

Preface

This pamphlet is based on IMF Working Paper WP/04/127, “Stress Testing Financial Systems: What to Do When the Governor Calls,” by Matthew T. Jones, Paul Hilbers, and Graham Slack, July 2004. Citations for the studies reviewed are provided in the original paper, which can be purchased from IMF Publication Services (US\$15.00) or downloaded from www.imf.org.

Stress Testing a Financial System

The international financial turmoil of the 1990s prompted the development of new frameworks, tools, and techniques to assess the stability of financial systems. These new approaches combined the analysis of relevant macroeconomic data, structural information about the financial system, market developments, financial soundness indicators, and the degree of compliance with international financial sector standards to understand the vulnerabilities of financial systems. But what happens if an actual shock hits the system—how will the system perform? Stress tests can be used as an additional instrument in the toolbox of financial sector watchdogs to help answer such questions. This pamphlet focuses in particular on the process of stress testing, from identifying vulnerabilities, to constructing scenarios, to interpreting the results.

What Is a Stress Test?

At its simplest, a stress test is a way of revaluing a portfolio using a different set of assumptions. The results of a stress test show the sensitivity of the portfolio to a particular shock. Stress tests can be useful because for most asset markets, the history of returns does not provide sufficient information about the behavior of markets under extreme events. Stress tests complement traditional models with estimates of how the value of a portfolio changes in response to *exceptional but plausible* changes in the underlying risk factors.

In individual financial institutions, stress tests have become widely used as a risk management tool to assess a variety of risks, including market risk (losses from changes in prices or yields), credit risk (losses from borrower defaults), and liquidity risks (illiquidity of assets and depositor runs). Gradually, the techniques have been applied in a broader context, with the aim of measuring the sensitivity of a group of institutions (such as commercial banks) or even an entire financial system to common shocks. However, most stress tests applied at the system level are really only performed on a subset of institutions and often ignore many of the complex institutional links that are inherent in any financial system. Thus, it may be more appropriate to describe stress tests of a financial system as “system-focused” stress tests, to acknowledge the limitations inherent in undertaking such an exercise.

System-focused stress tests, as the name implies, have several important differences from portfolio-level stress tests used by individual firms. The ultimate intent of system-focused approaches is to identify common vulnerabilities across institutions that could undermine the overall stability of a financial system. The focus is also more macroeconomic in nature, because the analyst is often interested in understanding how major changes in the economic environment may affect the financial system as a whole. Another difference between system-focused and portfolio-level stress tests lies in the complexity and degree of aggregation. System-focused stress tests may involve aggregation or comparison of more heterogeneous portfolios, often based on different assumptions and methods of calculation. This requires adding or comparing different entities (“apples” and “oranges”) to a much greater extent than is the case for a single institution’s portfolio.

The value added from system-focused stress tests derives from a consultative process that integrates a forward-looking macroeconomic perspective, a focus on the financial system as a whole, and a uniform approach to the assessment of risk exposures across institutions. These system-focused tests can complement stress tests conducted by individual institutions while also acting as a cross-check for other types of analysis. The information provided by system stress tests can also help to identify weaknesses in data collection, reporting systems, and risk management. The entire process itself can help to increase expertise in risk assessment by supervisors and the institutions involved, as well as promote cooperation and a broader understanding of risks by different regulatory institutions. In turn, this can contribute to a better understanding of the links between the financial sector and the macroeconomy.

System-focused stress tests are not intended to replace the regular stress testing done by individual financial institutions. Instead, they are designed to complement them with a broader understanding of the sensitivity of the overall system to a variety of shocks, and to leverage the existing expertise found in different institutions. Most system-focused stress tests apply a common scenario to a variety of institutions. This approach has the advantage in providing information on the overall impact of shocks as well as their distribution throughout the system, which can be useful for understanding the potential for contagion and confidence effects on stability. If data availability allows, conducting a stress test on an aggregated portfolio as well as on individual portfolios provides the maximum information about a system's vulnerabilities.

The Process of Stress Testing a System

System-focused stress testing is best seen as a process, beginning with the identification of specific vulnerabilities or areas of concern, followed by the construction of a scenario in the context of a consistent macroeconomic framework. The next step is to perform the numerical analysis, consider any second-round effects, and finally summarize and interpret the results. These stages are not necessarily sequential, and some modification or review of each component of the process may be desirable as work progresses. The process itself may be facilitated by forming a working group to draw on a range of expertise.

Identifying Vulnerabilities

The first step in the stress-testing process is to identify the main vulnerabilities in the financial system and narrow the focus of the exercise, because it is unrealistic to attempt to stress every possible risk factor. System-focused stress tests can make use of a range of numerical indicators to help isolate potential weaknesses, including the "big picture" or macro-level indicators and broad structural indicators, together with institution-focused or micro-level indicators. Qualitative information on the institutional and regulatory frameworks that govern financial activities can also help to interpret developments in a range of indicators.

Knowledge of the broader macroeconomic environment provides an overall context for the performance of the financial system and indicates potential sources of shocks. Understanding the macroeconomic picture aids the understanding of what is “normal” for an economy with respect to its own history and in comparison with other countries. Such an analysis can make use of data on the *real sector*, such as growth and utilization rates for different sectors, inflationary pressures, and measures of indebtedness, leverage, and debt-servicing ability. Useful information on the *government sector* includes measures of the deficit, debt stock, fiscal impulse, and how the government budget is financed. The *external sector* can also provide important information on vulnerabilities, using indicators of the magnitude of the current account deficit, official reserves, and how the deficit is financed; the relative size, maturity structure, and currency composition of external debt; and the extent of exchange rate misalignment and whether there are any pressures on the exchange rate.

A variety of indicators of the structure of the financial system can provide important insights into the location of risks in the financial system. Data on *ownership and market shares* help identify systemically important institutions and sectors. *Balance sheet structures*, derived from aggregate financial statements, can indicate significant exposures to particular classes of assets and liabilities or income sources. *Flow-of-funds accounts* can provide insights into major changes in the patterns of intermediation in the economy and trends in fundraising by different sectors and instruments.

In addition to using the broad macroeconomic context and structural indicators, a range of financial soundness indicators (FSIs) can be used to understand vulnerability to shocks and capacity to absorb the resulting losses. The health of the financial sector can be analyzed by looking at levels and trends in FSIs—typically of capital adequacy, asset quality, profitability, liquidity, and exposure to market risks. The IMF has developed a *core set* of FSIs covering the banking sector, reflecting the central role of the banking sector in many financial systems. An *encouraged set* of FSIs covers additional FSIs for the banking system as well as FSIs for key nonfinancial sectors, because weaknesses in these sectors are a source of credit risk for banks and, thus, help to detect banking sector vulnerabilities at an earlier stage.

Constructing Scenarios

Once the main vulnerabilities of interest have been identified, the next stage is to construct a scenario that will form the core of the stress test. Ideally, a macroeconomic or simulation model should form the basis of the stress-testing scenarios, because this provides a forward-looking and internally consistent framework for analyzing key linkages between the financial system and the real economy.

Drawing on the main macroeconomic vulnerabilities identified in the previous section, the analyst should arrive at a consensus for the key macroeconomic and financial variables that are the most volatile, misaligned, or likely to have the greatest impact on the financial system. Typically, such misaligned variables are susceptible to major shocks or realignments and, thus, can form the basis of a realistic simulation scenario. Depending on the structure and features of the model that is available, the simulation can produce a range of economic and financial variables as outputs. The feasibility of this approach will vary according to the range of modeling expertise available, as well as the type of macroeconomic model in place.

A hypothetical example of the process of developing a scenario may prove illustrative. Suppose that housing prices had risen sharply on the strength of rapid employment growth, rising household disposable incomes, and low interest rates, fueling a mortgage-lending boom. In this situation, an analysis of bank balance sheets and income statements shows a strong dependence on mortgage lending in both the stock of assets and the flow of income. One possible scenario could involve a shock to employment (a rise in unemployment), a fall in disposable incomes, and a sharp rise in interest rates affecting the debt-servicing capacity of households. The outputs from a macroeconomic model could provide a range of information on employment, real incomes, prices, and interest rates, which could be used to formulate a specific stress test for bank balance sheets.

It may not always be feasible to generate a scenario using a consistent macroeconomic model. Some authorities may not have available a well-developed model including a financial sector, or there may be difficulties in using a model to simulate relevant shocks. In the absence of a well-developed macro model, it may be necessary to rely on more rudimentary approaches. Even in these circumstances, it is still possible to frame the analysis in the context of an internally consistent, forward-looking macroeconomic scenario by using textbook

models, supplemented by existing empirical research. The objective of using an explicit macroeconomic model is to bring the discipline and consistency of an empirically based model and an explicit focus on the link between the macro-economy and the main vulnerabilities.

Balance Sheet Implementation

Once a set of scenarios has been produced in a consistent macroeconomic framework, the next step is to translate the various outputs into the balance sheets and income statements of financial institutions. There are two main approaches to translating scenarios into balance sheets: the “bottom-up” approach, where estimates are based on data for individual portfolios, and the “top-down” approach, which uses aggregated or macro-level data to estimate the impact.

Under the bottom-up approach, the response to various shocks in a scenario is estimated at the portfolio level, using highly disaggregated data from individual financial institutions. The results of the bottom-up approach can then be aggregated or compared to analyze the sensitivity of the entire sector or group of institutions. The bottom-up approach has the advantage of making better use of individual portfolio data, but at the cost of potential inconsistencies in how each institution applies the scenario and produces its numerical estimates. This type of stress test also provides useful information on the sensitivity of individual institutions to different shocks, as well as information on concentrations of risks in the financial system.

The top-down approach is used to estimate the responsiveness of a group of institutions to a particular scenario. This approach provides information on the overall sensitivity of the system to broad macroeconomic developments. Under this approach, a common parameter is derived from all institutions in the data set (e.g., using a regression of aggregated information on macroeconomic variables) to arrive at an estimate of the aggregate impact. The top-down approach is often easier to implement, because it requires only aggregated data, and is a consistent and uniform method, but is based on aggregate historical relationships that may not hold in the future.

The implementation of stress tests should involve the individual institutions themselves as much as possible, because they will typically have the best access to data and knowledge of their own portfolios. Most institutions with sophisticated risk management systems or significant international operations

will have systems and stress-testing procedures in place as part of their own internal risk-monitoring processes. For countries with more rudimentary systems and less expertise in modeling portfolios, it may be necessary for the central bank or supervisory agency to provide guidance or even undertake parts of the empirical analysis. Having institutions cooperate in a stress-testing exercise allows banks to benchmark their own results against their peer groups and learn from other participants. Ideally, both top-down and bottom-up methods should be applied, but data limitations may preclude this in practice.

The coverage of the stress-testing exercise should be broad enough to represent a meaningful critical mass of the financial system, while keeping the number of institutions involved at a feasible level (e.g., fewer than 20). Banks and significant nonbank financial institutions should be included in the analysis, although this may present some difficulties if they are supervised by different entities or have different balance sheet reporting dates or practices. Stress tests can also be applied to nonfinancial companies to understand the sensitivity of corporate sector balance sheets.

The availability and quality of data impose major constraints on the nature of stress tests that can be performed. There may be basic data limitations in countries where information on balance sheet exposures is not available. Significant exposures may be difficult to isolate, especially for large, complex financial institutions or institutions that are active in the derivative markets. Some risk measures may also be difficult to obtain (e.g., duration or default measures) in countries where risk management systems are less sophisticated. There may also be some confidentiality issues or limitations on what supervisors are legally able to share with other parties. To overcome these difficulties, it may be possible to work with the more sophisticated institutions in the system to obtain better data or to calibrate some parts of the exercise. When confidentiality issues do arise, it may be possible for the institution with access to the data to conduct the stress testing based on agreed-upon assumptions and methodologies and share the results in a form that is sufficiently informative of the risk exposures, but would not breach confidentiality laws or protocols.

The scenarios considered in a stress test should be beyond the normal range of experience, because stress testing involves discovering the impact of *exceptional but plausible* events. Although the object of stress testing is not to apply shocks until all major financial institutions fail, it is the exceptional outcomes that precipitate financial instability. Scenarios can be based on historical data (e.g., using the largest observed changes or extreme values over a specified period), or they can be hypothetical and involve large movements thought to be plausible. Historical

scenarios can be more intuitive because they were actually observed, but hypothetical scenarios may be more realistic, especially if the financial structure has changed significantly. Experiences of other countries can be a useful guide as well.

Conducting a top-down approach to stress testing provides a useful check on the results based on individual balance sheet information (the bottom-up approach). Furthermore, financial institutions in some countries may not have the capacity to estimate the impact of a given set of shocks on their portfolio. In this case, the agency coordinating the stress-testing exercise could adopt a top-down approach and apply adjustment parameters based on system-wide estimates. For example, a regression model of loan loss rates for the entire banking system could be used to estimate the impact of an adjustment scenario on the credit quality of an institution.

Second-Round Effects

Most stress-testing approaches assume there is no change in the behavior of the portfolio or no realignment of the portfolio structure in response to the change in risk factors. Stress tests are typically applied to a balance sheet at a point in time or in conjunction with a forecast over a specific horizon, and the impact is calculated as if the shock were valued at market prices. This approach is valid if the time horizon is relatively short or if changes in the underlying portfolio take time to implement. For example, assuming only a limited behavioral response in a large loan portfolio over a one- to three-month horizon may be a reasonable assumption, because it is often difficult to restructure a portfolio in less time without incurring losses from “fire-sale” prices. Such an assumption may also be justifiable for an individual institution that does not have a large impact on the financial system or the macroeconomy. But once the time horizon of a scenario extends beyond a year or more, the assumption of no behavioral response becomes harder to justify. Similarly, for systemically important institutions or for systems as a whole, the assumption of no feedback effects implicit in many stress tests may be an oversimplification. The policy environment may change over a longer horizon, as monetary or supervisory authorities react to a given set of shocks. Financial sector safety nets may also provide a buffer over longer horizons.

Second-round effects materialize as direct credit losses from counterparty failures, as increased funding costs for weakened banks, and as portfolio adjustments (such as a tightening of lending criteria) affecting aggregate demand.

These effects may all be present during periods of stress, particularly ones with longer time horizons. The challenge in incorporating these effects into a system-focused stress test is in understanding the complexity of the links between institutions. One approach that is often used to consider second-round effects and linkages between institutions is the use of contagion models. These models attempt to estimate the impact of the failure of key institutions on other institutions and, hence, the overall financial system. The exercise typically has two stages, beginning with a stress test of individual balance sheets and income statements. The second stage involves an examination of counterparty exposures to the institutions made most vulnerable by the stress test, for example, through interbank loans, cross-shareholdings, deposits, or other exposures.

Interpretation

Experience in conducting stress tests suggests they are a useful tool for identifying latent risk exposures in a systematic and intuitive manner. Stress tests can be particularly useful when they are conducted regularly, because this can provide information about changes in the risk profile of the system over time. Although stress test results are useful in evaluating effects of large movements in key variables, care should be taken not to portray them as providing a precise measure of the magnitude of losses.

Stress tests are also unlikely to capture the full range and interaction of risk exposures (such as operational risk and legal risk), and they may give only a partial picture of the true nature of risk-taking by participating institutions. It may be useful to compare stress test results with other complementary measures of risk exposure, such as financial soundness indicators. Finally, stress tests typically consider only part of a bank's income-generating operations; therefore banks may have significant income flows that are unaffected in performance or value by the specific stress test scenarios analyzed.

The analysis and discussion of stress-testing results can be facilitated and enhanced by a clear presentation of the output generated by stress tests. For bottom-up approaches, descriptive statistics (e.g., mean, median, standard deviation, minimum, maximum, and number of institutions in each decile) and peer-group analysis can be used to convey how the impact at the aggregate level is distributed across individual institutions. Having the supervisory agency conduct some stress tests on the balance sheet data reported to it by financial institutions using a common framework and methodology can play a useful role

in acting as an accuracy and consistency check of the results provided by individual institutions.

Publication of Results

Public dissemination of the results of stress tests can present some challenges to confidentiality and interpretation of results. Participating institutions may be reluctant to have any information disclosed that could identify specific firms, out of concern that markets may interpret such information negatively or competitors may take advantage of the information. Some analysts may also interpret the particular scenarios chosen as reflecting an official view of the most likely scenario or the most problematic one, which may not be the case. Nevertheless, the publication of summary or aggregated information on stress test results by a wide variety of countries suggests that these difficulties can usually be overcome. Disclosure of some summary information on the results (such as the mean and the range) can be informative for financial markets and individual institutions wishing to benchmark their own results against their competitors, without revealing the identities of individual institutions. Disclosure of the scenarios undertaken can also raise awareness of different risks for institutions to consider and incorporate into their own stress-testing programs.

FSAP Experience and Capacity Building

Stress tests are an integral part of Financial Sector Assessment Programs (FSAPs) conducted by the IMF and World Bank. They are designed to provide a quantitative measure of the vulnerability of the financial system to different shocks. They complement other elements of an FSAP, including qualitative assessments of the legal, institutional, regulatory, and supervisory framework and the empirical analysis of financial soundness indicators.

Data availability is a key factor in determining the approach and sophistication of stress tests performed as part of the FSAP. Most analyses are performed on a bank-by-bank basis, based on single factor and scenario approaches. Contagion risks and second-round effects have typically not been addressed in many FSAPs, although some have incorporated elements of interbank contagion into

the exercise. The involvement of the authorities has varied, according to their expertise and ability or willingness to provide data, with some country authorities precluded from providing data on individual institutions by bank secrecy laws or conventions. Among countries that have published the IMF's summary assessment of the FSAP mission (the *Financial System Stability Assessment or FSSA*), most have included a summary of the stress-testing results.

The overall approach and implementation of stress tests as part of the FSAP has evolved over time. Country authorities and individual financial institutions now play a greater role in the design and implementation of stress tests as familiarity and use of the techniques have spread. Increased reliance is being placed on using the internal models of banks to evaluate the impact of shocks. The use of macroeconomic models to calibrate a macro scenario has increased, as has the coverage of nonbank financial institutions.

As a follow-up to the FSAP, and on the basis of increasing demand of its member countries, the IMF has begun to offer technical assistance and cooperation with regard to the implementation of stress-testing programs. This assistance in capacity building is aimed at central banks and supervisors in a wide variety of member countries and includes not only bilateral assistance but also cooperation in the form of workshops and seminars.

Concluding Remarks

Stress testing is best seen as a process of identifying vulnerabilities and providing an estimate of the sensitivity of balance sheets to a variety of shocks. System-focused stress tests attempt to link a forward-looking macroeconomic perspective with an assessment of the sensitivity of a group of institutions to major changes in the economic and financial environment.

The process of conducting a system-focused stress test begins with the identification of specific vulnerabilities or areas of concern, followed by the construction of a scenario in the context of a consistent macroeconomic framework. Isolating key vulnerabilities is an iterative process involving both qualitative and quantitative elements. A range of numerical indicators can be used to help isolate potential weaknesses, including the "big picture" or macro-level indicators, broad structural indicators, and more institution-focused or micro-level indicators. Ideally, an econometric or simulation model should form the basis of the stress-testing scenarios. A working group of selected experts may facilitate the process.

Once a set of adjustment scenarios has been produced in a consistent macroeconomic framework, the next step is to translate the various outputs into the balance sheets and income statements of financial institutions. There are two main approaches to translating scenarios into balance sheets: the bottom-up approach, where the impact is estimated using data on individual portfolios, and the top-down approach, where the impact is estimated using aggregated data.

Public dissemination of the results of stress tests may present some challenges, but the publication of results by a broad range of countries has shown that these challenges are not insurmountable.

Experience with the IMF/World Bank FSAP process has shown that stress tests are useful because they provide a quantitative measure of the vulnerability of the financial system to different shocks, which can be used with other analyses to draw conclusions about the overall stability of a financial system. Recent trends show a shift toward greater integration of a macroeconomic perspective, more involvement by country authorities and individual institutions, and greater coverage of the financial sector.



Paul Hilbers is an area chief in the IMF's Monetary and Financial Systems Department. He has published extensively on monetary and financial policy issues. Before joining the IMF, he was with the Netherlands Bank. He has a Ph.D from the Free University in Amsterdam.



Matthew T. Jones is an economist in the IMF's Monetary and Financial Systems Department, where he works on stress testing and financial stability issues. Before joining the IMF, he worked at the Reserve Bank of Australia. He has a Ph.D from the University of California at Berkeley.