

Future of Modeling and Risk Management

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Aftermath of a crisis

- The global economic “pandemic” of 2007-2009 is the most serious global economic crisis of the past 60 years and was beyond doubt primarily due to mismanagement of risk by large financial institutions
- There will need to be many changes in financial industry structure in response. Proposals include:
 - Changes to the structure of executive compensation
 - Changes in the organization of national and international financial industry regulation
 - Limitations to the types of products that can be offered
 - Changes in the role and structure of ratings agencies
 - Increases in required capital cushions
 - **Changes to modeling and risk management**

Rounding up the usual suspects

Group of Thirty

- **Regulatory standards for governance and risk management should be raised, with particular emphasis on:**
 - a. Strengthening boards of directors with greater engagement of independent members having financial industry and risk management expertise;
 - d. Ensuring the risk management and auditing functions are fully independent and adequately resourced areas of the firm. The risk management function should report directly to the chief executive officer rather than through the head of another functional area;

Institute of International Finance

- **Governance and risk culture: It is critical for governance to embed a firm-wide focus on risk. The recent market turbulence has provided clear evidence that effective cultivation of a consistent “risk culture” throughout firms is the main enabling tool in risk management. Each firm should:**
 - Make clear that senior management, in particular the CEO, is responsible for risk management;
 - Establish the Board’s essential oversight role in risk management; and
 - Develop a robust risk culture that is embedded in the way the firm operates, covering all areas and activities, with accountability for risk management being a priority for the whole institution.
- **Role of the Chief Risk Officer: One clear lesson highlighted by the market turmoil is the need to strengthen risk-management organizational structures. In this context, firms should:**
 - Assign responsibility for risk management to an officer at a senior level, in most cases a Chief Risk Officer (CRO) who should have sufficient seniority, voice, and independence from line business management to have a meaningful impact on decisions;
 - Ensure that the CRO has the ability to influence key decision-makers in the firm, ...

A more radical approach

- Nassim Nicholas Taleb & Pablo Triana (Financial Times 12/7/08):
 - “Almost everyone in risk management knew that quantitative methods – like those used to measure and forecast exposures, value complex derivatives and assign credit ratings – did not work and could provide undue comfort by hiding risks....Almost everyone would accept that the failure in 1998 of Long Term Capital Management discredited the quantitative methods of the Nobel economists involved with it (Robert Merton and Myron Scholes) and their school of thought called “modern finance.”
 - “Yet a method heavily grounded on those same quantitative and theoretical principles, called Value at Risk, continued to be widely used. It was this that was to blame for the crisis.”
 - “Risk methods that failed dramatically in the real world continue to be taught to students in business schools, where professors never lose tenure for misapplications of these methods. As we are writing these lines, close to 100,000 MBAs are still learning portfolio theory...”
 - “So when you see a quantitative “expert”, shout for help, call for his disgrace, make him accountable. ... Ask for drastic overhaul of business schools (and stop giving funding). Ask for Nobel prizes in economics to be withdrawn from the authors of these theories... Boycott professional associations that give certificates in financial analysis that promoted these methods. Remove Value-at-Risk books from the shelves – quickly.”
- In particular, Felix Salmon, “Recipe for Disaster: The Formula That Killed Wall Street”, (Wired Magazine, 2/23/09):
 - [David] Li's Gaussian copula formula will go down in history as instrumental in causing the unfathomable losses that brought the world financial system to its knees.

What we already knew

- Black-Scholes-Merton has worked well in controlling risk of “plain vanilla” options. The problem was extending these methods without sufficient modification to less liquid instruments, such as subprime CDOs
- Value-at-risk measures were never designed to deal with highly-complex, highly-illiquid instruments, which is where the real problems came from
- Portfolio theory’s emphasis on undiversifiable vs. diversifiable risk was not given sufficient emphasis

As I have always said...

- Steve Allen, Financial Risk Management (2002):
 - The use of the variance-covariance method has now been virtually abandoned by sophisticated financial firms in favor of simulation methods. The primary reason for this is that relative to the simulation method, the variance-covariance method provides very little flexibility in evaluating the contribution of non-linear positions, notably options positions, to P&L distributions. . . . Secondary reasons [include]:
 - The greater difficulty that the variance-covariance method has in dealing with the fat-tailed distributions normally encountered in financial markets.
 - The inability of variance-covariance to pick up the phenomenon, often observed in financial markets, that the largest changes in variables often cluster together (e.g., the high correlation between stock markets in different countries in the 1987 stock crash) to a greater degree than will be indicated by correlation coefficients (i.e., the joint distribution is not bivariate normal).
 - This experience [in the Asian credit crisis of the Fall of 1997] persuaded [Chase Manhattan] management to experiment with tying the risk adjustment of business units relative to stress losses, as an incentive to reduce vulnerability to large market shocks. As business adjusted to the new performance measure in early 1998, we noticed a significant impact in terms of strategies to continue to meet P&L targets with less reliance on positions which were vulnerable to these shocks. The result was that Chase weathered the Fall 1998 market shock due to Russian default and the unraveling of Long Term Capital with much smaller losses than in the Fall of 1997 crisis and smaller losses than almost all of our largest competitors... Continued experience with the impact of this decision since then has continued to confirm its value.

As I have always said...

- Steve Allen, Financial Risk Management (2002):
 - Finally, we note that some of the determinants of exotic derivative prices are not market variables whose price history can be observed and so are not suitable for inclusion in a VaR analysis. ... such non-market observables cannot be included in VaR analyses and ... their risks should be accounted for separately, through reserves and stress tests.
 - So long as not all instruments have liquid markets, it will be necessary to utilize valuation models which require some inputs which cannot be extracted from liquid market prices. Since we cannot hope to eliminate this source of uncertainty, we must try to control in some way the possible impact it can have on trading profitability.
 - By placing a reserve against the valuation of a product, an attempt is made to only recognize that portion of P&L which is almost certain to be realized.
 - By placing limits on the amount of P&L which can be lost if non-liquid factors turn out to have values different from the assumed, an attempt is made to place an upper bound on future losses.

As I have **not** always said...

- Richard Bookstaber, *A Demon of Our Own Design* (2007), p. 255:
 - “... the positive effects of [financial market] innovation come at a price. Innovation increases complexity...When a market dislocation arises, it is difficult to know how the prices of these instruments will react. Innovation and mechanical efficiency have also increased complexity by pushing markets to become more interconnected.”
- Robert Schiller (Washington Post, Sept. 28, 2008):
 - “It is high time to redesign derivatives to avoid what Buffett called ‘catastrophic’ risks.”
- Stephen Schwartzman (Wall Street Journal, Nov. 4, 2008):
 - “A system of rules and regulations is utterly incapable of dealing with the speed and complexity of the modern financial system. ..[need to] regulate not by promulgating a blizzard of ever more complex rules, but by enunciating a set of guiding principles. ..coupled with strong disclosure and oversight, “

Options position risk

- Because of the wide variety of options contract specifications, there needs to be some underlying principle for integrating risk reporting
 - Puts and calls
 - Variety of dates that options expire
 - Variety of strikes at which options can be exercised
- The Black-Scholes-Merton model is the key to managing and reporting options position risk
 - It is used to interpolate market prices for all options from reported prices for a handful of options
 - It is used to identify a few key variables that impact the prices of all options
 - It is used to measure the change in options prices to changes in these key variables for position reports, for VaR, and for stress tests
 - There are known flaws in the model but risk managers and traders have developed procedures for dealing with them

Flaws in the Black-Scholes-Merton formula

- **Significant flaws concerning hedging**
 - **BSM assumes that hedging can take place without transaction costs**
 - **Large options trading desks only need to hedge net exposures which holds transaction costs down to a very small part of overall trading costs**
 - **Other users of options can count on large options trading desks to eliminate pricing discrepancies**
 - **BSM assumes that asset prices follow a smooth path with no sudden jumps**
 - **Risk reports need to be developed to show exposure to price jumps**
- **Significant flaws concerning volatility**
 - **BSM assumes that volatility is known in advance**
 - **Risk reports need to be developed to show exposure to volatility uncertainty**
 - **BSM assumes that volatility is constant when in fact volatility varies by time period and price level**
 - **Controlled for by utilizing a market-implied volatility surface**
 - **Risk reports on volatility exposure need to show details of exposure bucketed by tenor and strike**

How do we know that these fixes to BSM can be used to control risk?

- Historical experience shows there have been no major blow-ups due to market-making in reasonably liquid vanilla options
- Simulations can be performed to show that while risk has not been eliminated it has been reduced to controllable levels (see section 9.3 of Allen, Financial Risk Management for details)
- Adequate risk control requires frequent (but not continuous) trading in a liquid underlying asset and infrequent trading in a less liquid (but somewhat liquid) set of options with strike and tenor characteristics that reasonably approximate the options being hedged

The Li Model

- Is it fair to blame the Li model for the collapse of the subprime mortgage CDO market?
 - The major firms whose losses led to the largest part of the crisis were all using more sophisticated models than the Li model
 - The Li model was used in very much the same way for CDOs as the BSM model is successfully used for vanilla options, with market-implied correlation skews playing a parallel role to market-implied volatility surfaces
 - The big difference is liquidity: the CDO market does not possess somewhat liquid instruments with characteristics that approximate the CDOs needing to be hedged
 - The Li model could be used to reasonably accurately compute the dependence of tranches on undiversifiable risk and to produce stress test results

Model Risk

- **Liquid positions**

- Models may be used for interpolation between liquid price quotes
- Models will be used for calculation of the impact of market changes on positions in the VaR and stress test calculations
- These model uses are robust and easy to test, since they can constantly be checked against actual liquid market quotes
- Only need to be concerned with current Greeks (you can always ask that positions be reduced in future in reaction to changing Greeks)

- **Illiquid positions**

- Model becomes critical and hard to validate
- Must employ as much liquid market data in the model as possible to avoid unnecessary staleness of MTM
- Must clearly identify illiquid inputs and estimate liquidation risk through conservative assumptions (relative to **net** exposure to illiquid inputs)
- Model Greeks are only useful in representing sensitivities to liquid market data; they cannot be used in identifying the potential cost of being wrong about the illiquid inputs (since your risk on the illiquid inputs is not to small hedgable changes)
- Even for Greeks related to liquid market data, must be concerned about future evolution, since you may not be able to change positions easily

The nature of illiquid instrument risk

- Illiquid instrument risk can arise from
 - Instruments with one-way market – instruments for which almost all customer interest is on one side of the market and ability to lay off risk is limited by all dealers having similar positions (you can't take comfort from price quotes that can't be acted on)
 - Instruments that require extensive information disclosure and negotiation to realize anything other than fire-sale prices
 - Instruments that can only be liquidated under restrictive conditions

Using liquid proxies to estimate illiquid instrument risk

- Use liquid proxies to represent these trades in computations designed for the firm's liquid positions, such as MTM, VaR and stress tests
 - Avoids stale MTMs
 - Measures risk concentrations and encourages diversification
- Every model is a potential liquid proxy representation; every liquid proxy representation is a model subject to error
- Model difference between actual product and liquid proxy to create conservative valuation assumptions
 - **Modeling of differences must go all the way to final payout and must reflect the possibility that the model used for pricing and trading the product may be wrong**
 - Modeling as simulation over time generally very difficult to do and relies on insider trader knowledge
 - Modeling as infrequent re hedge can make use of more public information and can more easily reflect the risk that the model used for pricing and trading may be wrong (see section 8.2.2 and 10.3.3 of Allen, Financial Risk Management for details)
- The liquid proxy is just a form of representation; it is not intended to dictate hedging action to the trading desk
 - Traders who believe that they have better hedging strategies should be given sufficient limit room to act on these (plausible) beliefs and should reap the resulting gains (and losses)

VaR and Stress Tests

- There is never any excuse for a statistical computation such as VaR to ignore fat-tailed distributions, non-linear joint distributions or non-linear payouts
 - Dictates the use of simulation methodology, but leaves open choices between historical and Monte Carlo simulations or blends of the two
- All statistical computations such as VaR must be complemented by stress tests
 - To account for temporary periods of illiquidity in normally liquid markets
 - To account for crisis events that are not just extreme observations from the same distribution as everyday returns
- All statistical computations such as VaR must properly reflect positions in less liquid instruments and illiquidity due to concentrated positions in liquid instruments
 - Positions that can only be represented by a liquid proxy must separately model differences between the actual product and the liquid proxy
 - Concentrated positions require modeling of potential cost of liquidating over a longer time period or of impact of a large position on market prices

Regulatory capital requirements

- Institutions that place taxpayers in danger of significant loss require regulatory capital requirements.
 - This certainly includes commercial banks, but may also include other institutions so big or interconnected that they may require taxpayer backing in a crisis.
- Taxpayers primarily need protection against non-diversifiable risk.
 - Non-diversifiable risk, such as exposure to declines in the broad stock market, increases in credit spread levels, increases in government bond yield levels, or declines in broad housing price levels, have the potential to create solvency problems for many financial institutions simultaneously. This leads to situations in which it is difficult to have orderly liquidations of a few problem institutions and which can lead to heavy losses by taxpayers
 - By contrast, diversifiable risk, such as exposure to the spread between two different points on the yield curve or overconcentration in lending to a given region, even when large, can be dealt with through orderly liquidation of the few institutions impacted.

The need for industry-wide stress tests

- Capital needs to be there before the crisis hits – capital requirements that are pro-cyclical are counter-productive
 - Capital requirements that rise significantly during major economic downturns only succeed in freezing credit extension when it is most needed.
- Capital needs to be determined by stress tests
- Stress-tests need to be based on industry-wide assumptions as to undiversifiable risk factors
- An individual financial institution may develop specialized expertise in the detailed composition of its portfolio. But there is no reason to expect an individual institution to have specialized expertise concerning the distribution of macroeconomic factors, such as broad stock market levels, inflation rates, credit default levels, housing price levels, or energy price levels.
- Use of industry-wide stress tests should eliminate competitive pressure to undercapitalize
 - The common complaint of internal risk managers is that more severe stress tests would be rejected by management as unrealistic. This represents the natural bias of management towards capitalization levels that advantage stockholders over tax payers.

Countering pro-cyclicality of regulatory capital requirements

- Pro-cyclicality can be eliminated by the ability to sell liquid assets and by using a fixed target for non-liquid assets
 - There are two ways to deal with the pro-cyclical problem of higher demands for capital during economic downturns, when it is hardest to raise capital:
 - Positions can be liquidated
 - Adequate capital can be raised prior to the economic downturn
 - This implies that for liquid positions, capital can be tied to changes from current mark-to-market. Even though this will result in higher capital requirements during economic downturns, the ability to liquidate positions makes this manageable.
 - For illiquid positions, capital should not be tied to mark-to-market. In an economic downturn, capital will rise severely because losses on MTM cost capital on top of rising capital requirements tied to increased volatility. The option of position liquidation is not available to relieve this bind.

Regulatory capital for illiquid positions

- The alternative for illiquid positions is capital requirements tied to a fixed stress-level (e.g., default levels three times historical averages). This causes adequate capital to be raised when assets are first booked. When an economic downturn occurs, the capital drain of MTM losses is balanced by reduction of capital requirements, since current MTM is closer to the fixed stress-level.
- Accounting standards should impact disclosure to shareholders and lenders, not regulatory capital standards
 - This is a natural outcome of the recommendation to tie required capital to fixed stress-level losses.
 - De-coupling regulatory capital requirements from earnings reporting would ease SEC concerns that building up reserves during good times is a way of manipulating the reporting of earnings volatility

Industry-wide stress tests

- Two different types of industry-wide stress test scenarios are needed: for liquid asset classes, the size of market movements that can occur during brief temporary periods of lowered liquidity (e.g, Oct. 1987 stock market crash); for illiquid asset classes, fixed stress levels (e.g., default levels three times historical average)
- The type of stress test to apply to a position should depend only on liquidity and not on accounting treatment, such as whether it is accounted for as a trading account position or a banking book position.
- Stress tests require industry-wide uniformity with regard to liquidity classification of asset classes
 - There is no reason to expect an individual institution to have specialized expertise concerning which asset classes have sufficient liquidity to tie required capital to MTM
 - Individual institutions may have specialized knowledge about position sizes in liquid asset classes that have become so large as to compromise liquidity. This should be accounted for in their implementation of stress tests.

Stress tests of counterparty risk

- Stress tests need to be applied to all parts of the firm, including impact on losses from credit extension to counterparties on derivative transactions
 - Losses on credit extension to counterparties must fully take into account collateral in place and contractual terms for settlement and collateralization
 - Stress tests should specify an assumed level and pace of defaults of large financial firms which will drive the calculation of capital required against credit extension to counterparties
 - Direct regulatory actions to reduce the systemic risk arising from the potential of OTC derivatives to trigger cascading defaults of large financial firms can be usefully supplemented by capital requirements. If industry-wide stress tests are stringent enough to require substantial capital against these exposures, they will provide financial firms with the incentive to search for the most efficient innovations for reduction of OTC derivative exposures.

Hiding risk in the tails

- Supplemental stress tests are needed to prevent hiding risks in the tails
 - It's easy to design products around stress tests. For example: if capital is required to cover default loss levels of 10%, write a digital contract that pays nothing if default loss levels are 10% or less and pays out 20% if default loss levels are above 10%. This contract will attract zero capital but clearly will subject taxpayers to outsized losses if default loss levels reach 11%. This is an extreme example, but more subtle versions can be expected.
 - Supplemental stress tests can catch this. To continue with the above example: an “absurd” stress test that looks at default loss levels of 20% would show the equivalence at this level of the digital product and a standard loan portfolio. No additional capital would be required for the standard loan portfolio, since it already had capital assigned by the standard 10% loss stress test, but the digital product would need to provide some capital to compensate for not having any capital required by the standard stress test.

Role of a firm's risk managers

- Use of industry-wide stress tests should eliminate reliance on VaR for regulatory capital
 - VaR is largely unrelated to the potential size of large losses that impact the adequacy of regulatory capital. Presumably, the only reason that regulators chose to base market risk capital requirements on VaR was the relative objectivity of historical measures of price distributions that were input to VaR. Stress test levels were viewed as too subjective and likely to be chosen by an institution with a bias towards undercapitalization (favoring shareholders at the expense of tax payers).
- Individual firms should build stress scenarios and other risk measures, such as VaR, to balance risk and return for shareholders
 - Unlike regulators, shareholders are less concerned with small probabilities of catastrophic loss and more concerned with earnings variability.
 - It is entirely reasonable for different firms to try to differentiate themselves to potential shareholders by seeking competitive advantage through individual assessment of scenario probabilities and by emphasizing different tradeoffs between expected return and earnings variability.
- Risk managers at individual firms need to be responsible for thoroughness and accuracy of the implementation of all stress test calculations, whether firm-specified or industry-wide, with particular emphasis on the completeness and accuracy of trade representations in stress calculation systems.
 - The tradeoff between accuracy and computational feasibility requires ingenuity, experience and judgment.

Specification of industry-wide stress tests

- Industry-wide stress tests are best determined by regulators as representatives of the tax-payers who will ultimately bear the cost, but there are some important questions:
 - Will regulators want to specify full stress tests or only specify criteria for stress tests (e.g., stress to levels that will only occur one year in every 50)?
 - If regulators only specify stress test criteria, who will produce the full industry-wide stress tests? Leaving this task to an industry trade group will risk undercapitalization.
 - Should industry-wide stress tests be common across regulators in all countries? This may not be politically feasible – regulators in different countries may wish to make different tradeoffs between taxpayer protection and the limitations on banking that large capital requirements may lead to. But global interconnectedness argues for some common standards.
- Individual firms should build stress scenarios for diversifiable risks such as basis positions
 - Large diversifiable risk positions, such as basis positions, still should require regulatory capital, but the design of such stress tests are best left to individual firm risk managers, combining broad regulatory guidance with knowledge of firm-specific positions
- Large positions need to be reported to regulators so that new non-diversifiable risks can be identified
 - For example, if many firms started to take large similar positions in the same basis trade, it might now require an industry-wide stress test

A final thought

- The need for each individual to take responsibility:
 - Nassim Nicholas Taleb & Pablo Triana (Financial Times 12/7/08): “Listening to us, risk management practitioners would often agree on every point. But they elected to take part in the system and play bystanders. They tried to explain away their decision to partake in the vast diffusion of responsibility: ‘Lehman Brothers and Morgan Stanley use the model’ or ‘it is on the CFA exam’ or, the most potent argument ‘modern finance and portfolio theory got Nobels’ ”.