Stress Testing Practice for Risk Management

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Abstract. Risk-management practices at financial institutions have undergone a quantitative revolution. Increasingly, financial firms rely on statistical models to measure and manage financial risks, ranging from market risks (such as exchange rate fluctuations) to credit risks (such as borrowers' default probabilities) to operational risks (such as expected losses due to fraudulent transactions). Such models have gained credibility because they provide a coherent framework for identifying, analyzing and communicating these risks. These are only simplifications of reality and cannot capture every aspect of these risks. For example, unlikely yet possible events that could cause significant losses are not captured readily by models constructed to monitor typical risk outcomes. To address this shortcoming, risk managers have developed a practice known as "stress testing," which also has become an important element of the supervisory monitoring of financial firms. Indeed, many supervisory agencies have begun using stress-testing techniques to assess the capital adequacy of individual firms and even national financial systems. We define stress testing, describe its possible applications, and highlight certain techniques developed to conduct this testing, and survey its recent use by supervisory agencies. The European Union plans to conduct its bank stress tests as an industry wide look at the health of the financial system. That way, it is expected that an overall view of the euro zone's banking system will be obtained. The European bank stress test results should be ready by September, in the hopes that the information will be helpful for junior finance ministers and central bank representatives at their autumn meeting.

Keywords: methodologies, scenarios, stress testing practice, capital adequacy

INTRODUCTION

A stress test is a risk management tool used to evaluate the potential impact on portfolio values of unlikely, although plausible, events or movements in a set of financial variables (Lopez, 2005). Stress tests are designed to explore the tails of the distribution of losses beyond the threshold (typically 99%) used in Value-at-Risk (VaR) analysis. They provide two vital pieces of information: the extent of potential losses in catastrophic circumstances and the scenarios in which such losses might occur. Such information is an input to decisions concerning, amongst other things, hedging, limit setting, portfolio allocations and capital adequacy.

Recent Conference on Stress Testing and Financial Crisis Simulation Exercises (European Central Bank, Frankfurt am Main 12-13 July 2007) was based through statements from the Basel Committee on Supervision. It suggests a new emphasis on stress testing. Since the end of 1997 financial institutions using internal VaR models to assess capital adequacy have been required to implement stress testing (see Basel Committee on Banking Supervision, 1996). While stress testing has been an input to capital adequacy since that time, the link has now been made more direct, i.e. „A bank must ensure that it has sufficient capital to… cover the results of its stress testing” (Basel Committee on Bank Supervision (2006), at paragraph
The Stress Testing Requirements of Basel II involves (a) plausibility: “Quantitative criteria should identify plausible stress scenarios to which banks could be exposed.” (par. 718 (LXXIX)); (b) severity: “(...) a bank should also develop its own stress tests which it identifies as most adverse based on the characteristics of its portfolio” (par. 718 (LXXXIII)); (c) usefulness: “Qualitative criteria should emphasize that two major goals of stress testing are to evaluate the capacity of the bank’s capital to absorb potential large losses and to identify steps the bank can take to reduce its risk and conserve capital.” (par. 718 (LXXIX)).

Leading industry practitioners have called for successive re-examinations of stress testing methodologies (see Rowe (2005a) and Rowe (2005b)). Another recent survey of stress testing practice (Committee on the Global Financial System, 2005) shows that most stress tests are currently designed around a series of scenarios based either on historical events, hypothetical events, or some combination of the two. They are typically selected by supervisors, directors or risk managers to reflect the particular portfolio composition or to reflect the risks perceived to be most pressing in the current environment. These methods have been criticised by Berkowitz (1999) and Greenspan (2000) for their lack of rigour, as they are typically conducted without a risk model so the probability of each scenario is unknown, making its importance difficult to evaluate.

There is also a distinct possibility that many extreme yet plausible scenarios are not even considered. Boyer, Gibson and Loretan (1999) argue that stress tests should be based on an appropriate model for the data generation process of the portfolio's returns and that stress tests conducted in the context of that model can provide a useful alternative or complement to the current ad hoc methods of stress testing. Several authors have attempted to build such a bridge between stress tests and risk models. The StressVaR method, named by Kupiec (1998) places stress tests in the context of the analytical VaR approach. The advantage of StressVaR is that the analysis takes account of links between assets, rather than focussing on a single asset in isolation. Others studies including Kim and Finger (2000), Aragones, Blanco and Dowd (2001) and Tan and Chan (2003) have developed stress tests for specific contexts such as correlation breakdown based on a variety of assumptions.

### DEFINITION AND APPLICATIONS

An underlying principle of modern financial risk management is that statistical models can be used to estimate the distribution of possible future financial outcomes, such as changes in interest rates or a firm's credit quality. Academic and practitioner research supports the view that such models characterize the probabilities of most future outcomes reasonably well. For example, as part of managing the risk of a bond portfolio, a firm could estimate the distribution of possible outcomes, say, one-day-ahead by modelling the behaviour of a set of risk factors, such as changes in interest rates that affect the portfolio's value. That estimated distribution indicates the probability that the portfolio's value will be above (or below) any given value. With that information in hand, the firm can manage its portfolio's risk exposure by setting aside capital sufficient to cover, say, 95% of possible portfolio losses arising from adverse outcomes. Such value-at-risk (VaR) analysis has become a standard risk-management tool. However, VaR models cannot incorporate all possible risk outcomes. Historical experience has shown that they cannot capture sudden and dramatic changes in market circumstances since such changes are, by definition, atypical.

To address this shortcoming, risk managers have developed "stress testing," which is a risk-management tool used to evaluate the potential impact on portfolio values of unlikely,
although plausible, events or movements in a set of financial variables. While such unlikely outcomes do not mesh easily with VaR analysis, analysis of these outcomes can provide further information on expected portfolio losses over a given time horizon. Accordingly, stress testing is used increasingly as a complement to the more standard statistical models used for VaR analysis.

Stress testing is mostly used in managing market risk, which deals primarily with traded market portfolios. These portfolios include interest rate, equity, foreign exchange, and commodity instruments and are amenable to stress testing because their market prices are updated on a regular basis. Stress-testing applications have expanded to considering credit risk in loan portfolios as well as the impact of sudden interest rate changes on firms' funding sources.

In addition to providing a "reality check" on VaR models, stress testing has been found to be an effective communication tool between a firm's senior management and its business lines. The communication advantage that stress tests have over VaR analysis is their explicit linking of potential losses to a specific and concrete set of events. That is, stress tests can be thought of as exercises based on a unique set of outcomes for the relevant risk factors—interest rates change by a certain number of basis points, the U.S. dollar depreciates by a certain percent, and so on. In contrast, in the VaR framework, there is no unique configuration of the underlying risk factors that is identified with the value of, say, a portfolio falling below a given level. Again, however, stress tests and VaR analysis provide different information and are considered to be complementary.

TECHNIQUES FOR STRESS TESTING

Stress-testing techniques fall into two general categories: sensitivity tests and scenario tests.

Sensitivity tests assess the impact of large movements in financial variables on portfolio values without specifying the reasons for such movements. A typical example might be a 100 basis point increase across the yield curve or a 10% decline in stock market indexes. These tests can be run relatively quickly and are commonly used as a first approximation of the portfolio impact of a financial market move. However, the analysis lacks historical and economic content, which can limit its usefulness for longer term risk-management decisions.

Scenario tests are constructed either within the context of a specific portfolio or in light of historical events common across portfolios. In a stylized version of the specific portfolio approach, risk managers identify a portfolio's key financial drivers and then formulate scenarios in which these drivers are stressed beyond standard VaR levels. For the event-driven approach, stress scenarios are based on plausible but unlikely events, and the analysis addresses how these events might affect the risk factors relevant to a portfolio. Bank of England uses two macroeconomic scenarios (based on events for historical scenarios): (1) Recession in line with the situation in 1990, adverse condition/event affects the supply side negatively and this leads to increasing interest rates and inflation; (2) Fast global increase in interest rates and risk premiums. Other commonly used events could be the Asian financial crisis of 1997, financial market developments following the September 11, 2001, terrorist attacks in the United States, the US sub-prime crises in mortgage portfolios.

The choice of portfolio-based or event-based scenarios depends on several factors, including the relevance of historical events to the portfolio and the firm resources available for conducting the exercise. Historical scenarios are developed more fully since they reflect an actual stressed market environment that can be studied in great detail, therefore requiring
fewer judgements by risk managers. Since such events may not be relevant to a specific portfolio, hypothetical scenarios that are directly relevant can be crafted, but at the cost of a more labour-intensive and judgmental process. Hybrid scenarios are commonly used, where risk managers construct scenarios that are informed by historical market movements that may not be linked to a specific event. Historical events also can provide information for calibrating movements in other market factors, such as firm credit quality and market liquidity. More generally, risk managers always face a trade-off between scenario realism and comprehensibility; that is, more fully developed scenarios generate results that are more difficult to interpret.

Recent market events have highlighted the importance of stress testing within banks and other financial services organisations. There are several key themes in the initial lessons learned from recent market turmoil:

- Senior management involvement: It is essential that senior management are involved in overseeing a comprehensive and coordinated stress and scenario testing programme. Governance, resourcing and methodology (including ongoing review) are all important for achieving high quality and relevant stress and scenario analysis. Senior management engagement is a necessary condition for integration of stress testing into business, risk and capital decisions and encourages more thorough exploration of tail risks as well as milder adverse scenarios.

- Contagion: It is important for firms to pursue more thorough analysis of risk transmission and contagion mechanisms (including ripple and reinforcing effects from a primary stress scenario extending to other markets or products) and also to better reflect how risk correlations may vary in stressed conditions.

- Firm-wide holistic view: Firms should be able to conduct stress and scenario testing that helps them identify and assess risks at a firm-wide level. A firm’s stress testing programme should be holistic in terms of risk capture and coverage. A firm needs to be able to carry out stress testing at different levels (for example also at business unit, or business line, level) and to bring together top-down and bottom-up risk assessment in a coherent manner.

- Liquidity stresses: Contagion from a liquidity stress situation in one market may spread across multiple markets, and as well as affecting firms’ liquidity positions may ultimately also expose firms to capital stresses, including those arising from pipeline transactions which cannot be distributed as planned in conditions of decreased demand, and off-balance sheet exposures which are re-assumed.

**CENTRAL BANKS STRESS TESTING INITIATIVES AND PURPOSES**

Central banks monitor the current condition and risk exposures of individual financial institutions. Hence, supervisors now generally work to understand and assess whether institutions' risk-management systems actually measure and assist managers in controlling the relevant financial risks. Although risk-management systems vary widely across financial institutions, supervisors have worked to set forth general principles that are widely applicable; for example, see the Trading and Capital Market Activity Manual of the Federal Reserve System (2003) and also Systemic Risk Monitor: Risk Assessment and Stress Testing for the Austrian Banking System (2006). Central banks are also concerned that institutions monitor their risk exposures with appropriate reference to unlikely events that could cause portfolio losses. Furthermore, they are interested in ensuring that stress testing procedures are detailed in the firm’s risk-management policies and that senior management actively uses the
information, for example, in setting trading limits. As highlighted in the Committee on the Global Financial System survey (CGFS 2005), some supervisory concerns remain, including the need to improve credit and liquidity risk stress testing as well as the need to integrate market and credit risks across the institution.

In addition to assessing firms' risk-management practices, supervisors have developed stress-testing tools for their own monitoring purposes. Some uses a stress-testing model to identify depository institutions that are potentially vulnerable to real estate markets. The models can be also used to detect banks that would appear to be the most vulnerable to rising interest rates.

Banking supervisors have recently been developing similar tools for assessing national financial systems overall. For example, macroeconomic stress-testing techniques, as surveyed by Sorge (2004), are used to assess the vulnerability of a financial system to exceptional, but plausible, macroeconomic shocks. These stress tests have become an important component of the Financial Sector Assessment Programs (FSAPs) initiated by the International Monetary Fund in the late 1990s and conducted by national policymakers. There are two main methodological approaches here. The piecewise approach evaluates the vulnerability of the financial sector to individual risk factors, such as nonperforming loan ratios, by forecasting their behaviour under various macroeconomic stress scenarios. The integrated approach analyzes the sensitivity of the financial system to multiple risk factors by generating a distribution of aggregate portfolio losses that could occur under macroeconomic stress scenarios.

There has been a great deal of buzz lately surrounding the bank stress tests administered in the U.S. 19 of the largest banks was considered, and 10 of them were found to be in need of capital. While the debate over the meaningfulness and effectiveness of the U.S. stress tests continues, the European Union has announced its own stress test intentions. However, the European Union plans to conduct its bank stress tests differently. Instead of singling out individual institutions and telling them that they need cash, the EU plans to conduct an industry wide look at the health of the financial system. That way, it is expected that an overall view of the euro zone's banking system will be obtained. Britain has already administered bank stress test; before insuring the risky assets of Lloyds and RBS, the British government conducted stress tests. These tests were used to determine whether the banking institutions were worth saving. In the U.S., it came out that the analysis of the bank stress tests was changed to reflect more favourably on banks. The European bank stress test results should be ready by September, in the hopes that the information will be helpful for junior finance ministers and central bank representatives at their autumn meeting.

CONCLUSION

Stress and scenario testing should form a key part of a suite of tools used by a firm's senior management in making integrated business strategy, risk management and capital planning decisions. Recent market events have shown the importance of strong governance in firms. Senior management at less affected firms had more successfully established comprehensive firm-wide risk assessment processes in which thoughtful stress and scenario testing played a material part, allowing better-informed and more timely decision-making. Hence, stress testing may be increasingly used by financial firms for both internal and external purposes.

In order to achieve the EU objectives in an effective and efficient manner, stress and scenario testing precede the arrangements for crisis management. The resolution should be
consistent with the arrangements for crisis prevention, including financial stability monitoring and assessment. This entails a need to explore thoroughly how to strengthen cooperative arrangements for financial stability especially, but not exclusively, in the increasingly integrated European financial system which, however, is characterised by institutional arrangements in which authorities have an essentially national responsibility and accountability.

REFERENCES