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A STRESS TESTING PERSPECTIVE
Insights on risk management to the global risk community

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The financial crisis has highlighted a number of shortcomings in risk management. Models are powerful tools but necessarily involve simplifications. Risk metrics, models and ratings are not ends in themselves and must not become obstacles to risk identification. Expert judgment and critical analysis are always necessary. Overall, the risk control/risk management function must be more transparent about limitations of risk metrics and models in practice, and find ways to improve their capabilities and effectiveness.

VaR (Value-at-Risk) has been a standard model in the banking industry since the late 1990s. It serves as a useful risk measure during normal market conditions. However, the recent crisis highlighted its limitations when liquidity dries up or large tail events occur. Such events are a common feature of financial crises and VaR, as a static model, does not adequately capture their impact. VaR analysis as commonly practiced also fails to address volatility jumps and changing correlations and misses important non-linearity in structured products such as subprime CDOs. Many VaR models focus on hypothetical mark-to-market (MtM) changes but fail to model risk related to collateral calls (e.g. on a repo transaction), credit-related downgrades, operational risk events (e.g. fraud) and so on.

Combining VaR with additional risk-measurement tools such as stress tests adds qualitative judgement to quantitative rigour. Exposures in trending markets over multi-year time periods (e.g. during bubbles) and instruments with non-linear price movements (e.g. exotic derivatives) are not easily captured by the traditional VaR model (e.g. a dramatic jump in an implied volatility surface for an exotic option). Stress and scenario analyses complement VaR by assessing losses that result from unlikely but realistic market conditions.[1] Stress tests and worst case scenarios should include business cycle stresses as well as event specific "tail risks." For example, markets with low historical volatility may experience large discrete movements reflecting the intersection of market risk, trading liquidity risk and credit risk for corporate bonds. Risks related to account concentration, correlation, and liquidity must be considered, as should on- and off-balance sheet assets and liabilities.

Of course, pricing risk in stress markets is not easy. Stress testing margin calls for a levered hedge fund, for example, requires significant information about where the firm is "today" as well as where it could be at any point in the future. Liquidity risk can also be difficult to measure. *Funding liquidity risk* describes potential challenges to meeting collateral and margin calls, difficulty accessing capital markets, or not being able to tap other financing sources when funds are required. *Trading liquidity risk* means not being able to exit a trading position within a desired period of time, or only at a firesale price. Metrics such as cash-flow-

[1] Scenario analysis involves a holistic approach in which all the risk factors are assumed to change simultaneously according to a specific market event, characterized as extreme but plausible and relevant. Stress analysis usually refers to techniques in which only one factor or parameter is changed, maintaining the others unchanged. See, e.g., Crouhy M., D. Galai and R. Mark, 2006, *The Essentials of Risk Management*, McGraw Hill, pp.173-179; Rowe D., 2006, From VaR to Stress Testing, Risk Magazine, December; Schachter B., 2010, Stress Testing and Scenario Analysis, *The Encyclopedia of Quantitative Finance*. and Ray, C. *Extreme Risk Management,* McGraw-Hill, *2010*

at-risk (CFaR) and liquidity-at-risk (LaR), while not perfect, can help capture the amount of liquidity risk in adverse markets.

Superior stress testing establishes an integrated view of risk that stresses components on an individual as well as an aggregate basis, while modeling extreme events in significant detail. Effective scenario analysis takes into account events unfolding over time, for example a quarter of limited liquidity during which it becomes impossible to hedge positions in a timely manner. They also require context. How would (did) a hypothetical (historical) stress test event unfold over time? (This can be as important as the final outcome.)

Forward-looking stress and scenario tests must specify length, speed and magnitudes of events and describe the dynamics between transactions (e.g. unstable correlations that move towards one or minus one in stressed markets).

Scenarios must also address correlations between risk factors and distinguish between static and dynamic scenarios, i.e., one-period vs. multi-period frameworks. While trading liquidity risk rarely factors into traditional VaR analysis, a multi-period framework can incorporate hedging strategies to protect against losses in illiquid markets over time and incorporate management intervention as part of the picture. Well-developed, they form an integral part of the management culture in a way that has meaningful impact on business decisions.

> "We believe it makes sense to incorporate integrated stress test results into setting risk appetite. However, it remains an open question whether it is wise to use stress tests to determine economic capital and regulatory capital... These new rules to derive regulatory capital could lead to the absurd situation where the amount of regulatory capital is greater than the exposure of the portfolio. To the extent that determining capital levels is a function of the desired confidence interval to protect the institution against default, incorporating stress testing considerations appears to muddy the waters."

Importantly, since individual firms strengths and weaknesses are different, there is no "one size fits all" approach to stress testing. Scenarios must be "severe" but "plausible" for *that* firm. Effective stress tests should highlight specific weaknesses and surface "hot spots" visible under extreme conditions. Worst-case scenarios must measure "knock-on" risks like the unexpected write-downs and collateral calls that devastated AIG, which had to post about $50 billion in collateral to offset drops of more than $400 billion in the value of securities it insured.[2] Most importantly, stress testing needs to be part of a dialogue between senior management and the risk function about the most relevant stresses, scenarios and potential impacts.

Management response is a critical component to risk modeling as well. A stress test committee that collects practical views from risk takers and managers should identify *"warning signals"* to be incorporated into governance responsibilities and reports. The stress test committee should also determine the required feedback such as who acts on the results of the stress test and the appropriate follow up with the risk takers in case of any violations of limits (e.g. exceeding either soft stress test limits or hard stress test limits). Additional activities include developing *"contingency action plans"* to deal with catastrophic situations in advance, including written plans that connect plans to the procedures established to set stress limits. Ultimately, stress test limits

[2] Reportedly, no scenario was run at AIG that considered the impact of a sharp drop in housing prices on collateral calls and write-downs. See Wall Street Journal Europe, November 3, 2008.

should be approved by the board based on the risk appetite of the firm. Methodologies and policies must be appropriately consistent across multiple factors and business units.

We believe it makes sense to incorporate integrated stress test results into setting risk appetite. However, it remains an open question whether it is wise to use stress tests to determine economic capital and regulatory capital. Capital required based on the VaR approach was typically a function of a desired credit risk rating (e.g., a AA institution has a 4 to 6 bp probability to default within the next 12 months). Basel II regulatory calculations did not originally account for stress tests either. Now, following the financial crisis of 2007-2009, regulators require banks to add "Stress VaR" as part of regulatory capital calculation.[3] These new rules to derive regulatory capital could lead to the absurd situation where the amount of regulatory capital is greater than the exposure of the portfolio.[4] To the extent that determining capital levels is a function of the desired confidence interval to protect the institution against default, incorporating stress testing considerations appears to muddy the waters.

We welcome your views on the role stress testing should play when determining the economic capital and regulatory capital.

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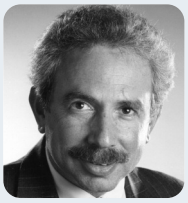

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The authors of this article wrote the *Essentials of Financial Risk Management* (McGraw-Hill, 2006) — the best-seller that is adopted as the sole course text for our Associate PRM certificate. All of the authors are founding members of PRMIA.

[3] Revisions to the Basel II market risk framework, July 2009

[4] The new rules to calculate the amount of regulatory capital in the trading book can be summarized by the formula:

Capital = max {(VaR, 3*(average VaR over 60 days)} + max {StressVaR, 3*(average StressVaR over 60 days)} + IRC

where VaR is measured at the 99% confidence level over a 10 day period, StressVaR is computed using data from a stressful period such as 2007-2008, and IRC (incremental risk charge) is the CreditVaR over a one-year period at the 99.9% confidence level.

Assume for illustrative purpose that volatility under stressed market conditions is 3 times volatility in a normal market environment and returns are normally distributed, so that StressVaR is 3 times NormalVaR, neglecting IRC for the purpose of the exercise.

Now suppose that the portfolio has an annualized volatility in normal market conditions of 10%. Then, over 10 days, the standard deviation is 2%. The 10-day standard deviation in stress conditions is thus 6%, according to our (not unreasonable) assumption. The sum of these, i.e. 8%, must be multiplied by the 99% standard normal critical value of 2.33, and then by a multiplier of at least 3. Assuming a green zone model, i.e. a multiplier of 3, regulatory capital under the new rules (and ignoring the IRC) is $2.33 \times 3 \times 8\% = 56\%$ of the portfolio exposure.

Note that under our simple, but illustrative, assumptions the new regulatory capital charge will always be 4 times the capital charge without the stressed component. For instance, with a well-diversified and partially hedged portfolio, having an annualized volatility of 5% and an old regulatory capital of 7% of the exposure, the new charge will be 28%. But with a partially diversified and lightly hedged portfolio having normal volatility 15% and a stress volatility of 60%, the new rules lead to a capital charge of 105% of the size of the portfolio, which, if the positions are long, is higher than the maximum loss that could be incurred on this portfolio.