The Crash of 2008: A Mathematician's View

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There have been financial crashes long before there was any mathematical input into finance. One good side-effect of current events is that they encourage greater awareness of previous crashes (those who do not know their history are condemned to re-live it, as they say). One might start with the Tulip Mania (Netherlands, 1636-7), or the South Sea Bubble (UK, 1720); recall Newton's bitter comment, on losing the then vast sum of 20,000, that he could more easily predict the movements of the heavens than those of irrational men.

The first real mathematical input into finance (Harry Markowitz, 1950) gave the world two key insights (now so ubiquitous they seem obvious). Firstly, think of risk and return together, not separately (risk is variance, return is mean, hence 'mean-variance analysis'). Secondly, diversify (don't put all your eggs in one basket) - and balance your holdings by including lots of negative correlation (so that losses on the swings will be offset by gains on the roundabouts). Then in came 1973 came the Black-Scholes formula (and Merton's work), giving a formula for valuing, or pricing, options (the right but not the obligation to buy or sell - derivatives, so called because they are derived from the underlying, stock and cash). Not only was there no way of valuing options previously, it had seemed clear that there could be no way, as the answer would depend on the attitude to risk of the individual investor. This overlooked that (standard) options can be replicated - by suitable combinations of cash and stock, and any fool can value that knowing the current stock price.

I am a probabilist. For over two decades, I viewed the increasing demand for the mathematics of (what I used to call) filthy capitalism with distaste. Then in 1995, as the newly appointed Professor of Statistics at Birkbeck College, London (Birkbeck is the 'University of London night school') I taught an MSc class, most of whom were City traders, who knew there was a theory behind what they spent the day doing, and asked me to teach them it. I swallowed hard, agreed, and then had to learn the subject. I promptly fell in love with it - the mathematics is so nice (I am uncomfortably reminded of Feynman's comment, on the creation the atom bomb at Los Alamos, that

it was technically so sweet they couldn't not do it). There were then two widely different kinds of book - those by and for people like me, and those for students with little mathematics. Out of that came my book on the subject, with my friend and then Birkbeck colleague Rüdiger Kiesel [1].

The first (1998) edition of [1], largely on Black-Scholes(-Merton) theory, contained eight chapters. Then Russia defaulted on its debt, triggering the collapse of Long-Term Capital Management; on the LTCM board were Scholes and Merton, both Novel Prize winners and the two survivors of the trio. Rüdiger commented to me that some of the egg on their faces would rub off on ours, as the subject would lose credibility. The second (2004) edition has a ninth chapter, on credit derivatives - including credit default swaps. CDSs are the principal culprits behind the current agonies over toxic debt, and I felt that here history was repeating itself at our expense (as authors, and as citizens).

Rüdiger and I make an interesting and complementary pair. I am of the left, he is of the right. Our book discusses hedging and speculation. I had always regarded hedgers as good guys (honest businessmen who want to protect their productive operations by buying insurance against adverse price movements in their supplies, etc.), and speculators as bad guys (who don't care about the real economy, but just want to make money out of pieces of paper). In several discussions over drinks, Rüdiger relentlessly pointed out that one cannot buy an insurance policy - lay off risk - unless someone else is prepared to take it on. Thus the relationship between hedging and speculation is symbiotic: the first cannot happen without the second. He also disapproved of the Fed (under Greenspan) bailing out LTCM - though he could understand the decision. This need to balance moral hazard - failing to allow misdeeds to undo their doers, and so purge them from the system - against the duty of government to protect the stability of the system, on which its citizens depend - is the essence of the dilemma of today.

Once upon a time, banks took savings from citizens (who might negotiate loans as overdrafts), and lent money to businessmen (who could otherwise not act as entrepreneurs unless they had been lucky enough to inherit the necessary capital). Banks were companies - public for the big banks, private for the small ones. If one wanted to buy a house, one went to a building society and took out a mortgage. Building societies were mutual societies - taking in savings from their members, and lending to members and the wider public, providing mortgages for house purchase - safe, stable and irreproachable.

Then came the great era of deregulation. The Big Bang in the City of 1986 abolished the separation between jobbers and brokers (which the government regarded as a restrictive practice). Note in passing the role of conflict of interest, following deregulation, in many of the major corporate failures or scandals of the last two decades. During this time, finance came to account for more and more of GDP. Building societies demutualized, and became banks (this made money for members, who were given shares, and for directors, who also acquired shares - to say nothing of the fees of those who implemented these changes). Some former building societies even specialized in buy-to-let - which would have been regarded as unthinkable, as well as immoral and antisocial, in former times. Big banks took over smaller banks, killing two birds with one stone - providing fees for those involved, and playing to the British genius for deal-making, rather than making things. The author remembers with affectionate nostalgia the era when Britain, having given the world the Industrial Revolution, made such things as ships, trains, volume cars, steel and the like, and admires the fact that Germany, for example, still does.

I welcomed the chance to put my thoughts on the current crash on paper, as it helped me to organize the results of long conversations with my wife, who not unreasonably regarded the co-author of a book on mathematical finance as fair game to ask the obvious questions: where has all this mess come from, why has it blown up so suddenly now, why is it on such a gigantic scale, and why should we be expected to pay for it and bail out those responsible? Indeed. Having spent the first half of this article outlining the problem, I will spend the second half offering some thoughts.

First, a little economic history. The essence of finance, and indeed of capitalism, is compound interest, the mathematics of which is essentially that of exponential growth. Exponential growth is highly unstable. For this reason alone, instability is built into capitalism. The wonder is not that crises occur, but that capitalism - the system we have - works as well as it does, most of the time.

Even more basic (one doesn't need any mathematics to describe them) are two of the key foundations of economic life. The first is double-entry book-keeping. This originated in Renaissance Italy in the 15th century (I learned double-entry book-keeping only in the 1980s – as Honorary Treasurer of Finchley Chess Club - and was shocked to learn that none of the class I am currently teaching Black-Scholes theory to knew it). This is essential to the keeping of proper accounts, and balance sheets (and the view

it gives - everything has both a credit side and a debit side - is just what one needs to handle the arbitrage arguments that are the essence of mathematical finance). Recall that publicly quoted companies have to have their accounts audited annually, and signed off by accredited accountants. The second is the limited liability company. This limits one's losses to one's stake, an essential prerequisite for anyone with any sense investing in anything (readers will recall the unlimited liability of Lloyds names in the Lloyds of London crisis - Lloyds predates modern company law). Other essentials for economic life include the rule of law, political stability and the like - without these we are back to sewing savings into the mattress, the barter economy, the strong robbing the weak, and general mayhem all round.

I remember when I read *Madame Bovary* being surprised when the doomed heroine's creditor tells her, when she asks for more time (or more money) that he has sold her debt. This is as good an example as any to bear in mind when thinking about the process that led to the current crisis, securitization. Here, one takes a source of risk (against which economic agents may wish to insure or hedge), offers a financial product to address this risk, sets up a market to sell cover (so transferring the risk to the seller) - and then regards the resulting contracts as objects to be traded in their own right. The market in CDSs alone has grown astronomically. This is partly driven by the compulsion to trade (nature abhors a - financial - vacuum, and fees and commission can be made by trading anything, however artificial), and partly driven by the possibility of taking things off balance sheet (where they are free from the prying eyes of auditors, shareholders, financial journalists and the like). The result is the toxic debt that triggered the current crisis, stemming from the collapse of the US sub-prime mortgage market. The trouble with hiding things from the auditor is that one hides it from one's counter-parties in trading (which is why banks won't lend to each other - they don't trust each other), and even from oneself, or one's superiors in one's organization (the big US investment banks ended up by not knowing what their exposure to toxic debt was).

But this cuts the ground from under one's feet, by demolishing the preconditions for any form of economic activity - not just those involving mathematics, be it humdrum (compound interest/exponential growth), fancy (Black-Scholes theory - which depends on the mathematics - stochastic processes - that probabilists do), or exotic (the more exotic credit derivatives are so complex that a whole legal speciality has grown up around what happens when defaults occur).

It may have struck the reader that there is some parallel between the growth of the trade in derivatives described above, in the private sector, and that of the Private Finance Initiative and Public-Private Partnerships, in the public sector (or, 'public sector as was'). This similarity is not accidental: one of the main attractions for PFI/PPP, from the government's point of view, is that it takes what would be public expenditure off balance sheet (and, notionally at any rate, transfers risk - that is, until the consortium taking it on - rail, London underground etc. - goes under, and the public purse is called upon, as the taxpayer would be even harder hit having to cope with railways or tube going bust, etc.).

It may seem that the last paragraph is rather political, and one doesn't usually discuss political matters in the pages of the journal of a learned society. The trouble is, of course, that anything important enough becomes political (a dictum I learned from the former French Foreign Minister, M. Couve de Murville). One can't get much more important than the events of the current crisis. No one with any sense is interested in scoring cheap political points - what we are all interested in is understanding what is going on, as a necessary (but not sufficient) condition for not getting in this mess again.

What is clear is that the key to avoiding repetition of this mess is regulation. The citizen may do what the law does not forbid. We look back on the laws of former times with bemusement – slavery was allowed, and so was marital rape, but the penalty for stealing goods over a certain value (two pounds at one time) was public hanging, etc. Future generations may look back on the 'light touch' regulation of recent decades with equal bemusement. Government, now part owner and underwriter of the banking system, must necessarily regulate banking (and much else) much more closely. This must include incentives: one of the causes of the present crisis is bonuses that encouraged excessive risk-taking, with upside split between trader and firm, and as we now see, downside carried by the public. Equally, with globalization of trade has come globalization of financial crisis, and from that must come internationalization at least, and globalization preferably, of regulation.

As with politicians, the reputations of economists change with the times. The stock in trade of J. M. Keynes, the architect of recovery from the Great Crash of 1929, has risen recently, and so has that of J. K. Galbraith. Marx's stock was much diminished after the collapse of communism (though how much Marx there was in Marxism-Leninism, let alone Stalinism, is debatable). One thing Marx said that is now accepted by everyone is that the

greatest danger to capitalism comes from the behaviour of capitalists - hence the supreme importance of regulation, as above.

I note the praise given by this year's Nobel laureate in economics, Paul Krugman, to the UK Prime Minister Gordon Brown, for identifying the root cause of the problem and giving a lead.

It may be, as has been said in the press recently, that 2008 will come to be seen as being for finance-led capitalism as 1989 was for Soviet communism. Time will tell. Meanwhile, one could do no better than read, or re-read, some of the masters - Galbraith's The Great Crash: 1929, and Money, and Keynes' The General Theory of Employment, Interest and Money, as well as the several popular accounts of corporate failures such as those of Barings or LTCM. Meanwhile, I count my blessings in being a mathematician - one can't argue with a mathematical theorem, whereas in finance or economics, things are fuzzy and argument becomes unavoidable.

I close with some thoughts on tangibles and intangibles. The real economy deals with tangible objects - things bought and sold, such as commodities and manufactures; much of economics deals with how prices are arrived at (supply and demand, etc.). Finance accepts prices as given, and deals with money, derivatives etc. Money is both tangible (one can touch it - and count it), and intangible (UK banknotes still bear the legend 'I promise to pay the bearer on demand the sum of n pounds', real before Britain went off the gold standard and merely self-referential now, pounds being all we have). Money ultimately rests on confidence. Confidence really is intangible, and is conspicuous by its absence in the current crisis. The main thing is to restore confidence (as bankers have opined through the ages) - easier said than done. One shouldn't have to start from here - but here we are. When in a hole, as Dennis Healey said, the first thing to do is to stop digging.

[1] N. H. Bingham and Rüdiger Kiesel: *Risk-neutral valuation: Pricing and hedging of financial derivatives*, Springer, 2004 (1st ed. 1998).

PRESS RELEASE

Markets need regulation to stay stable. We have had thirty years of financial deregulation. Now we are seeing chickens coming home to roost. This is the key argument of Professor Nick Bingham, a mathematician at Imperial College, in an article published today in Significance, a journal of the Royal Statistical Society.

There is no such thing as laying off risk if no one is able to insure it. Big new risks were taken in extending mortgages to far more people than could

handle them, in the search for new markets and new profits. Attempts to insure these by securitization - aptly described in this case as putting good and bad risks into a blender and selling off the results to whoever would buy them - gave us toxic debt, in vast quantities.

Once the scale of the problem was unmistakably clear from corporate failure of big names in the financial world, banks stopped lending to each other. They couldn't quantify their own exposure to toxic debt - much of it off balance sheet - so couldn't trust other banks to be able to quantify theirs. That led to a collapse of confidence, and the credit crunch. That turned a problem in the specialized world of exotic financial derivatives into a crisis in the real world. Once the problem became systemic, government had to step in, to bail the system out with vast quantities of public money.

Even Alan Greenspan, the long-serving former chairman of the US Federal Reserve, admits that mistakes were made in the past. To avoid repeating these mistakes, we need to learn from them. This needs a new mind-set, new policies, and much more proactive regulation.

Bankers complain that the risk models they used predicted problems as dramatic as today's only every few centuries. This, says Professor Bingham, is like talking about the details of how to steer a boat on a river. What matters there is whether or not the river is going to go over a waterfall, like the Niagara Falls.