# Chapter 1

# Nature of Financial Risk

> "The value added of a good risk management system is that you can take more risks." [Anonymous risk manager, Spring 2007]

One of the paradoxes of the recent global financial crisis is that the crisis erupted in an era when risk management was at the heart of the management of the largest and most sophisticated financial institutions. For institutions who see their role as making money by taking judicious risks, the management of those risks is pivotal in their daily operations. The risk manager quoted above was merely re-affirming the firm's goals. The risk manager's task is to enable the firm to fulfill its purpose by providing the framework for measuring risks accurately, enabling the firm to take advantage of greater precision so as to extract the last ounce of return from the firm's portfolio.

Financial risk is endogenous due in large part to the reasoning embedded in the opening quote. Endogenous risk refers to risks that are generated and amplified within the financial system, rather than risks from shocks that arrive from outside the financial system. The precondition for endogenous risk is the conjunction of circumstances where individual actors react to changes in their environment and where those individuals' actions *affect* their environment. As we will see in the course of these lectures, the financial system is the supreme example of an environment where individuals react to what's happening around them and where their actions drive the realised outcomes themselves.

Underpinning this two-way flow is the galvanising role of market prices which serves to synchronise and amplify the feedback process. In an era

where loans are packaged into securities and balance sheets are continuously marked to market, the galvanising role of market prices reaches into every nook and cranny of the financial system. It will be a central thesis in these lectures that the severity of the global financial crisis is explained in large part by financial development that put marketable assets at the heart of the financial system, and the increased sophistication of financial institutions that held and traded the assets.

## Millennium Bridge

But before we deal with the financial system, it is instructive to study the potency of synchronised feedback from an example from outside economics or finance. The saga of the Millennium Bridge in London is a revealing lesson on market failure from outside economics. Many readers will be familiar with the Millennium Bridge. As the name suggests, the bridge was part of the Millennium celebrations in the year 2000. It was the first new crossing over the Thames for over a hundred years, constructed at a cost of £18 million. The sleek 325 metre-long structure used an innovative "lateral suspension" design, built without the tall supporting columns that are more familiar with other suspension bridges. The vision was of a "blade of light" across the river, connecting St. Paul's with the new Tate Modern gallery. The bridge was opened by the Queen on a sunny day in June, and the press was there in force. Many thousands of people turned up after the tape was cut and crowded on to the bridge to savour the occasion. However, within moments of the bridge's opening, it began to shake violently. The shaking was so severe that many pedestrians clung on to the side-rails. The BBC's website has a page dedicated to the episode and posts some dramatic video news clips of the opening day.[1] The bridge was closed shortly after the opening and was to remain closed for 18 months.

When engineers used shaking machines to send vibrations through the bridge, they found that horizontal shaking at 1 hertz (that is, at one cycle per second) set off the wobble seen on the opening day. Now, this was an important clue, since normal walking pace is around two strides per second, which means that we're on our left foot every second and on our right foot every second. Walking produces a vertical force (depending on our body mass) of around 750 Newtons or 165 pounds at 2 hertz. However, there

[1] http://news.bbc.co.uk/hi/english/static/in_depth/uk/2000/millennium_bridge/default.stm

is also a small sideways force caused by the sway of our body mass due to the fact that our legs are slightly apart. Anyone who has been on a rope bridge should be well aware of the existence of this sideways force. This force (around 25 Newtons or 5.5 pounds) is directed to the left when we are on our left foot, and to the right when we are on our right foot. This force occurs at half the frequency (or at 1 hertz). This was the frequency that was causing the problems.

But why should this be a problem? We know that soldiers should break step before crossing a bridge. For thousands of pedestrians walking at random, one person's sway to the left should be cancelled out by another's sway to the right. If anything, the principle of diversification suggests that having lots of people on the bridge is the best way of cancelling out the sideways forces on the bridge.

Or, to put it another way, what is the probability that a thousand people walking at random will end up walking exactly in step, and remain in lock-step thereafter? It is tempting to say "close to zero". After all, if each person's step is an independent event, then the probability of everyone walking in step would be the product of many small numbers - giving us a probability close to zero.

However, we have to take into account the way that people react to their environment. Pedestrians on the bridge react to how the bridge is moving. When the bridge moves from under your feet, it is a natural reaction to adjust your stance to regain balance. But here is the catch. When the bridge moves, everyone adjusts his or her stance *at the same time*. This synchronised movement pushes the bridge that the people are standing on, and makes the bridge move even more. This, in turn, makes the pedestrians adjust their stance more drastically, and so on. In other words, the wobble of the bridge feeds on itself. When the bridge wobbles, everyone adjusts their stance, which makes the wobble even worse. So, the wobble will continue and get stronger even though the initial shock (say, a small gust of wind) has long passed, as depicted in Figure 1.1.

Arup, the bridge's engineers found that the critical threshold for the number of pedestrians that started the wobble was 156. Up to that number, the movement increased only slightly as more people came on the bridge. However, with ten more people, the wobble increased at a sharply higher rate.[2]

[2]http://www.arup.com/millenniumbridge/challenge/results.html

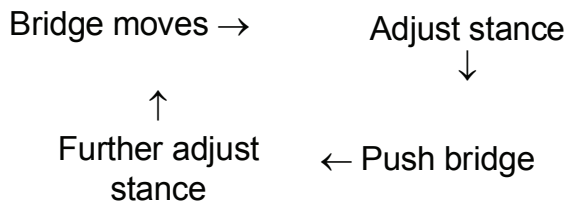


Figure 1.1: Millennium Bridge Feedback

The wobble is an example of a shock that is generated and amplified *within* the system. It is very different from a shock that comes from a storm or an earthquake which come from outside the system. Stress testing on the computer that looks only at storms, earthquakes and heavy loads on the bridge would regard the events on the opening day as a "perfect storm". But this is a perfect storm that is guaranteed to come every day.

## Dual Role of Prices

What does all this have to do with financial markets? Financial markets are the supreme example of an environment where individuals react to what's happening around them, and where individuals' actions affect the outcomes themselves. The pedestrians on the Millennium Bridge are rather like modern banks that react to price changes, and the movements in the bridge itself are rather like price changes in the market. So, under the right conditions, price changes will elicit reactions from the banks, which move prices, which elicit further reactions, and so on.

Financial development has meant that banks and other financial institutions are now are at the cutting edge of price-sensitive incentive schemes and price-sensitive risk-management systems. Mark-to-market accounting ensures that any price change shows up immediately on the balance sheet. So, when the bridge moves, banks adjust their stance more than they used to, and marking to market ensures that they all do so *at the same time*.

The Millennium Bridge example serves to highlight the dual role of prices. Prices play two roles. Not only are they a reflection of the underlying economic fundamentals, they are also an imperative to action. That is, prices induce actions on the part of the economic agents. Some actions induced by price changes are desirable, not only from the point of view of the individual, but from a system perspective, too. However, some actions borne out of

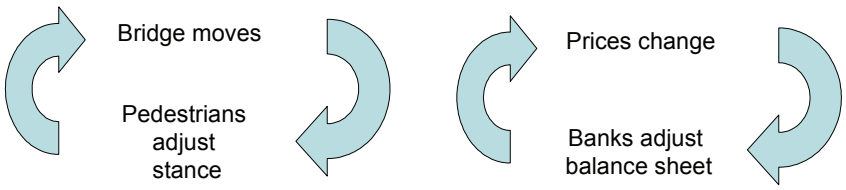


Figure 1.2: Feedback in Financial Systems

binding constraints or actions that exert harmful spillover effects on others are undesirable when viewed from the perspective of the group. It is when the action-inducing nature of price changes elicit harmful spillover effects that the double-edged nature of prices takes on its maximum potency. The problem comes when the *reliance* on market prices *distorts* those same market prices. The more weight is given to prices in making decisions, the greater are the spillover effects that ultimately undermine the integrity of those prices. When prices are so distorted, their allocational role is severely impaired. Far from promoting efficiency, contaminated prices undermine their allocational role.

Financial crises could almost be defined as episodes where the allocational role of prices break down. The action-inducing role of price changes introduce distortions and cause an amplified spiral of price changes and actions that can cause great damage along the way. Financial crises are often accompanied by large price changes, but large price changes by themselves do not constitute a crisis. Public announcements of important macroeconomic statistics, such as the U.S. employment report, are sometimes marked by large, discrete price changes at the time of announcement. However, such price changes are arguably the signs of a smoothly functioning market that is able to incorporate new information quickly. The market typically finds composure quite rapidly after such discrete price changes.

In contrast, the distinguishing feature of crisis episodes is that they seem to gather momentum from the endogenous responses of the market participants themselves. Rather like a tropical storm over a warm sea, they appear to gather more energy as they develop. As financial conditions worsen, the willingness of market participants to bear risk seemingly evaporates. Such episodes have been dubbed "liquidity black holes". The terminology is perhaps overly dramatic, but it conveys the sense of free-fall. As prices fall or measured risks rise or previous correlations break down (or some combina-

tion of the three), previously overstretched market participants respond by cutting back, giving a further push to the downward spiral. The global financial crisis that erupted in 2007 has served as a live laboratory for many such distress episodes.

Imagine an emerging market country defending a currency peg in adverse circumstances in the face of deteriorating macroeconomic conditions and hostile capital markets. Similar forces operate in more recent crises, including the events surrounding the runs on Bear Stearns and Lehman Brothers in the crisis of 2008. Defending the peg is often dictated by political goals more than economic ones, such as eventual accession to the European Union, the adoption of the euro, or keeping the peg in tact in order to shield domestic borrowers who have borrowed in dollars or euros.

However, defending the currency also entails raising interest rates and keeping them high. The costs of defending the currency bear many depressingly familiar symptoms - collapsing asset values and a weakened domestic banking system that chokes off credit to the rest of the economy. Whatever the perceived political benefits of maintaining a currency peg, and whatever their official pronouncements, all governments and their monetary authorities have a pain threshold at which the costs of defending the peg outweighs the benefits of doing so. Speculators understand well that their job is almost done when the finance minister of the stricken country appears on evening television vowing never to devalue the currency. Understanding the source and the severity of this pain is a key to understanding the onset of currency attacks.

Facing the monetary authority is an array of diverse private sector actors, both domestic and foreign, whose interests are affected by the actions of the other members of this group, and by the actions of the monetary authority and government. The main actors are domestic companies and households, domestic banks and their depositors, foreign creditor banks, and outright speculators - whether in the form of hedge funds or the proprietary trading desks of the international banks. Two features stand out, and deserve emphasis.

First, each of these diverse actors faces a choice between actions which exacerbate the pain of maintaining the peg and actions which are more benign. Second, the more prevalent are the actions which increase the pain of holding the peg, the greater is the incentive for an individual actor to adopt the action which increases the pain. In other words, the actions which tend to undermine the currency peg are mutually reinforcing.

Imagine that we are in Thailand in the early summer of 1997 just prior to the onset of the Asian financial crisis. For domestic financial institutions or companies which had borrowed dollars to finance their operations, they can either attempt to reduce their dollar exposures or not. The action to reduce their exposure - of selling Baht assets to buy dollars in order to repay their dollar loans, for example, is identical in its mechanics (if not in its intention) to the action of a hedge fund which takes a net short position in Baht in the forward market. For domestic banks and finance companies which have facilitated such dollar loans to local firms, they can either attempt to hedge the dollar exposure on their balance sheets by selling Baht in the capital markets, or sitting tight and toughing it out. Again, the former action is identical in its consequence to a hedge fund short-selling Baht. As a greater proportion of these actors adopt the action of selling the domestic currency, the greater is the domestic economic distress, and hence the greater is the likelihood of abandonment of the peg. Everyone understands this, especially the more sophisticated market players that have access to hedging tools. As the pain of holding on to the peg reaches the critical threshold, the argument for selling Baht becomes overwhelming. In this sense, the actions which undermine the currency peg are mutually reinforcing.

The action-inducing nature of price changes turns up in this scenario through balance sheet stress in the twin crisis that combines a banking crisis with a currency crisis. The precipitous decline in the exchange rate means that the Baht value of foreign currency debts balloon past the value of Baht assets that have been financed with such loans. At the same time, the higher domestic interest rates put in place to defend the currency undermines the Baht value of those assets. Assets decline and liabilities increase. Equity is squeezed from both directions. As the Thai Baht collapses, the mutually reinforcing nature of price changes and distressed actions gathers momentum. As domestic firms with dollar liabilities experience difficulties in servicing their debt, the banks which have facilitated such dollar loans attempt to cover their foreign currency losses and improve their balance sheet by a contraction of credit. For foreign creditor banks with short-term exposure, this is normally a cue to cut off credit lines, or to refuse to roll over short term debt. Even for firms with no foreign currency exposure, the general contraction of credit increases corporate distress. Such deterioration in the domestic economic environment exacerbates the pain of maintaining the peg, thereby serving to reinforce the actions which tend to undermine it. To make matters worse still, the belated hedging activity by banks is usually accompanied by

a run on their deposits, as depositors scramble to withdraw their money.

To be sure, the actual *motives* behind these actions are as diverse as the actors themselves. A currency speculator rubbing his hands and looking on in glee as his target country descends into economic chaos has very different motives from a desperate owner of a firm in that country trying frantically to salvage what he can, or a depositor queuing to salvage her meagre life savings. However, whatever the motives underlying these actions, they are identical in their consequences. They all lead to greater pains of holding to the peg, and hence hasten its demise.

## Booms

The action-inducing nature of market prices are at their most dramatic during crisis episodes, but arguably they are at their most damaging in boom times when they operate away from the glare of the television cameras. Financial crises don't happen out of the blue. They invariably follow booms. As Andrew Crockett (2000) has put it,

> The received wisdom is that risk increases in recessions and falls in booms. In contrast, it may be more helpful to think of risk as *increasing* during upswings, as financial imbalances build up, and *materialising* in recessions.

To fully grasp this point, recall the opening quote from the anonymous risk manager who insisted that the value-added of a good risk management system is that one can take more risks. The risk manager was re-affirming the importance of a framework for measuring risks accurately, thereby enabling the bank to deploy its scarce capital in the most efficient way. During a boom, the action-inducing nature of market prices do their work through the increased capacity of banks to lend. When asset prices rise or measured risks fall, less capital is needed to act as a loss buffer for a given pool of loans or securities. At the same time, higher bank profits also add to the bank's capital. In boom times, banks have surplus capital.

When balance sheets are marked to market, the surplus capital becomes even more apparent. In the eyes of the bank's top management, a bank with surplus capital is like a manufacturing plant with idle capacity. Just as good managers of the manufacturing plant will utilise surplus capacity to expand their business, so the bank's top management will expand its business. If

they fail to expand their business, they know that the ranks of bank equity analysts will start to castigate them for failing to achieve the 20% return on equity achieved by some of their peers.

For a bank, expanding its business means expanding its balance sheet by purchasing more securities or increasing its lending. But expanding assets means finding new borrowers. *Someone* has to be on the receiving end of new loans. When all the good borrowers already have a mortgage, the bank has to lower its lending standards in order to lend to new borrowers. The new borrowers are those who were previously shut out of the credit market, but who suddenly find themselves showered with credit. The ballooning of subprime mortgage lending could be seen through this lens.

The pressure on the bank's managers to expand lending reveals an important feature of the capital constraint facing banks. As with any meaningful economic constraint, the capital constraint binds all the time - in booms as well as in busts. Binding capital constraints during bust phase is well understood. However, less appreciated is the binding nature of the capital constraint in boom times. In boom times, the constraint operates through channels that appear more benign, such as the pursuit of shareholder value by raising return on equity.

The action-inducing effect of market prices derive their potency from the apparently tangible nature of the wealth generated when asset prices appreciate. Consider the following passage from a commentary published in the *Wall Street Journal* in May 2005, at the height of the housing boom in the United States.[3]

> While many believe that irresponsible borrowing is creating a bubble in housing, this is not necessarily true. At the end of 2004, U.S. households owned $17.2 trillion in housing assets, an increase of 18.1% (or $2.6 trillion) from the third quarter of 2003. Over the same five quarters, mortgage debt (including home equity lines) rose $1.1 trillion to $7.5 trillion. The result: a $1.5 trillion increase in net housing equity over the past 15 months.

The argument is that when the whole U.S. housing stock is valued at the current marginal transactions price, the total value is $17.2 trillion (although

[3] "Mr. Greenspan's Cappuccino" Commentary by Brian S. Wesbury, Wall Street Journal, May 31, 2005. The title makes reference to Alan Greenspan's comments on the "froth" in the U.S. housing market.

it was to rise much more subsequently). Although household debt had increased by over a trillion dollars in the meanwhile, this still left them an increase in net worth of $1.5 trillion.

One can question how tangible this increase in housing wealth is in the face of a possible downturn. But for banks and other financial institutions who mark their balance sheets to market continuously, the increase in marked-to-market equity, is very tangible indeed. The surplus capital generated by asset price appreciation and greater profits weigh on the bank's top management, and induces them to take on additional exposure. Risk spreads fall, and borrowers who did not meet the necessary hurdle begin to receive credit. The seeds of the subsequent downturn are thus sown.

The action-inducing nature of asset price booms is strongest for leveraged institutions such as banks and securities firms since leverage magnifies the increase in marked-to-market equity. Thus, the reasoning quoted above in the Wall Street Journal commentary ripples through the financial system through the actions of leveraged financial institutions.

The classic signs of the late stages of a boom are the compression of risk spreads and the erosion of the price of risk. The phenomenon of "search for yield" often appears in the late stages of a boom as investors migrate down the asset quality curve as risk spreads are compressed. The following commentary from the Bank of England's *Financial Stability Review* of December 2004 describes the classic symptoms.

> "Financial intermediaries and investors appear to have continued their 'search for yield' in a wide range of markets, holding positions that could leave them vulnerable to instability in the pattern of global capital flows and exchange rates, credit events or sharper-than-expected interest rate rises. A number of market participants have also discussed the possibility that risk is being underpriced. In the event of an adverse shock, any over-accumulation of exposures from the mis-pricing of assets may result in an abrupt, and costly, adjustment of balance sheets."
> [Bank of England (2004, p. 49)]

In Chapter 3, we examine a general equilibrium model of the credit sector that plays the role of the engine of the boom-bust cycle. We will see that the double-edged nature of price changes operates in booms as well as in busts, but arguably the biggest damage is done in the boom phase of the financial

cycle when the outward signs are benign. The apparent "underpricing of risk" arises as a integral part of a general equilibrium of the economy where financial intermediaries use Value-at-Risk to deploy capital in the most efficient way. In this way, the biggest damage is done in booms, because that is when the worst quality loans are made.

The action-inducing nature of market prices during booms operate away from the glare of the television cameras, and without the chorus of politicians complaining about the effects of mark-to-market accounting rules. But the insidious effects of mark-to-market accounting are at their most potent during the booms. Andrew Crockett's statement that risks *increase* in booms and *materialise* in busts is an important lesson that is relearnt after each financial crisis. The challenge for policy makers is to reduce the frequency with which we undergo the re-education.

## Marking to Market

The double-edged nature of market prices raises important issues for accounting, especially on the role of mark-to-market accounting rules. Some proponents of marking to market like to pose the issues in black and white terms, asking rhetorically, "Do you want the truth, or do you want a lie?"

The unstated assumption behind this rhetorical question is that accounting is just a measurement issue, leaving what is measured completely undisturbed. The assumption is that accounting is just a veil that merely obscures the true economic fundamentals, and that the role of accounting is to shine a bright light into the dark corners of a firm's accounts to illuminate the true state of that firm. In the context of completely frictionless markets, where decision making is done without distorting constraints or inefficient spillover effects, such a world view would be entirely justified.

On the other hand, in such a perfect world, accounting would be irrelevant since reliable market prices would be readily available to all, and it would simply be a matter of reading off the available prices. Just as accounting is irrelevant in such a world, so would any talk of establishing and enforcing accounting standards.

To state the proposition the other way round, accounting is relevant *only because* we live in an imperfect world, where actions may reflect distorted incentives or self-defeating constraints as well as the hypothetical economic fundamentals. In such an imperfect world, transaction prices may not always be readily available. Even those prices that are available may not correspond

to the hypothetical fundamental prices that would prevail in frictionless perfect markets. Therefore, when we debate issues regarding accounting, it is important to be clear on the nature and consequences of the imperfections.

The key to the debate on marking to market is whether mark-to-market accounting injects artificial volatility into transactions prices - an additional, endogenous source of volatility that is purely a consequence of the accounting norm, rather than something that reflects the underlying fundamentals. Real decisions would then distorted due to the measurement regime. As we have seen from the subprime crisis, distortions to real decisions can sometimes exact very large economic costs.

It is important here to distinguish volatility of prices that merely reflect the volatility of the underlying fundamentals from volatility that cannot be justified by these fundamentals. If the fundamentals themselves are volatile, then market prices will merely reflect the underlying reality. However, the "artificial" nature of the volatility refers to something more pernicious. When the decision horizon of market participants are shortened due to short-term incentives, binding constraints or other market imperfections, then short term price fluctuations affect the interests of these market participants, and hence will influence their actions. There is then the possibility of a feedback loop where anticipation of short-term price movements will induce market participants to act in such as a way as to amplify these price movements. When such feedback effects are strong, then banks' decisions are based on the second-guessing of others' decisions rather than on the basis of perceived fundamentals. In this sense, there is the danger of the emergence of an additional, endogenous source of volatility that is purely a consequence of the accounting norm, rather than something that reflects the underlying fundamentals.

Ultimately, it is important to be clear on the ultimate objectives of the accounting regime. What is the purpose of accounting standards? Whom should they serve? Should they serve the interests of equity investors? Should they serve the interests of a wider class of investors? Or, should we look beyond investors *per se* to the wider public interest, as for any other public policy issue?

Of course, in practice we may expect wide overlaps between the interests of equity investors, creditors and the wider public interest. However, they are logically distinct, and sometimes lead to very different policy prescriptions. Traditionally, accounting standard setters have not seen their remit extending as far as to take account of the broader public interest. In this respect,

accounting may be too important to be left solely to the accountants.

## Upward-Sloping Demand Responses

We will see in Chapter 3 that in a boom phase, we can characterise the decisions of a leveraged financial institution as if coming from a decision maker who has become less risk averse, even though the underlying preferences of that institution has remained unchanged. The shift in the "as if" preferences flow from the capital gains of the institution which feeds into an increased capacity to bear risk. To an outside observer, all the outward signs are that the decisions emanate from someone who has become less risk averse. The upshot is that demand responses to price changes are upward-sloping. When the price of the risky asset rises, the leveraged financial institution purchases more of the risky asset. The apparent increase in risk appetite induced by the price rise results in a desired holding of the asset that is larger than before the price increase. But then, the additional purchases of risky assets that result from such increased risk appetite fuels the asset price boom further, giving further impetus to the boom. The upward-sloping demand response has a mirror image in the downward phase of the financial cycle. When price falls, the risk appetite of the leveraged institution falls so much that, in spite of the fall in the price, the desired holding of the risky asset falls. The supply response is downward-sloping. As price falls, more of the asset is dumped on the market, depressing the price further.

The theme of upward-sloping demand response and the downward-sloping supply response goes hand in hand with the dual role of prices as both the reflection of fundamentals and the imperative for action. In Chapter 4, we see this theme being played out in the market-wide impact of dynamic hedging of options that lay behind the stock market crash of October 1987.

The Presidential Commission appointed to investigate the circumstances of the crash (and chaired by the future Treasury Secretary Nicholas Brady) identified dynamic trading strategies by portfolio insurers as one of main contributing factors in the cash (Brady (1988)). Dynamic hedging attempts to position one's portfolio in reaction to price changes in order to mimic the payoffs from a put option. Since put options pay out when prices are low, this means maintaining a short position in the asset that becomes steeper as the price falls. In other words, dynamic hedging dictates that when the price falls, you sell more of the asset. This is a strategy that induces upward-sloping demand responses and downward-sloping supply responses - exactly the type

of portfolio rebalancing responses that tends to amplify price changes. Just as with the leveraged financial institutions with apparently shifting risk appetite, the portfolio insurers who relied on dynamic hedging were an illustration of the principle that prices play a dual role - both as a reflection of actions (prices fell when they sold) as well as an imperative for actions (they sold when prices fell). Once locked into this loop, the feedback effect gained momentum.

Dynamic hedging relies on liquid markets - on there being others who will buy when I sell. But liquidity is a public good that comes from the diversity of trading positions. When a large segment of the market is engaged in such trading strategies, they become consumers of liquidity rather than providers of liquidity. But when price goes down, dynamic hedging dictates even larger sales. And as the market adage goes, one should never try to catch a falling knife, and so potential buyers stand on the sidelines until the knife drops to the ground.

Indeed, upward-sloping demands and downward-sloping supplies turn out to be much more pervasive when we look around the key players in financial markets. Many hedging strategies that attempt to rebalance assets and liabilities to shifts in market prices turn out, on closer inspection, to be variations of the dynamic hedging strategy described above. Market participants who pursue such strategies are consumers of liquidity rather than providers of liquidity. The demand and supply responses that such hedging stratgies give rise to are often reinforced by regulations. Such regulations, although sensible in isolation, tends to promote instability in aggregate. The matching of asset and liability durations by pension funds is a good example, and is examined in Chapter 5.

The marking to market of pension fund liabilities is a practice adopted by pension regulators motivated by the desire to ensure the solvency of pension funds and to guide them toward better risk management practices in matching their assets to their future commitments. Accounting standards combined with solvency regulation have been important spurs to the adoption of asset-liability hedging strategies by pension funds who mark their liabilities to market and then hold an asset portfolio that shifts in line with the value of its liabilities. But as we will see in Chapter 5, such hedging techniques give rise to exactly the type of perverse demand and supply responses that tends to amplify the financial cycle. Once again, there is a divergence between what is prudent from the point of view of an individual actor and what promotes a resilient financial system.

Above all, the boom bust financial cycle owes itself to the way that the individual motives interact with the aggregate outcome in the financial system. One of the characteristic features of the financial system in the run-up to the global financial crisis of 2007 and 2008 has been the increased cross-exposures between financial institutions whereby balance sheets of financial institutions have become more intertwined.

We construct a framework for analysis in Chapters 6 and 9 that delves deeper into the structural features of interconnected markets. The organising framework is the aggregate balance sheet of the banking and intermediary sector as a whole, where the assets are summed across individual institutions and the liabilities are summed across, also. Every liability that a bank has to another bank is an asset when viewed from the point of view of the lending bank. One asset cancels out another equal and opposite liability. In aggregate, all the claims and obligations across banks cancel out. Thus, in aggregate, the assets of the banking sector as a whole against other sectors of the economy consists of the lending to non-bank borrowers. This lending must be met by two sources - the total equity of the banking system, and the liabilities that banks have to lenders *outside* the banking system.

In a boom scenario where the marked-to-market equity of the banks are healthy and the measured risks are low, banks attempt to increase their balance sheets - sometimes quite substantially. The fluctuations in financial intermediary balance sheets in aggregate tend to be much larger in scale compared to the available funding that is available from ultimate creditors (such as retail depositors) from outside the banking sector. Aggregate balance sheets can then grow only by the banks lending and borrowing more from each other. The desired risk-taking profiles and desired high leverage mean that banks take on more of each others' debts, and the intertwining of claims and liabilities become more far-reaching. As a consequence, the balance sheet trail from ultimate lender to ultimate borrower grows longer, and more tenuous.

The image is of an increasingly elaborate edifice built on the same narrow foundation, so that the structure becomes more and more precarious. The systemic risks therefore increase during the boom scenario.

The shortening of maturities is a natural companion to the lengthening of intermediation chains. In order for each link in the chain to be a profitable leveraged transaction, the funding leg of the transaction must be at a lower interest rate. When the yield curve is upward-sloping, this entails funding with shorter and shorter maturities at each step in the chain. The prevalence

of the overnight repo as the dominant funding choice for securities firms before the current crisis can be understood in this context. The use of ultra-short term debt is part and parcel of long intermediation chains, as is the importance of short-term interest rates in determining the rate of growth of the financial sector balance sheets that fuel the boom.

Eventually, when the boom scenario gives way to the bust, all the processes that were involved in the boom then go into reverse in the bust. Leverage and risk spreads reverse leading to smaller balance sheets. Just as expanding balance sheets entails greater intertwining of bank balance sheets, so the contraction of balance sheets entails the withdrawal of the funds that banks had granted to each other. This is a class run scenario where banks run on other banks. The runs on Northern Rock, Bear Stearns and Lehman Brothers are all instances of such a run. Chapter 8 is a case study of Northern Rock - the U.K. mortgage bank that failed in 2007, thereby heralding the global financial crisis that followed.

This brings us back full circle to the opening quote by the anonymous risk manager. Risk management is an essential part of the operation of a financial institution, and the value-added of a good risk management system can indeed be substantial. But there may be a divergence of interests between an individual firm and the system as a whole. Exploring exactly how the divergence of interests play out in the economy is an urgent modelling task for economists. As a first step, putting Value-at-Risk into a general equilibrium context is an important conceptual task that has barely begun. More needs to be done.

As well as the intellectual endeavours, there is also a need for a clear identification of the policy priorities. Academics, policy makers and market participants have pondered the lessons from the financial crisis, and are beginning to arrive at a consensus on the need for tougher regulatory oversight of financial institutions. However, as desirable as such regulatory changes are, they are almost certainly inadequate by themselves in meeting the challenge of the next boom-bust cycle. As the following lectures will hope to demonstrate, boom-bust cycles are driven by the fluctuations in the price of risk. Even if a new set of regulatory rules can be put in place that would have been effective at preventing yesterday's crisis, there is little guarantee that they will continue to be effective against new crises, riding on the back of as yet unimagined innovations designed to circumvent the rules.

Indeed, the greatest danger of the newly-found consensus on the need for tougher regulation arises not from the possible circumvention of the rules,

but rather from the opportunities that the new consensus will present to central banks to repeat their mistakes in the conduct of monetary policy by giving them the all-clear to go back to business as usual, leaving the messy and unglamorous business of financial stability to others. As we will see in these lectures, financial stability has to do with fluctuations in the price of risk, and monetary policy must play its part in regulating the pricing of risk. Changes to financial regulation will be for nothing if the intellectual landscape at the institution at core of the financial system (the central bank) does not change.

## Notes on Further Reading

The discussion of the Millemmium Bridge is drawn from Danielsson and Shin (2003), who coined the term "endogenous risk" in the context of financial market risk. The analogy cropped up again in Shin (2005a) at the 2005 Jackson Hole symposium in a discussion on increasing financial risks. Further details on the wobble of the Millennium Bridge can be obtained from "Bad Vibrations" *New Scientist*, vol. 167, issue 2246, July 8th 2000. The webpage[4] set up by Arup, the contruction engineers of the bridge is also a useful reference on the diagnosis of the problem and the remedies that were used.

Liquidity black holes were studied in Morris and Shin (2004), which drew on the global game analysis of currency crises in Morris and Shin (1998, 1999). The terminology stems from use by market practitioners, and was popularised by Persaud (2001). Crisis dynamics using competitive equilibrium were studied by Genotte and Leland (1990) and Geanakoplos (1997, 2009). Shleifer and Vishny's (1997) observation that margin constraints limit the ability of arbitrageurs to exploit price differences, as well as Holmstrom and Tirole's (1997) work on debt capacities brought ideas and tools from corporate finance into the study of financial market fluctuations. Building on these themes has been a large body of recent theoretical work. Amplification through wealth effects was studied by Xiong (2001) and Kyle and Xiong (2001). He and Krishnamurthy (2007) look at a dynamic asset pricing model where the intermediaries' capital constraints enter into the asset pricing problem as a determinant of portfolio capacity. Balance sheet constraints enter in Gromb and Vayanos (2002) and Brunnermeier and Pedersen (2009), who

[4] http://www.arup.com/millenniumbridge/challenge/oscillation.html

coined the term "margin spiral". Incorporating balance sheet constraints on asset pricing problems have been examined by Adrian, Etula and Shin (2009) for the foreign exchange market, Etula (2009) for the commodities market and by Adrian, Moench and Shin (2009) for the interaction between macro and balance sheet variables. Garleanu and Pedersen (2009) derive an extension of the capital asset pricing model that incorporate balance sheet constraints.

The role of mark-to-market accounting in amplifying financial market fluctuations was examined in Plantin, Sapra and Shin (2008), which describes the tradeoff between mark-to-market and historical cost accounting regimes. The link between marking to market and balance sheet management in financial booms was examined by Adrian and Shin (2007) which provides a commentary on the fluctuating fortunes of the (then) five stand-alone U.S. investment banks.