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Stress Tests: Useful Complements to Financial Risk Models

Risk-management practices at financial institutions have undergone a quantitative revolution over the past decade or so. 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. However, models 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. In this *Economic Letter*, I define stress testing, describe its possible applications, highlight certain techniques developed to conduct this testing, and survey its recent use by supervisory agencies.

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 modeling the behavior 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. A survey of financial firms by the Committee on the Global Financial System (CGFS, 2005) found that more than 80% of stress tests were applied to traded portfolios and that interest rate movements are the basis for most of them; however, 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. Commonly used events for historical scenarios are the large U.S. stock market declines in October 1987, the Asian financial crisis of 1997, the financial market fluctuations surrounding the Russian default of 1998, and financial market developments following the September 11, 2001, terrorist attacks in the United States.

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 labor-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.

With respect to credit risk, stress testing is of two main types: stress testing of credit spreads, such as corporate bond spreads, in trading portfolios and the less frequent stress testing of loan portfolios. Stress testing credit spreads in trading portfolios is reasonably straightforward and more directly related to market risk analysis. For stress testing of loan portfolios, variables such as borrower credit ratings and collateral values are stressed, often using scenarios based on shocks to the macroeconomy. Although based on a common source of risk, efforts to integrate credit risk stress tests for both trading and loan portfolios have been hindered by several factors, such as differences in accounting treatment and a lack of trading in certain credit instruments. At an even more basic level, many firms lack sufficient historical data for such analyses as well as the system infrastructure to generate integrated credit risk profiles.

Supervisory issues and uses

Supervisors of financial institutions 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). With respect to stress testing, supervisors are 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 CGFS survey, 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. As summarized by Collier et al. (2003), the Federal Deposit Insurance Corporation uses a stress-testing model to identify depository institutions that are potentially vulnerable to real estate markets. The model is calibrated to the New England real estate crisis of the early 1990s, which caused the closure of several depository institutions. With regard to interest rate risk, the Federal Reserve System maintains a duration-based valuation

model that examines the impact of a 200-basis-point increase in rates on bank portfolio values; see Sierra and Yeager (2003). The model can be used to detect banks that would appear to be the most vulnerable to rising interest rates.

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 behavior 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.

Hoggarth et al. (2004) summarize the FSAP for the United Kingdom. Their macroeconomic scenarios were derived using the Bank of England's own macroeconometric model and were supplied to ten large domestic banks as inputs to their own assessments. For example, one stress scenario was based on the macroeconomic impact of a 35% decline in global stock prices; another scenario was based on a 12% decline in domestic real estate prices; the magnitudes for these hypothetical macroeconomic scenarios were consistent with the range of historical estimates and broadly corresponded to movements that tended to occur with less than a 1% probability. FSAP provided UK policymakers with evidence supporting the stability of their banking system with respect to a wide range of plausible adverse shocks.

Conclusion

Stress testing is an appealing risk-management tool because it provides risk managers with additional information on possible portfolio losses arising from extreme, although plausible, scenarios. In addition, stress scenarios can often be an effective communication tool within the firm and to outside parties, such as supervisors and investors. In fact, the U.S. banking firm JP Morgan Chase provided internal stress-testing results in its 2003 and 2004 annual reports to investors. Hence, stress testing may be increasingly used by financial firms for both internal and external purposes.

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