

Date: February 26, 2007  
To: Board of Governors  
From: Andrew Huszar (FRBNY)  
Subject: Stress Testing Horizontal Background Paper for the March FSR

The goals of this memorandum are to provide some background on the theory, mechanics, and mandates of stress testing, and to offer insights on the practical implementation of such testing by firms.<sup>1</sup> The memorandum is divided into three sections: "Background," "Results of the Recent Federal Reserve System Horizontal Review of Stress Testing Practices," and "Supervisory Assessment." Those generally familiar with the theory and practice of stress testing may wish to skip ahead to the discussion of the horizontal review, which begins on page 6.

## I. Background

**A. Definition and Characteristics of Stress Testing.** Stress testing is a generic term that refers to risk management techniques designed to examine the consequences of extreme but conceivable scenarios. Stress testing typically involves testing a process beyond normal capacity, often to a breaking point, to evaluate inherent stability.<sup>2</sup>

The focus and design of stress tests may vary significantly depending on the perspective and objectives of the party conducting them. At financial institutions, stress testing normally addresses the financial consequences of extreme market moves or operational disruptions, encompassing such risk dimensions as market risk, funding liquidity risk, credit risk, and (increasingly) operational risk. Products or portfolios may be individually or collectively exposed to any number of consistent and coherent market and/or non-market risk factor shocks. As a result, stress testing may serve as a valuable diagnostic tool for an institution wishing, for example, to assess and potentially recalibrate firm policies and/or risk exposures.<sup>3</sup>

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<sup>2</sup> Committee on the Global Financial System, *Stress testing at major financial institutions: survey results and practice*, Basle, January 2005, page 3 ("CGFS"). This document can be downloaded at <http://www.bis.org>.

<sup>3</sup> See CGFS, page 5.

Stress testing often acts as a complement to other risk measurement techniques. For example, in the context of market risk measurement, a statistical model such as “value at risk” (“VaR”) is often used in the initial quantification of risk. Stress testing may then be employed to capture and quantify the impact of scenarios that fall outside the confidence intervals of the VaR analyses. Additionally, stress testing may offer insight on the direction of vulnerability and permit greater customization of parameters, such as, among others, changing embedded historical correlations across risk factors, altering the distributional assumptions used in calculating the VaR, or serving as a specific alternative to the VaR’s “past as prologue” approach.

There are four basic steps to formulating and utilizing a stress test. First, a firm must decide which risk factors or combination of risk factors should be stressed (for example, market risk factors may include volatility levels, implicit correlation coefficients, and variations in interest rates, interest rate spreads and/or exchange rates, among others; non- or quasi-market factors may include, among others, counterparty credit risk, liquidity risk both in the context of instruments’ market liquidity and firms’ funding liquidity, and any number of concentration risks, such as to industries or regions). Second, the firm must decide the degree to which these risk factors will be stressed. Third, the firm must calculate the resulting impact of these stresses on the financial measure of interest (generally, profits), which will rely importantly on underlying aggregation assumptions. Fourth, the firm must interpret the results and formulate a potential response.

Stress tests are commonly seen to fall into two overlapping categories: sensitivity tests and scenario tests:

Sensitivity tests are typically more basic and thus used as the building blocks for scenario tests. Sensitivity tests involve determining the impact on a portfolio’s value of a series of predefined moves in one particular market risk factor or in a closely aligned set of risk factors. Sensitivity tests consider a risk factor or set of risk factors in isolation, with all others held constant. In a common type of sensitivity test, risk parameters are moved instantaneously by a specific amount, such as a ten percent decline or a ten basis point rise. These tests can be run relatively quickly to approximate the impact of such a move. As a result, sensitivity tests are widely used at the trading desk and business line level.<sup>4</sup>

A second group of sensitivity tests examines historical movements in a number of factors. These tests can take several forms. One form is based on worst-case movements for particular risk factors over a given historical period (*e.g.*, the worst change in the last ten years for interest rates and equities). This test is objective and provides a maximum loss, but the unrealistic combination of risks – the time periods for each risk factor do not have to be coincident – may result in a loss that is overly pessimistic. An alternative uses a historical data set over a fixed period to determine what actual, previous movements in risk factors would result in the largest loss for a portfolio, thereby taking into account observed market and price correlations. A variation on this technique is to specify a

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<sup>4</sup> See CGFS, page 8.

movement in one risk factor, but then to derive movements in other factors using correlations measured during normal periods. These methodologies provide a less pessimistic assessment, but they do not address the possible breakdown of historical patterns during stress situations. To address this limitation, some firms base their correlation patterns on a recently stressed period.<sup>5</sup>

In contrast to sensitivity tests, scenario tests expose a discrete set of financial risk parameters to a well-defined source of shock, or “stress event.” Scenario stress tests are generally based on either a portfolio-driven approach or an event-driven approach. In a stylized version of the portfolio-driven approach, key risk managers in a firm initially identify the vulnerabilities in the portfolio and formulate plausible scenarios under which these vulnerabilities are stressed. For firms that identify interest rate risk as their main vulnerability, for example, stress tests are formulated around movements in interest rates. Alternatively, in event-driven scenarios, the test is formulated based on credible events, such as a run-up in oil prices, to assess how the relevant risk factors in a firm’s portfolio may be affected. Correlations across asset classes are normally implicit, although some firms will also examine the implied correlations in order to ensure the results are not overly conservative.<sup>6</sup>

The scenarios employed may be classified as either historical or hypothetical. The choice depends on a number of factors, including contemporary relevance and resources (particularly, time and labor). While potentially outdated as a contemporary business prism, historical scenarios tend to be more fully articulated as they leverage actual market conditions and therefore involve fewer judgments by risk managers. By contrast, hypothetical scenarios are potentially more relevant to the risk profile of the firm and more readily permit modeling of “contagion” effects that reveal risk interactions within a portfolio, but they are labor-intensive and involve considerably more judgment and management- and business-level support. In practice, hybrids are quite common, *i.e.*, hypothetical scenarios that are informed by historical market moves but not necessarily linked to a specific crisis.<sup>7</sup>

With respect to implementation, firms’ stress testing will generally be conducted both at the business line and at the corporate, senior management (“corporate”) level. The designs of the stress testing performed at these two levels, however, may diverge considerably. Business line stress testing will typically be narrower in scope and specifically focused on a product or a portfolio. For example, in the market risk context, it may be used to assess the ongoing validity of a particular limit structure. On the other hand, corporate stress testing, which is often motivated by the desire to develop and maintain a more overarching perspective on a firm’s risks, normally addresses firm-wide vulnerability to systemic risk factors, such as interest rate levels, credit spreads, and exchange rate changes.

Nonetheless, given current IT system limitations and the varying degrees of

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<sup>5</sup> See CGFS, page 8.

<sup>6</sup> See CGFS, pages 6-8.

<sup>7</sup> See CGFS, pages 6-8.

evolution in the stress testing for different types of risk, stress testing at the corporate level remains fairly divided by risk type, with varying approaches and degrees of evolution for the different risk dimensions. For example, as will be explored below, general market risk measurement and stress testing practices differ conceptually and computationally from those for credit risk.

**B. Supervisory and Regulatory Requirements for Stress Testing.** Stress testing has traditionally played a role in the supervisory oversight of banking organizations, an element both in the assessment of an institution's safety and soundness and of requirements contained by various regulations, such as those established by risk-based capital rules.

From a safety and soundness perspective, supervisors have generally included the use of stress testing as a critical component of sound risk management practices. Indeed, many traditional financial ratios used by supervisors and market analysts are, in concept, reduced-form stress test measures. Correspondingly, by way of another example, the U.S. bank supervisory agencies have long maintained that contingency funding plans that compare an institution's funding sources to its funding needs are integral parts of a satisfactory liquidity risk management framework.<sup>8</sup> Over the past twenty years, supervisory guidance on safe and sound risk management practices for investment, trading, and derivative activities and for managing interest rate risk and various types of credit risk have emphasized the importance of stress testing in the context of what may be characterized generally as a principles-based approach by U.S. bank supervisory agencies.

From a regulatory standpoint, one must highlight the rules for assessing capital for the market risks of trading activities, as specified by the "Amendment to the Capital Accord to Incorporate Market Risk," otherwise known as the "Market Risk Amendment" ("MRA").<sup>9</sup> These regulations permit U.S. banks to use their own internal models for capital adequacy measurement if they comply with a specified set of conditions. Under these rules, stress tests are to be evaluated by examiners on both quantitative and qualitative bases. The quantitative criteria require identification of plausible stress scenarios to which banks could be exposed. The qualitative criteria emphasize that two major goals of stress testing are to evaluate the capacity of the bank's capital to absorb potentially large losses and to identify steps the bank can take to reduce its risk and conserve capital. The guidance associated with these rules establishes that supervisory authorities may require banks to provide information on stress testing in three broad areas: first, the largest losses experienced during the reporting period available for supervisory review; second, the results of any and all simulated stress scenarios to which banks subject their portfolios; and, third, the rationale for the stress tests that banks have

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<sup>8</sup> The agencies articulated these elements when they established the 1979 Uniform Financial Institutions Rating System Uniform Financial Institutions Rating System (Federal Financial Institutions Examination Council, November 21, 1979). The Uniform Financial Institutions Rating System ("UFIRS") was re-issued on December 19, 1996.

<sup>9</sup> These Federal Reserve System regulations are located in 12 C.F.R. 208 (with reference to state banks) and 12 C.F.R. 225 (with reference to bank holding companies).

developed and explanations as to why a particular design may highlight the most adverse result, based on portfolio characteristics. Finally, banks are required to have their stress testing results reviewed periodically by senior management and to have results reflected in the banks' policies and limits.<sup>10</sup>

**C. Limitations of Stress Testing.** There are both theoretical and practical limitations to stress testing:

From a theoretical standpoint, two central limitations of stress testing derive from the subjectivity of its design and its inability to assign probabilities to outcomes. Regarding subjectivity, the "extreme but plausible" event intended to be addressed by stress testing is inherently challenging to design. For example, the choice of a particular historical scenario, such as the 1987 U.S. equity markets crash, suffers from the same "past as prologue" limitations as VaR calculations. Furthermore, the underlying aggregation assumptions of such a scenario may vary dramatically from one bank to another due to differing risk managerial judgment regarding this scenario's likely impact, for example, on a novel class of financial instruments or a newly evolved market. Similarly, the development of a hypothetical scenario depends heavily on individual judgment and experience, as does the evaluation of which specific results can provide management with useful insight.

Regarding the issue of probability, stress testing can provide detailed insight into the potential impact of a "tail" stress event, but limited information on the likelihood of its occurrence. In this context, we do note an evolving, but still embryonic, effort by certain firms to address this probability quandary by developing historical scenarios based on events such as the "worst in a year" or the "worst in ten years" moves. A related point here is that most stress testing is not dynamic and thus does not account for the "knock-on" effects of a stress event or the firm's accompanying response, thereby either potentially under- or over-estimating the impact of the event.

The practical limitations of stress testing reflect principally the broader context of the particular firm in which it is conducted. First, since stress testing is performed both at the business line and corporate levels and these hierarchies possess differing objectives and perspectives, the use and design of stress testing across firms may diverge significantly yet not be adequately considered in combination. Second, as mentioned earlier, given current IT system limitations and the varying degrees of evolution of stress testing for different types of risk, stress testing results within a firm may remain separated by risk dimension or portfolio. As a result, consideration of risk exposures or interrelationships may be incomplete due to the absence of sufficient integration.<sup>11</sup> Finally, because stress testing is perceived by firms to be complementary to their principal risk measurement tools, cost is a key issue. In this vein, expanding stress testing programs or developing "ad hoc" scenarios usually requires "buy in" from several

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<sup>10</sup> The Basel document can be downloaded at <http://www.bis.org>.

<sup>11</sup> Complementary considerations in this context are the historic separation of banks' accrual and trading books and the hurdles to developing firm-wide stress tests presented by differences in accounting treatments and/or organizational structures.

constituencies. Pragmatically speaking, the overall level of philosophical commitment by an organization to the value of stress testing will normally drive the overall quality and comprehensiveness of its stress testing.

Given the absence of universally mandated benchmarks or standards for stress testing, as well as these theoretical and practical limitations, the architectures of different firms' stress testing regimes are idiosyncratic, reflecting the individual firms' objectives and choices.

## **II. Results of the Recent Federal Reserve System Horizontal Review of Stress Testing Practices**

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**III. Supervisory Assessment**

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