Testimony of Richard Bookstaber

Submitted to the U. S. House of Representatives, Committee on Science and Technology Subcommittee on Investigations and Oversight For the Hearing: "The Risks of Financial Modeling: VaR and the Economic Meltdown" September 10, 2009

Mr. Chairman and members of the Committee, I thank you for the opportunity to testify today. My name is Richard Bookstaber. Over the past decade I have worked as the risk manager in two of the world's largest hedge funds, Moore Capital Management and, most recently, Bridgewater Associates. In the 1990s I oversaw firm-wide risk at Salomon Brothers, which at the time was the largest risk-taking firm in the world, and before that was in charge of market risk at Morgan Stanley.

I am the author of *A Demon of Our Own Design – Markets, Hedge Funds, and the Perils of Financial Innovation*. Published in April, 2007, this book warned of the potential for financial crisis resulting from the growth of leverage and the proliferation of derivatives and other innovative products.

Although I have extensive experience on both the buy-side and sell-side, I left my position at Bridgewater Associates at the end of 2008, and come before the Committee in an unaffiliated capacity, representing no industry interests.

My testimony will discuss what VaR is, how it can be used and more importantly, how it can be misused. I will focus on the limitations of VaR in measuring crisis risk. I will then discuss the role of VaR in the recent market meltdown, concluding with suggestions for ways to fill the gaps left by the limitations of VaR.

What is VaR?

VaR, or value-at-risk, measures the risk of a portfolio of assets by estimating the probability that a given loss might occur. For example, the dollar VaR for a particular portfolio might be expressed as "there is a ten percent probability that this portfolio will lose more than $VaR over the next day".

Here is a simplified version of the steps in constructing a VaR estimate for the potential loss at the ten percent level:

1. Identify all of the positions held by the portfolio.
2. Get the daily returns for each of these positions for the past 250 trading days (about a one-year period).
3. Use those returns to construct the return to the overall portfolio for each day over the last 250 trading days.
4. Order the returns for those days from the highest to the lowest, and pick the return for the day that is the 25th worst day's return. That will be a raw estimate of the daily VaR at the ten percent level.
5. Smooth the results by fitting this set of returns to the Normal distribution function.[1]

Limitations of VaR

The critical assumptions behind the construction of VaR are made clear by the process described above:

1. All of the portfolio positions are included.
2. The sample history is a reasonable representation of what things will look like going forward.
3. The Normal distribution function is a reasonable representation of the statistical distribution underlying the returns.

[1] The risk for a Normal distribution is fully defined by the standard deviation, and the results from step 3 can be used to estimate the standard deviation of the sample. If the estimated standard deviation is, say, five percent, then the VaR at the ten percent level will be a loss of eight percent. For a Normal distribution the ten percent level is approximately 1.6 standard deviations.

The limitations to VaR boil down to issues with these three assumptions, assumptions that are often violated, leading VaR estimates to be misleading.

Incomplete positions

Obviously, risk cannot be fully represented if not all of the risky positions are included in the analysis. But for larger institutions, it is commonplace for this to occur. Positions might be excluded because they are held off-balance sheet, beyond the purview of those doing the risk analysis; they might be in complex instruments that have not been sufficiently modeled or that are difficult to include in the position database; or they might be in new products that have not yet been included in the risk process. In the recent crisis, some banks failed to include positions in collateralized debt obligations (CDOs) for all three of these reasons.[2] And that exclusion was not considered an immediate concern because they were believed to be low risk, having attained a AAA rating.

The inability to include all of the positions in the VaR risk analysis, the most rudimentary step for VaR to be useful, is pervasive among the larger institutions in the industry. This provides a compelling reason to have a 'flight to simplicity' in financial products, to move away from complex and customized innovative products and toward standardization.[3]

Unrepresentative sample period

VaR gives a measure of risk that assumes tomorrow is drawn from the same distribution as the sample data used to compute the VaR. If the future does not look like the past, in particular if a crisis emerges, then VaR will no longer be a good measure of risk.[4] Which is to say that VaR is a good measure of risk except when it really matters.[5]

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[2] Regulatory capital on the trading assets that a bank does not include in VaR – or for which the bank's VaR model does not pass regulatory scrutiny – is computed using a risk-rating based approach. However, the rating process itself suffers from many of the difficulties associated with calculating VaR, as illustrated by the AAA ratings assigned to many mortgage-backed CDOs and the consequent severe underestimation of the capital required to support those assets.

[3] I discuss the complexity and related risk issues surrounding derivatives and related innovative products in Testimony of Richard Bookstaber, Submitted to the Senate of the United States, Committee on Agriculture, Nutrition, and Forestry for the Hearing: "Regulatory Reform and the Derivatives Markets", June 4, 2009.

[4] One way to try to overcome the problem of relying on the past is to use a very long time period in the VaR calculation, with the idea that a longer period will include many different regimes, crises and

It is well known that VaR cannot measure crisis risk. During periods of crisis the relationship between securities changes in strange and seemingly unpredictable ways. VaR, which depends critically on a set structure for volatility and correlation, cannot provide useful information in this situation. It contains no mechanism for predicting the type of crisis that might occur, and does not consider the dynamics of market crises. This is not to say that VaR has no value or is hopelessly flawed. Most of the time it will provide a reasonable measure of risk – indeed the vast majority of the time this will be the case. If one were forced to pick a single number for the risk of a portfolio in the near future, VaR would be a good choice for the job. VaR illuminates most of the risk landscape. But unfortunately, the places its light fails to reach are the canyons, crevices and cliffs.

Fat Tails and the Normal Distribution

Largely because of crisis events, security returns tend to have fatter tails than what is represented by a Normal distribution. That is, there tend to be more outliers and extreme events than what a Normal distribution would predict. This leads to justifiable criticism of VaR for its use of the Normal distribution. However, sometimes this criticism is overzealous, suggesting that the professionals who assume a Normal distribution in their analysis are poorly trained or worse. Such criticism is unwarranted; the limitations of the Normal distribution are well-known. I do not know of anyone working in financial risk management, or indeed in quantitative finance generally, who does not recognize that security returns may have fat tails. It is even discussed in many investment textbooks, so it is a point that is hard to miss.[6]

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relationships. Such a view misses the way different regimes, essentially different distributions, mix to lead to a final result. A long time period gives muddied results. To see this, imagine the case where in half of the past two assets were strongly positively correlated and the other half they were strongly negatively correlated. The mixing of the two would suggest the average of little correlation, thus giving a risk posture that did not exist in either period, but that also incorrectly suggests diversification opportunities.

[5] As a corollary to this, one could also say that diversification works except when it really matters.

[6] For example, *Investments*, by Bodie, Kane, and Marcus, 8th edition (McGraw-Hill/Irwin), has a section (page 148) entitled "Measurement of Risk with Non-normal Distributions".

The issue is how this well-known inaccuracy of the Normal distribution is addressed. One way is knowingly to misuse VaR, to ignore the problem and act as if VaR can do what it cannot. Another is to modify the distribution to allow for fatter tails.[7] This adds complication and obfuscation to the VaR analysis, because any approach employing a fat-tailed distribution increases the number of parameters to estimate, and this increases the chance that the distribution will be misspecified. And in any case, simply fattening up the tails of the distribution provides little insight for risk management.

I remember a cartoon that showed a man sitting behind a desk with a name plate that read 'Risk Manager'. The man sitting in front of the desk said, "Be careful? That's all you can tell me, is to be careful?" Stopping with the observation that extreme events can occur in the markets and redrawing the distribution accordingly is about as useful as saying "be careful." A better approach is to accept the limitations of VaR, and then try to understand the nature of the extreme events, the market crises where VaR fails. If we understand the dynamics of market crisis, we may be able to improve risk management to make it work when it is of the greatest importance.

Understanding the Dynamics of Market Crises

A starting point for understanding financial market crises is leverage and the crowding of trades, both of which have effects that lead to a common crisis dynamic, the liquidity crisis cycle.

Such a cycle begins when an exogenous shock causes a drop in a market that is crowded with leveraged investors. The highly leveraged investors are forced to sell to meet their margin requirements. Their selling drops prices further, which in turn forces yet more selling, resulting in a cascading cycle downward in prices. Those investors that are under pressure discover there is no longer liquidity in the stressed market, so they start to liquidate their positions in other markets to generate the required margin. If many of the

[7] Extreme value theory is the bastion for techniques that employ distributions with a higher probability of extreme events.

investors that are in the first market also have high exposure in a second one, the downward spiral propagates to this second market.[8]

This phenomenon explains why a crisis can spread in surprising and unpredictable ways. The contagion is driven primarily by what other securities are owned by the funds that need to sell.[9] For example, when the silver bubble burst in 1980, the silver market became closely linked to the market for cattle. Why? Because when the Hunt family had to meet margin calls on their silver positions, they sold whatever else they could. And they happened also to be invested in cattle. Thus there is contagion based not on economic linkages, but based on who is under pressure and what else they are holding.

This cycle evolves unrelated to historical relationships, out of the reach of VaR-type models. But that does not mean it is beyond analysis. Granted it is not easy to trace the risk of these potential liquidity crisis cycles. To do so with accuracy, we need to know the leverage and positions of the major market participants. No one firm, knowing only its own positions, can have an accurate assessment of the crisis risk. Indeed, each firm might be managing its risk prudently given the information it has at its disposal, and not only miss the risk that comes from crowding and leverage, but also unwittingly contribute to this risk. Gathering these critical data is the first step in measuring and managing crisis risk. This should be the role of a market regulator.[10]

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[8] The use of VaR-based capital can actually contribute to this sort of cycle. VaR will increase because of the higher volatility – and also possibly because of the higher correlations – leading potential liquidity providers and lenders to pull back. This was a likely exacerbating effect during the 1997 Asian crisis.

[9]As an illustration, the proximate cause of Long Term Capital Management's (LTCM's) demise was the Russian default in August, 1998. But LTCM was not highly exposed to Russia. A reasonable risk manager, aware of the Russian risks, might not have viewed it as critical to LTCM. But the Russian default hurt LTCM because many of those who did have high leverage in Russia also had positions in other markets where LTCM was leveraged. When the Russian debt markets failed and these investors had to come up with capital, they sold their more liquid positions in, among other things, Danish mortgage bonds. So the Danish mortgage bond market and these other markets went into a tail spin, and because LTCM was heavily exposed in these markets, the contagion took LTCM with it.

[10] I discuss the need for firm-level position and leverage data in crisis risk management in previous testimony before both the House and the Senate. For example, Testimony of Richard Bookstaber, Submitted to the Congress of the United States, House Financial Services Committee, for the Hearing: "Systemic Risk: Examining Regulators Ability to Respond to Threats to the Financial System", October 2, 2007, and Testimony of Richard Bookstaber, Submitted to the Senate

The Role of VaR in the Current Crisis

The above discussion provides part of the answer to the question of the role of VaR in the current market crisis: If VaR was used as the source of risk measurement, and thus as the determinant of risk capital, then it missed the potential for the current crisis for the simple reason that VaR is not constructed to deal with crisis risk. And if VaR was applied as if it actually reflected the potential for crisis, that is, if it was forgotten that VaR is only useful insofar as the future is drawn from the same distribution as the past, then this led to the mismeasurement of risk. So if VaR was the sole means of determining risk levels and risk capital coming into this crisis, it was misused. But this does not present the full story.

Whatever the limitations of VaR models, they were not the key culprits in the case of the multi-billion dollar writedowns during the crisis. The large bank inventories were there to be seen; no models or detective work were needed. Furthermore, it was clear the inventories were illiquid and their market values uncertain.[11] It is hard to understand how this elephant in the room was missed, how a risk manager could see inventory grow from a few billion dollars to ten billion dollars and then to thirty or forty billion dollars and not react by forcing that inventory to be brought down.

Of course, if these inventories were not properly included in the VaR analysis, the risk embodied by these positions would have been missed, but one has to look beyond VaR, to culprits such as sheer stupidity or collective management failure: The risk managers missed the growing inventory, or did not have the courage of their conviction to insist on its reduction, or the senior management was not willing to heed their demands. Whichever the reason, VaR was not central to this crisis.[12] Focus would be better placed

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of the United States, Senate Banking, Housing and Urban Affairs Subcommittee on Securities, Insurance and Investment, for the Hearing: "Risk Management and Its Implications for Systematic Risk", June 19, 2008.

[11] This is especially true when one considers the business of the banks, which is to package the securities and sell them. The growth of inventory was outside the normal business of the banks. That the securities were not moving out the door should have been an immediate indication they were not correctly priced.

[12] Indeed, in some important cases, VaR was not even employed in the risk process. Page: 7
A case in point is the 'super senior' mortgage CDO positions which caused huge trading losses at a number of banks. There is a common misconception that regulatory capital for trading assets is automatically computed using VaR. In fact, trading assets are eligible for VaR-based capital only if the bank can demonstrate to its supervisor that its model is robust. Absent this, a coarser method is applied. Many of the

on failures in risk governance than failures of risk models.

Summary: VaR and Crisis Risk

There are two approaches for moving away from over-reliance on VaR.

The first approach is to employ coarser measures of risk, measures that have fewer assumptions and that are less dependent on the future looking like the past.[13] The use of the Leverage Ratio mandated by U.S. regulators and championed by the FDIC is an example of such a measure.[14] The leverage ratio does not overlay assumptions about the correlation or the volatility of the assets, and does not assume any mitigating effect from diversification, although it has its own limitations as a basis for capital adequacy.[15]

The second approach is to recognize that while VaR provides a guide to risk in some situations, it must be enhanced with other measures that are better at illuminating the areas it does not reach. For example, Pillar II of Basel II has moved to include stress cases for crises and defaults into its risk capital process. So in addition to measuring risk using a standard VaR approach, firms must develop scenarios for crises and test their capital adequacy under those scenarios. Critical to the success of this approach is the ability to ferret out potential crises and describe them adequately for risk purposes.

This means that for crisis-related stress testing to be feasible, we first must believe that it is indeed possible to model financial crisis scenarios, i.e. that crises are not 'black swans'. This is not to say that surprises do not occur. Though recently popularized, the

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highly complex securities at the heart of the recent crisis were not regarded as being suitable for VaR treatment, and received a simpler ratings-based treatment, which proved to severely underestimate the capital required to support the assets.

[13] I believe coarse measures – measures that are not fine tuned to be ideal in any one environment, but are robust across many environments – are a key to good risk management.

[14] The Leverage Ratio is the ratio of Tier 1 capital, principally equity and retained earnings, to total assets.

[15] The Leverage Ratio is inconsistent with Basel II because it is not sensitive to the riskiness of balance sheet assets and it does not capture off-balance sheet risks. By not taking the relative risk of assets into account, it could lead to incentives for banks to hold riskier assets, while on a relative basis penalizing those banks that elect to hold a low-risk balance sheet. In terms of risk to a financial institution, the time horizon of leverage is also important, which the Leverage Ratio also misses. The problems with Bear Stearns and Lehman was not only one of leverage per se, but of funding a sizable portion of leverage in the short-term repo market. They thus were vulnerable to funding drying up in the face of a crisis.

recognition that we are beset by unanticipatable risk, by events that seemingly come out of nowhere and catch us unawares, has a long history in economics and finance, dating back to Frank Knight in the 1920s.[16] The best defense against such risks is to maintain a coarse, simple and robust financial structure. Rather than fine-tuning for the current environments, we need risk measures and financial instruments which, while perhaps not optimal for the world of today, will be able to operate reasonably if the world changes in unexpected ways. VaR as currently structured is not such a risk measure.

However, although surprises do occur, crisis scenarios are not wholly unanticipatable; they are not in the realm of Knightian uncertainty. We have had ample experience with financial crises. We know a thing or two about them.[17] And we can further anticipate crisis risk by amassing data on the positions and leverage of the large investment firms. The regulator is best suited to take on this task, because these are data that no one firm can or should fully see.[18] With these critical data we will be better able to measure the crowding and leverage that lead to liquidity crisis cycles and begin to shed light on the areas of financial risk that fail to be illuminated by VaR.[19]

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[16] Knight makes the distinction between risks we can identify and measure and those that are unanticipatable and therefore not measurable in *Risk, Uncertainty, and Profit*. (1921), Boston, MA: Houghton Mifflin Company.

[17] For example, even beyond the insights to be gained from a detailed knowledge of firm-by-firm leverage and market crowding, there are some characteristics of market crisis that can be placed into a general scenario. When a crisis occurs, equity prices drop, credit spreads rise, and the volatility of asset returns increases. The yield curve flattens and gold prices rise. Furthermore, the correlation between individual equities rises, as does the correlation between equities and corporate bonds. The riskier and less liquid assets fare more poorly, so, for example, emerging markets take a differentially bigger hit than their G-7 cousins. More broadly, anything that is risky or less liquid becomes more common and negative in its return; the subtleties of pricing between assets becomes overshadowed by the assets' riskiness. However, short-term interest rates and commodity prices are less predictable; in some cases, such as in the case of the inflation-laden crisis of 1973-1974, they rise, while in other cases, such as in the current crisis, they drop. Each of these effects can occur with a ferocity far beyond what is seen in normal times, so if these crisis events are overlaid on the distribution coming out of the VaR model based on those normal times one will come away saying the crisis is a 100-year flood event, a twenty standard deviation event, a black swan. But it is none of these things. It is a financial crisis, and such crises occur frequently enough that to be understood without such shock and awe.

[18] Financial firms will be justifiably reticent to have their position and leverage information made public, so the collection and analysis of the data will have to reside securely in the regulator.

[19] With these data, the regulator is also in a position to run risk analysis independent of the firms. Under Basel II, the regulator still depends on the internal processes of the banks for the measurement of risk and the resulting capital requirements.

Appendix

Related Blog Posts on VaR and Risk Management

The Fat-Tailed Straw Man

See *http://rick.bookstaber.com/2009/03/fat-tailed-straw-man.html*

My Time article about the quant meltdown of August, 2007 started with "Looks like Wall Street's mad scientists have blown up the lab again." Articles on Wall Street's mad scientist blowing up the lab seem to come out every month in one major publication or another. The New York Times has a story along these lines today and had a similar story in January.

There is a constant theme in these articles, invariably including a quote from Nassim Taleb, that quants generally, and quantitative risk managers specifically, missed the boat by thinking, despite all evidence to the contrary, that security returns can be modeled by a Normal distribution.

This is a straw man argument. It is an attack on something that no one believes.

Is there anyone well trained in quantitative methods working on Wall Street who does not know that security returns have fat tails? It is discussed in most every investment text book. Fat tails are apparent – even if we ignore periods of crisis – in daily return series. And historically, every year there is some market or other that has suffered a ten standard deviation move of the "where did that come from" variety. I am firmly in the camp of those who understand there are unanticipatable risks; as far back as an article I co-authored in 1985, I have argued for the need to recognize that we face uncertainty from the unforeseeable. To get an idea of how far back the appreciation of this sort of risk goes in economic thought, consider the fact that it is sometimes referred to as Knightian uncertainty.

Is there any risk manager who does not understand that VaR will not capture the risk of market crises and regime changes? The conventional VaR methods are based on historical data, and so will only be an accurate view of risk if tomorrow is drawn from the same population as the sample it uses. VaR is not perfect, it cannot do everything. But if we understand its flaws – and every professional risk manager does – then it is a useful guide for day-to-day market risk. If you want to add fat tails, fine. But as I will explain below, that is not the solution.

So, then, why is there so much currency given to a criticism of something that no one believes in the first place?

It is because quant methods sometimes fail. We can quibble with whether 'sometimes' should be replaced with 'often' or 'frequently' or 'every now and again', but we all know

they are not perfect. We are not, after all, talking about physics, about timeless and universal laws of the universe when we deal with securities. Weird stuff happens. And the place where the imperfection is most telling is in risk management.

When the risk manager misses the equivalent of a force five hurricane, we ask what is wrong with his methods. By definition, what he missed was a ten or twenty standard deviation event, so we tell him he ignored fat tails. There you have it, you failed because you did not incorporate fat tails. This is tautological. If I miss a large risk – which will occur on occasion even if I am fully competent; that is why they are called risks – I will have failed to account for a fat tailed event. I can tell you that ahead of time. I can tell you now – as can everyone in risk management – that I will miss something. If after the fact you want to castigate me for not incorporating sufficiently fat tailed events, let the flogging begin.

I remember a cartoon that showed a man sitting behind a desk with a name plate that read 'risk manager'. The man sitting in front of the desk said, "Be careful? That's all you can tell me, is to be careful?" Observing that extreme events can occur in the markets is about as useful as saying "be careful". We all know they will occur. And once they have occurred, we will all kick ourselves and our risk managers and our models, and ask "how could we have missed that?"

The flaw comes in the way we answer that question, a question that can be stated more analytically as "what are the dynamics of the market that we failed to incorporate." If we answer by throwing our hands into the air and saying, "well, who knows, I guess that was one of them there ten standard deviation events", or "what do you expect; that's fat tails for you", we will be in the same place when the next crisis arrives. If instead we build our models with fatter and fatter tailed distributions, so that after the event we can say, "see, what did I tell you, there was one of those fat tailed events that I postulated in my model", or "see, I told you to be careful", does that count for progress?

So, to recap, we all know that there are fat tails; it doesn't do any good to state the mantra over and over again that securities do not follow a Normal distribution. Really, we all get it. We should be constructive in trying to move risk management beyond the point of simply noting that there are fat tails, beyond admonitions like "hey, you know, shit happens, so be careful." And that means understanding the dynamics that create the fat tails, in particular, that lead to market crisis and unexpected linkages between markets.

What are these dynamics?

One of them, which I have written about repeatedly, is the liquidity crisis cycle. An exogenous shock occurs in a highly leveraged market, and the resulting forced selling leads to a cascading cycle downward in prices. This then propagates to other markets as those who need to liquidate find the market that is under pressure no longer can support their liquidity needs. Thus there is contagion based not on economic linkages, but based on who is under pressure and what else they are holding. This cycle evolves unrelated to

historical relationships, out of the reach of VaR-types of models, but that does not mean it is beyond analysis.

Granted it is not easy to trace the risk of these potential liquidity crisis cycles. To do so with accuracy, we need to know the leverage and positions of the market participants. In my previous post, "Mapping the Market Genome", I argued that this should be the role of a market regulator. But even absent that level of detail, perhaps we can get some information indirectly from looking at market flows.

No doubt there are other dynamics that lead to the fat tailed events currently frustrating our efforts to manage risk in the face of market crises. We need to move beyond the fat-tail critiques and the ‘be careful’ mantra to discover and analyze them.

The Myth of Noncorrelation

See *http://rick.bookstaber.com/2007/09/myth-of-noncorrelation.html*

[This is a modified version of an article I wrote that appeared in the September, 2007 issue of Institutional Investor].

With the collapse of the U.S. subprime market and the aftershocks that have been felt in credit and equity markets, there has been a lot of talk about fat tails, 20 standard deviation moves and 100-year event. We seem to hear such descriptions fairly frequently, which suggests that maybe all the talk isn't really about 100-year events after all. Maybe it is more a reflection of investors' market views than it is of market reality.

No market veteran should be surprised to see periods when securities prices move violently. The recent rise in credit spreads is nothing compared to what happened in 1998 leading up to and following the collapse of hedge fund Long-Term Capital Management or, for that matter, during the junk bond crisis earlier that decade, when spreads quadrupled.

What catches many investors off guard and leads them to make the "100 year" sort of comment is not the behavior of individual markets, but the concurrent big and unexpected moves among markets. It's the surprising linkages that suddenly appear between markets that should not have much to do with one other and the failed linkages between those that should march in tandem. That is, investors are not as dumbfounded when volatility skyrockets as when correlations go awry. This may be because investors depend on correlation for hedging and diversifying. And nothing hurts more than to think you are well hedged and then to discover you are not hedged at all.

Surprising Market Linkages

Correlations between markets, however, can shift wildly and in unanticipated ways — and usually at the worst possible time, when there is a crisis with volatility that is out of hand. To see this, think back on some of the unexpected correlations that have haunted us in earlier market crises:

- The 1987 stock market crash. During the crash, Wall Street junk bond trading desks that had been using Treasury bonds as a hedge were surprised to find that their junk bonds tanked while Treasuries strengthened. They had the double whammy of losing on the junk bond inventory and on the hedge as well. The reason for this is easy to see in retrospect: Investors started to look at junk bonds more as stock-like risk than as interest rate vehicles while Treasuries became a safe haven during the flight to quality and so were bid up.
- The 1997 Asian crisis. The financial crisis that started in July 1997 with the collapse of the Thai baht sank equity markets across Asia and ended up enveloping Brazil as well. Emerging-markets fund managers who thought they had diversified portfolios — and might have inched up their risk accordingly — found themselves losing on all fronts. The reason was not that these markets had suddenly become economically linked with Brazil,

but rather that the banks that were in the middle of the crisis, and that were being forced to reduce leverage, could not do so effectively in the illiquid Asian markets, so they sold off other assets, including sizable holdings in Brazil.

- The fall of Long-Term Capital Management in 1998. When the LTCM crisis hit, volatility shot up everywhere, as would be expected. Everywhere, that is, but Germany. There, the implied volatility dropped to near historical lows. Not coincidentally, it was in Germany that LTCM and others had sizable long volatility bets; as they closed out of those positions, the derivatives they held dropped in price, and the implied volatility thus dropped as well. Chalk one up for the adage that markets move to inflict the most pain.

And now we get to the crazy markets of August 2007. Stresses in a minor part of the mortgage market — so minor that Federal Reserve Board chairman Ben Bernanke testified before Congress in March that the impact of the problem had been "moderate" — break out not only to affect other mortgages but also to widen credit spreads worldwide. And from there, subprime somehow links to the equity markets. Stock market volatility doubles, the major indexes tumble by 10 percent and, most improbable of all, a host of quantitative equity hedge funds — which use computer models to try scrupulously to be market neutral — are hit by a "100 year" event.

When we see this sort of thing happening, our not very helpful reaction is to shake our heads as if we are looking over a fender bender and point the finger at statistical anomalies like fat tails, 100-year events, black swans, or whatever. This doesn't add much to the discourse or to our ultimate understanding. It is just more sophisticated ways of saying we just lost a lot of money and were caught by surprise. Instead of simply stating the obvious, that big and unanticipated events occur, we need to try to understand the source of these surprising events. I believe that the unexpected shifts in correlation are caused by the same elements I point to in my book as the major cause of market crises: complexity and tight coupling.

Complexity

Complexity means that an event can propagate in nonlinear and unanticipated ways. An example of a complex system from the realm of engineering is the operation of a nuclear power plant, where a minor event like a clogged pressure-release valve (as occurred at Three Mile Island) or a shift in the combination of steam production and fuel temperature (as at Chernobyl) can cascade into a meltdown.

For financial markets, complexity is spelled d-e-r-i-v-a-t-i-v-e-s. Many derivatives have nonlinear payoffs, so that a small move in the market might lead to a small move in the price of the derivative in one instance and to a much larger move in the price in another. Many derivatives also lead to unexpected and sometimes unnatural linkages between instruments and markets. Thanks to collateralized debt obligations, this is what is at the root of the first leg of the contagion we observed from the subprime market. Subprimes were included in various CDOs, as were other types of mortgages and corporate bonds. Like a kid who brings his cold to a birthday party, the sickly subprime mortgages mingled with these other instruments.

The result can be unexpected higher correlation. Investors that have to reduce their derivatives exposure or hedge their exposure by taking positions in the underlying bonds will look at them as

part of a CDO. It doesn't matter if one of the underlying bonds is issued by a AA-rated energy company and another by a BB financial; the bonds in a given package will move in lockstep. And although subprime happens to be the culprit this time around, any one of the markets involved in the CDO packaging could have started things off.

Tight Coupling

Tight coupling is a term I have borrowed from systems engineering. A tightly coupled process progresses from one stage to the next with no opportunity to intervene. If things are moving out of control, you can't pull an emergency lever and stop the process while a committee convenes to analyze the situation. Examples of tightly coupled processes include a space shuttle launch, a nuclear power plant moving toward criticality and even something as prosaic as bread baking.

In financial markets tight coupling comes from the feedback between mechanistic trading, price changes and subsequent trading based on the price changes. The mechanistic trading can result from a computer-based program or contractual requirements to reduce leverage when things turn bad.

In the '87 crash tight coupling arose from the computer-based trading of those running portfolio insurance programs. On Monday, October 19, in response to a nearly 10 percent drop in the U.S. market the previous week, these programs triggered a flood of trades to sell futures to increase the hedge. As those trades hit the market, prices dropped, feeding back to the computers, which ordered yet more rounds of trading.

More commonly, tight coupling comes from leverage. When things start to go badly for a highly leveraged fund and its collateral drops to the point that it no longer has enough assets to meet margin calls, its manager has to start selling assets. This drops prices, so the collateral declines further, forcing yet more sales. The resulting downward cycle is exactly what we saw with the demise of LTCM.

And it gets worse. Just like complexity, the tight coupling born of leverage can lead to surprising linkages between markets. High leverage in one market can end up devastating another, unrelated, perfectly healthy market. This happens when a market under stress becomes illiquid and fund managers must look to other markets: If you can't sell what you want to sell, you sell what you can. This puts pressure on markets that have nothing to do with the original problem, other than that they happened to be home to securities held by a fund in trouble. Now other highly leveraged funds with similar exposure in these markets are forced to sell, and the cycle continues. This may be how the subprime mess expanded beyond mortgages and credit markets to end up stressing quantitative equity hedge funds, funds that had nothing to do with subprime mortgages.

All of this means that investors cannot put too much stock in correlations. If you depend on diversification or hedges to keep risks under control, then when it matters most it may not work.