may indeed be an opportunity to redouble efforts to rethink and improve risk-management institutions. Modern finance continues to serve as a powerful engine of economic growth, from underwriting new businesses in the private sector to supporting vital research in the universities to building schools and hospitals in the public sector. The need of the hour is institutional reforms that will provide a strong framework within which real estate and financial markets can operate.

Today, as we emerge from the sub prime crisis, the whole paradigm of banking and risk management is being reexamined. But one fundamental principle will not change. Risk taking is essential for the progress of mankind. As Dan Ariely, mentioned recently[145], "Imagine a society in which no one would take on the risk of creating startups, developing new medications or opening new businesses. We know most new enterprises fail in the first few years. Yet they crop up all the time, sometimes jumpstarting entirely new sectors. A society in which no one is overtly optimistic and no one takes too much risk? Such a culture wouldn't advance much."

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[144] January 24, 2009, In the erstwhile Soviet Union, it was common to see the excess production of boots for one leg even as there was a shortfall in production of boots for the other leg (of the same size)!
[145] "The curious paradox of optimum bias," *Businessweek,* August 24/31, 2009, p.48

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