FEDERAL RESERVE BANK OF NEW YORK

CURRENT ISSUES IN ECONOMICS AND FINANCE

November 2001 Volume 7 Number 10

An International Survey of Stress Tests

Ingo Fender, Michael S. Gibson, and Patricia C. Mosser

In the summer of 2000, central banks from the Group of Ten countries surveyed large international banks about their use of stress tests—a risk management tool that measures a firm's exposure to extreme movements in asset prices. The survey findings highlight the risks that most concern financial institutions and clarify how these institutions use stress tests in their overall risk management programs.

In recent years, large financial institutions have made stress tests a key tool in assessing the sensitivity of their businesses to sharp changes in asset prices. Like other risk measurement tools, stress tests gauge how the value of an institution's portfolio of securities and derivatives will be affected by large movements in, say, stock prices or exchange rates. What sets stress tests apart from similar tools, however, is their ability to measure directly how a particular economic or financial event—typically an extreme event such as a stock market crash—will affect the profitability of an institution's portfolio at a specified point in time.[1]

Stress tests are of considerable interest to central banks because many of the tests used by financial institutions simulate the effects of the large financial shocks that can undermine the normal functioning of markets and impair market liquidity. To shed light on such events and to identify the risks of greatest concern to financial institutions, central bank representatives from the Group of Ten (G-10) countries in the summer of 2000 conducted a survey of stress tests used by large international financial institutions. In this edition of *Current Issues*, we provide an overview of the survey and summarize its principal findings. The complete report, *A Survey of Stress Tests and Current Practice at Major Financial Institutions*, is available from the Committee on the Global Financial System (CGFS 2001).

The survey results reveal much about banks' risk concerns. Although stock market crashes and emerging market crises are the most common scenarios tested, the risks covered by the stress tests span all major asset classes and all geographic areas. Moreover, despite broad similarities in the types of risks tested, individual stress test scenarios often differ markedly across banks, suggesting that risk managers tailor their scenarios to their banks' positions, business lines, and risk appetite.

The survey findings also cast light on the role of stress tests in risk management. Banks rely on stress tests to assess exposures in those asset markets where illiquid conditions and poor historical data make the use of other risk measures difficult. In addition, risk managers see stress tests as an effective means of communicating risks to bank senior management.

What Are Stress Tests?

Stress tests are designed to answer such questions as "If the stock market falls 20 percent, how much will the value of my firm's portfolio of securities, loans, and derivatives change?" or "If U.S. interest rates increase 100 basis points, how much will the value of my firm's portfolio rise or fall?" In conducting firm-wide stress tests, banks measure the impact of such extreme changes, or "shocks," across all their business lines and trading operations.

The two most common types of stress tests are *sensitivity stress tests* and *stress test scenarios*. A sensitivity stress test measures the impact on a portfolio's value of a large change in a particular asset price or in a small number of tightly linked asset prices. One of the standard sensitivity stress tests used by risk managers measures the

effect of a parallel shift in the yield curve—that is, an identical change in the yields on short- and long-term bonds. The survey findings regarding sensitivity stress testing are discussed in detail in CGFS (2001).

A stress test scenario—the chief focus of this article—is more complicated. This type of stress test measures the effect on a firm's portfolio of simultaneous extreme moves in several different asset prices—for example, equity prices, exchange rates, interest rates, and interest rate spreads. It can be based on a significant market event in the past (a historical scenario) or on a plausible market event that has yet to happen (a hypothetical scenario).

Stress tests are considered complements to firms' other risk management tools, particularly value-at-risk (VaR) models. VaR models provide a statistical measure of the maximum loss in value that a firm's portfolio is likely to sustain over a given time horizon as a result of changes in market prices or rates.[2] Because VaR models use average historical correlations among asset prices to make such statistical assessments, they have limited ability to capture the risks of exceptional market events, especially those in which asset prices move in ways that differ sharply from historical norms. In contrast, stress tests are designed to mimic specific large market shocks, independent of statistical relationships. Thus, stress testing requires risk managers to make informed judgments about the appropriate design and plausibility of different stress test scenarios.

Purpose and Scope of the Stress Test Survey

In 2000, the Committee on the Global Financial System, a group established by the G-10 central bank governors to discuss issues related to financial market stability, formed a task force to conduct a census of stress test scenarios.[3] The task force had three goals: to learn more about the role of stress testing in risk management, to identify the exceptional financial and economic events considered by market participants to pose significant risks to profitability, and to develop information on the heterogeneity of risk taking across banks at a point in time.

The survey asked risk managers of financial institutions to list the most important stress test scenarios run for all business lines and positions of the firm. In addition, for each firm-wide scenario, risk managers were asked to identify the key risk factors or asset prices. Lastly, the survey asked several questions about how the firms conduct stress tests and how they use their results in their overall risk management systems.[4] In follow-up interviews, risk managers from several of the reporting institutions commented on survey results and clarified their responses.

Forty-three commercial and investment banks from ten countries participated in the census; they reported 293 stress test scenarios. To facilitate peer group comparisons, the CGFS task force divided reporting banks into two groups. "Global dealer banks" comprise nineteen institutions active worldwide as market makers trading in all types of financial instruments, including derivatives. "Other internationally active banks"—the remaining twenty-four institutions—regularly conduct business outside their home country but generally focus on a limited set of markets.[5]

We note two caveats regarding the census results. First, although banks stress-test what they regard as *important* risks, they have many different reasons for judging a particular risk to be important. For example, a bank might use a stress test to monitor those markets or business lines in which it has a very large exposure, to monitor hedge positions that it considers vulnerable to extreme market movements, or to ensure that it is not exposed to a particular extreme financial event. Thus, a bank's stress tests are related to its asset and derivatives positions, but are not mirror images of them. In addition, stress tests do not necessarily reflect a bank's perception of the likelihood of a given event.

Second, the results present a portrait of stress tests in use on May 31, 2000. Because market conditions and banks' exposures have changed since then, the stress tests in use at the reporting institutions have undoubtedly evolved. However, respondents noted that firm-wide stress tests are reviewed frequently but changed infrequently. One reason for this practice is that repeating stress tests on a regular basis is considered a useful way to monitor how a firm's exposure changes over time.

What the Survey Shows about Bank Perceptions of Risk

The 293 stress test scenarios reported by the banks fall into nine broad categories or "themes." Four of these themes relate to events within particular asset markets—equities, interest rates, credit spreads, and commodities. The scenarios associated with these themes typically center on a shock to market rates or prices. Another four themes relate to events in different geographical areas—Europe, Japan, North America, and the emerging market countries. These scenarios tend to center on conditions such as a sustained currency appreciation or market-wide stress within countries. The final theme, designated "other," encompasses a variety of scenarios, many reflecting volatility shocks to options markets.

A breakdown of the scenarios by theme highlights the risks that most concern financial institutions as a group (Chart 1). We measure the prevalence of each theme in two ways—by the number of banks running one or more stress tests for that theme and by the total number of scenarios tested for the theme. When the number of banks is the measure, the four most common themes for stress testing are equity prices, interest rates, emerging markets, and credit or liquidity spreads. The results are similar when the total number of scenarios is the measure, except that emerging markets is the most prevalent theme.

If we compare the stress test themes favored by the two groups of reporting banks, some differences emerge (Chart 2). Global dealer banks place particular emphasis on scenarios focusing on equities, emerging markets, and credit or liquidity spreads. While other internationally active banks also emphasize such scenarios, they accord noticeably greater importance to scenarios relating to interest rates, Europe, and Japan than do the global dealer banks. These differences may reflect the nature of risk taking at the two groups of institutions. Banks operating in a limited number of foreign markets are likely to favor interest rate scenarios because their risk exposures are more closely linked to traditional banking businesses; similarly, these banks are likely to choose regional stress scenarios because their exposures are often tied to their home markets.

A more detailed breakdown of the survey data provides additional information about the banks' risk concerns. Table 1 lists specific types of scenarios within each theme and reports the frequency with which each type was tested. In this accounting, the most common scenarios are Black Monday 1987 (run by twenty banks), a widening of spreads in credit markets (fifteen banks), and a hypothetical stock market crash (thirteen banks).

The numbers in the table also show that financial institutions see their risks as asymmetrical. That is, banks are much more likely to stress-test crashes in equity prices and emerging markets than to test booms. Similarly, banks tend to stress-test increases in interest rates and credit or liquidity spreads more often than decreases. Only the foreign exchange rate stress tests are more balanced.

In the follow-up interviews arranged by the CGFS task force, risk managers at reporting banks gave three reasons for treating risks asymmetrically. They noted that in the interest rate and credit areas, banks have asymmetric exposures because of the nature of their business: an increase in interest rates or credit spreads will generally reduce bank profitability. In addition, risk managers suggested that asymmetries may reflect a bank's view that a particular market event is more likely in the near future. For example, some managers chose to run an equity crash scenario in May 2000 because equity market valuations were at historically high levels. A final reason cited for the asymmetry of the scenarios is senior managers' interest in ensuring that their institution is not exposed to the particular stress events they have experienced personally.

The high incidence of certain scenarios also suggests that banks rely heavily on stress tests to uncover risks that might escape detection by a statistical risk measure such as VaR. For example, the 1994 global bond market crash (stress-tested by nine banks) involved a common upward movement in government bond yields in the United States, Europe, and Japan. Because bond yields in these markets are not tightly linked in normal times, a VaR model using historical correlations could not quantify the risk associated with such an event.

In the follow-up interviews, risk managers gave additional reasons for preferring stress tests to statistical measures as a tool for assessing certain kinds of risk. They suggested that stress tests may be usefully applied to markets that lack good historical price data for conducting statistical tests or markets in which illiquid conditions produce asset price jumps and impede securities trading during times of stress.[6]

For these reasons, emerging market risks are well suited to stress testing, and indeed, a large number of emerging market scenarios are reported in the survey. Although only twenty-four banks run emerging markets scenarios, banks that do perform the tests tend to run multiple scenarios across several different regions.

Chart 1
Stress Test Scenarios, by Theme

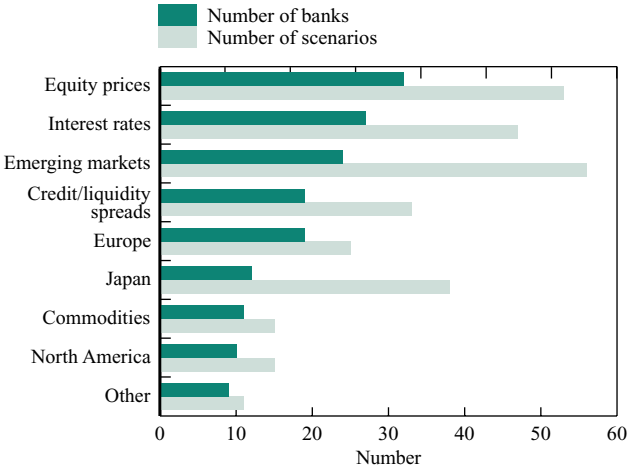
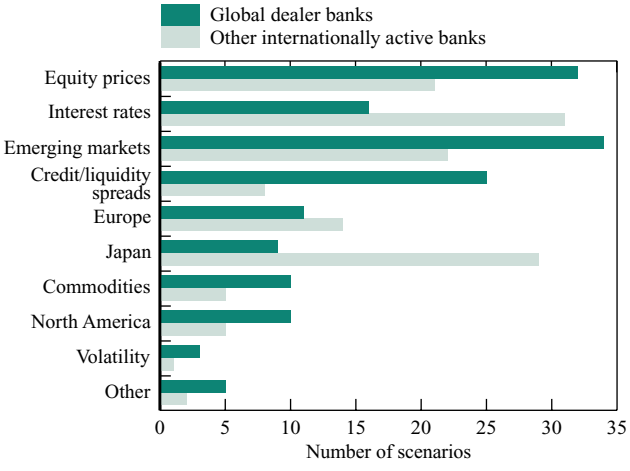


Chart 2
Stress Test Scenarios, by Peer Group and Theme



Consider, for example, the "country risk" scenarios. These scenarios track a bank's exposure to a stress event in a single emerging market (country or region) with shocks across multiple asset classes—a sovereign bond spread, an exchange rate, and, less frequently, an equity index. Each bank that reported a country risk scenario ran it for multiple emerging markets, with several institutions reporting that they base their country risk limits on the results of such stress tests. Although the table reports seven banks running nine such scenarios, the total number of stress tests would be much higher if all country risk scenarios were counted for each emerging market individually.

Table 1
Firm-wide Stress Test Scenarios

	Number of Banks	Number of Scenarios
Equities	32	53
Black Monday 1987	20	20
Hypothetical stock market crashes	13	13
New Economy scenarios*	5	13
Other*	6	7
Interest rates	27	47
Other historical interest rate increases	9	16
Bond market crash 1994	9	9
Global tightening	6	7
U.S. tightening	5	5
Other historical interest rate declines	3	5
Other*	5	5
Emerging markets	24	56
Asia*	12	14
Latin America*	8	16
Country risk*	7	9
Russia*	7	8
Eastern Europe	4	4
Global emerging markets crises	3	4
Other	1	1
Credit	19	33
Spread widening*	15	22
Fall 1998	8	9
Other	2	2
Europe	19	25
European stress 1992	11	11
European stress/weak Euro	5	5
European divergence	4	5
European boom/strong Euro	4	4
Japan	12	38
Interest rate increase scenarios*	5	11
Japan market-wide stress*	5	7
December 1998	4	4
Strong yen	4	6
Other*	4	10
Commodities	11	15
Middle East crisis*	7	8
Commodity stress	5	7
North America	10	15
Weak dollar*	7	8
Strong dollar*	3	3
U.S. market-wide stress	3	3
Other	1	1
Other	9	11
Volatility disruption	3	4
Total		293

Notes: Scenarios based on historical events are in italics. An asterisk indicates a mix of historical and hypothetical scenarios.

Variations in Stress Testing across Institutions

One of the striking findings of the survey is that the magnitude of shocks used in stress testing varies substantially among scenarios that on the surface look quite similar. For example, the Black Monday 1987 scenarios reported in the survey include declines in the S&P 500 stock price index that range from 4 percent to 36 percent (the median decline was 23 percent). In addition, cross-market effects assumed within the 1987 stock market crash scenarios vary widely. Only half of the scenarios include shocks to interest rates, and of those, 60 percent include declining interest rates and 40 percent include increasing rates. Similarly, only a few institutions include equity volatility shocks as a part of their stock market crash scenarios.

Risk managers suggested several reasons for the large degree of heterogeneity in stress testing. Banks' use of different time horizons to define stress events—one day, two weeks, or peak-to-trough[7]—leads to different shock sizes even for historical scenarios, and to different assumptions about cross-market shocks. In addition, the diversity in cross-market effects across similar scenarios may reflect differences in the underlying portfolios and business lines of financial institutions. For example, because the equity options market is dominated by a small number of firms, only those firms with volatility exposure choose to include equity volatility shocks in their equity crash scenarios.

The Role of Stress Tests in Risk Management

How do financial institutions use stress tests in risk management? The CGFS survey represents the first effort to investigate this question on a broad international scale.

The survey responses indicate that stress testing is a standard risk management technique for the reporting institutions (Table 2). All the banks use stress tests to understand their risk profiles and to communicate their risks to senior management. Information obtained in the follow-up interviews suggests that senior managers generally examine the results of stress testing at regular high-level "risk committee" meetings. About half the banks use stress tests to conduct contingency planning for times of market stress. One-quarter or fewer use stress tests to allocate capital across business lines or to monitor liquidity risk for a particular asset class.

A majority of the reporting banks use stress tests to set limits on the size of trades and asset positions, and most have adjusted trading positions in accordance with the stress test results. Global dealer banks, with the largest trading and derivatives operations, are more likely to use stress tests in this way.

In the follow-up interviews, risk managers revealed that responses to stress test results are handled on a case-by-case basis. Banks use the trading limits established through stress testing in combination with trading limits derived from other information such as the size of positions, the sensitivity of a position to price changes, and VaR model results. Risk managers reported a wide variety of responses to a breach of a stress test limit, ranging from a discussion between the risk manager and the business unit about the reason for the breach to a mandatory unwinding of positions. How a particular bank responds depends on its attitude toward stress test limits, the size of the breach, and market conditions. Even those banks that do not use "hard" trading limits based on stress tests will treat stress test results as a trigger for further inquiry.[8]

Table 2
How Financial Institutions Use Stress Tests

	Percentage Responding Affirmatively		
Survey Questions and Responses	All Banks	Global Dealers	Internationally Active Banks
How are stress test results used? (Check all that apply)			
To communicate the firm's risk profile to senior management	100.0	100.0	100.0
To understand the nature of the firm's risk profile	95.3	94.7	95.8
To set limits	60.5	78.9	45.3
To conduct contingency planning	48.8	42.1	54.2
To monitor liquidity risk	25.6	31.6	20.8
To allocate capital	18.6	21.1	16.7
Have the results of stress tests ever directly led your firm to hedge or unwind a position?			
Yes	65.1	73.7	58.3
How often are firm-wide stress tests run? (Check all that apply)			
Daily	41.9	47.4	37.5
Weekly	46.5	42.1	50.0
Monthly	51.2	42.1	58.3
Quarterly	20.9	15.8	25.0
How often are firm-wide stress test results presented to senior management? (Check all that apply)			
Daily	23.3	31.6	16.7
Weekly	39.5	47.4	33.3
Monthly	53.5	31.6	70.8
Quarterly	23.3	26.3	20.8
Which business line risks are captured by your stress tests? (Check all that apply)			
Trading book	100.0	100.0	100.0
Banking book	67.4	68.4	66.7
Offline/spreadsheet deals	32.6	47.4	20.8
Specific risk of individual securities	27.9	42.1	16.7
Do any of your stress tests allow for the interaction of market risk and counterparty (default) credit risk?			
Yes	25.6	42.1	12.5

Several risk managers emphasized that stress tests were often most informative in measuring how an institution's risk profile changes over time. Large changes in portfolio valuations produced by a given stress test from one month to the next were often considered more revealing than the actual level of the stress test result. Risk managers regard such changes as a sign that a firm's risk profile has shifted significantly enough to warrant further investigation. For this reason, risk managers change scenarios rarely, and often run the same stress test scenarios at regular intervals, even when economic and financial conditions suggest that some stress events are unlikely in the near term.

Most banks run at least some stress tests at a high frequency (daily or weekly), although in interviews, some risk managers noted that the more complicated scenarios are costly to implement and can only be run at monthly or quarterly intervals. Global dealer banks run stress tests at a slightly higher frequency than do other internationally active banks—a difference that reflects the dealer banks' more active role in trading and market making.

All banks report that stress tests are conducted across all trading operations in securities and derivatives; two-thirds report that stress tests also cover their banking book. While a minority of banks in both peer groups include offline or spreadsheet deals and the specific risk of individual securities in their stress tests, global dealer banks are more likely to capture these types of risk.[9]

One-quarter of the banks report that some stress tests allow for interaction of market risk and credit risk (the risk of counterparty default). Risk managers indicated that, at present, such interactions are limited to emerging markets and other business lines in which market risk and counterparty risk are likely to become closely linked during times of stress.[10]

Conclusion

The survey of stress test scenarios conducted by the Committee on the Global Financial System in 2000 provides information about both the types of risks that concern large financial institutions and the role of stress tests in the institutions' risk management programs:

- Stress test scenarios reflect a perceived asymmetry in risks: negative shocks (crashes) are stressed much more often than positive ones. The largest number of reported scenarios focus on equities and emerging markets.

- Despite these broad similarities, the stress test scenarios themselves are quite heterogeneous.

The array of risks assessed is large, covering every geographic region and all types of financial assets and derivatives. Scenarios vary widely across firms as well. Even apparently similar scenarios run by different firms can diverge markedly in the size of the shocks and the size and breadth of cross-market effects.

- Financial institutions rely heavily on stress tests for markets and products whose risks may be inadequately measured by statistical tools such as VaR. Stress test scenarios usually involve crises in which the historical asset price relationships used in VaR modeling break down.

- Stress tests are universally used for reporting on risks to senior management. The tests are commonly used to assess risks across the trading and lending businesses of banks, and are often used by the larger global dealer banks to set trading limits.

Notes

1. For a discussion of the use of stress testing by large international financial institutions, see CGFS (2000) and Fender and Gibson (2001).

2. For a discussion of value-at-risk models, see Hendricks (1996) or Linsmeier and Pearson (2000). VaR is a confidence interval in which losses in excess of a chosen benchmark are estimated to occur with a specified likelihood. A useful feature of VaR is that it allows the aggregation of risk across different assets and risk factors to provide estimates of the overall risk of a portfolio or institution.

3. The CGFS is chaired by Yutaka Yamaguchi, Deputy Governor of the Bank of Japan. Alain Duchateau of the Banque de France/ Commission Bancaire headed the CGFS task force.

4. The survey questions and reporting forms were developed with the aid of private-sector risk managers from several large international financial institutions. Survey responses were collected by central banks in the home country of the participating institutions.

5. Classification of the participating financial institutions was done by the central banks in their home country.

6. Some stress test scenarios also simulated extreme illiquidity by including trading constraints such as limits on the amount of an asset that a trader could buy or sell over a particular time period.

7. The different time horizons may reflect different assumptions about the availability of market liquidity in periods of stress.

8. According to risk managers, other responses to a breach of stress test limits include the adoption of a "macro hedge" at the firm level.

9. Offline or spreadsheet deals typically represent new structured financial products that are not yet fully incorporated in a bank's risk management information systems. The specific risk of an asset is that portion of the asset's price risk that is distinct from market-wide price fluctuations. It is determined by characteristics that are unique to the issuer of the security and can be reduced or eliminated with sufficient diversification.

10. Risk managers noted that emerging market stress events precipitated by market risks could lead very quickly to credit risk problems as falling asset prices transformed previously creditworthy counterparties into poor credit risks.

References

Committee on the Global Financial System (CGFS). 2000. *Stress Testing by Large Financial Institutions: Current Practice and Aggregation Issues.* Available at <http://www.bis.org/>.

———. 2001. *A Survey of Stress Tests and Current Practice at Major Financial Institutions*. Available at <http://www.bis.org/>.

Fender, Ingo, and Michael Gibson. 2001. "The BIS Census on Stress Tests." *Risk* 14, no. 5 (May): 50-2.

Hendricks, Darryll. 1996. "Evaluation of Value-at-Risk Models Using Historical Data." Federal Reserve Bank of New York *Economic Policy Review* 2, no. 1 (April): 39-69.

Linsmeier, Thomas J., and Neil D. Pearson. 2000. "Value at Risk." *Financial Analysts Journal* 56, no. 2 (March-April): 47-67.

About the Authors

Ingo Fender is an economist at the Bank for International Settlements; Michael S. Gibson is chief of the Trading Risk Analysis Section at the Board of Governors of the Federal Reserve System; Patricia C. Mosser is an assistant vice president in the Capital Markets Function of the Federal Reserve Bank of New York's Research and Market Analysis Group.

Current Issues in Economics and Finance is published by the Research and Market Analysis Group of the Federal Reserve Bank of New York. Dorothy Meadow Sobol is the editor.