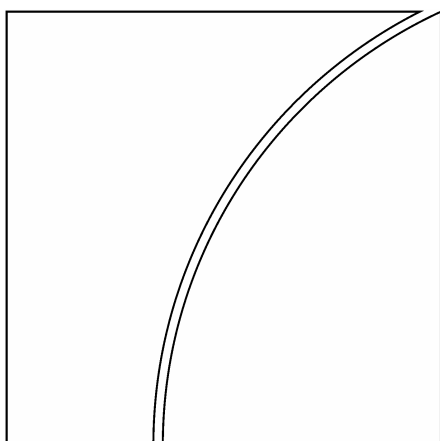


Committee on the Global Financial System



Stress testing at major financial institutions: survey results and practice

Report by a working group established by the Committee on the
Global Financial System

January 2005



BANK FOR INTERNATIONAL SETTLEMENTS

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CH-4002 Basel, Switzerland

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ISBN 92-9131-675-X (print)

ISBN 92-9197-675-X (online)

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Preface

The Committee on the Global Financial System (CGFS) is a central bank forum established by the Governors of the G10 central banks. It monitors and examines broad issues relating to global financial markets. The Committee seeks to identify and assess potential sources of stress, further the understanding of the underpinnings of these markets, and promote the development of well functioning and stable financial markets. Recent projects by CGFS subgroups have included studies on foreign direct investment in emerging market economies and the role of rating agencies in structured finance.

The CGFS decided in May 2004 to set up a group which would review what banks and securities firms perceived to be material risks for them at that time based on the stress tests they were running, as well as explore some of the more structural aspects of stress testing at major financial institutions. In doing this, the CGFS was looking to build on previous work it had undertaken on stress tests in May 2000. The results of the latest effort, as detailed in this report, were discussed at the September 2004 and November 2004 meetings of the CGFS. The publication of the report is intended to contribute to the general understanding of the use of stress tests as a risk management tool.

The material contained in this report is designed to assist those people seeking to better understand where stress testing fits in the risk management frameworks of banks and securities firms. It may also be useful as background material for market practitioners assessing their own stress test programmes.

The group was chaired by Hiroshi Nakaso of the Bank of Japan. He joins the Committee in expressing appreciation for the cooperation of the participating firms with the working group member central banks.

The CGFS continues to be interested in this topic. Accordingly, I would like to invite comments on the report.

Roger Ferguson
Chairman, Committee on the Global Financial System
Vice Chairman, Board of Governors of the Federal Reserve System

Executive summary

Stress testing has evolved as a practical risk management tool and its applications are expanding. This is evident in the following report, which summarises the findings of a Committee on the Global Financial System (CGFS) exercise on stress testing at banks and securities firms. The aims of the project were to review what financial institutions perceived to be the main risk scenarios for them based on the stress tests they were running, and to examine how stress test practices have evolved over the past few years. As part of the exercise, 64 banks and securities firms representing 16 countries participated in a survey of enterprise-wide stress tests they were running as of the end of May 2004; national central banks also conducted interviews with a number of financial institutions.

The practice of stress testing

The exercise illustrated the wide range of stress test practices at banks and securities firms. The use of stress tests continues to broaden from the exploration of exceptional but plausible events - the traditional focus of stress testing - to cover a much wider range of applications. These include the exploration of the risk profile of a firm, the allocation of economic capital, the verification of existing limits, and the evaluation of business risks. The expanded usage of stress testing derives from its wider acceptance within firms. Aside from its inherent flexibility, it benefits from explicitly linking potential impacts to specific events.

Nonetheless, stress tests continue to focus primarily on traded market portfolios. These portfolios are well suited to stress testing as they can be marked to market on a regular basis. Stress tests on loan books are conducted less frequently and, quite often, by separate business units of the firm. Stress testing of funding liquidity and operational risk is employed regularly, though, again, this may be undertaken in different parts of the firm from the market risk stress tests.

Survey results

Numerous stress tests were reported in the survey, with stress tests based on movements in interest rates being the dominant type of stress test. Stress tests based on credit were the next most common form of stress test. The majority of tests focus on markets in more than one region, though there is also a large number of tests which concentrate on developments in the United States and emerging markets. Historical stress events with particular relevance to bank and security firm portfolios are Black Monday (1987), the Asian financial crisis (1997) and financial market gyrations associated with the failure of LTCM and the Russian default in 1998. In addition, developments in financial markets around the time of the terrorist attacks in the United States in 2001 now form the basis for numerous historical and hypothetical scenarios.

Specific issues

Notwithstanding the progress that has been made, a number of challenges remain. One area that arose repeatedly in discussions on stress tests with reporting firms was the need to develop better stress tests incorporating loan portfolios. It was felt that developments in this area lagged those in the market risk area by a large margin, owing partly to the difficulty in marking to market loan portfolios and insufficient data accumulation.

The integration of risk management for different types of risks also remains a challenge for those firms wishing to move in that direction (not all firms have the underlying risk profile warranting such an investment). Efforts to develop firm-wide credit stress tests for both trading and loan books have been hindered by differences in accounting treatment, regulatory environments, a lack of trading markets for certain products, and/or the organisational structure of firms. Some of these hurdles are gradually being overcome, assisted by improvements in technology, increased market transparency and the broadening of traded credit markets. Nonetheless, the full integration of credit and market risks remains an issue, as does the consistent application of stress testing by financial conglomerates across banking, life insurance and wealth management operations.

The treatment of market liquidity in stress tests varies across firms. Although firms recognise the potential for feedback effects - which measure the second-round impact of firms' own activities on prices - these effects are rarely incorporated in stress tests because they are difficult to measure.

Funding liquidity scenarios were well articulated. A number of these scenarios were linked to the formulation of contingency funding plans.

Conclusion

Stress testing works as a complement, rather than as a supplement, to major risk management tools such as value-at-risk. It is therefore becoming an integral part of the risk management frameworks of banks and securities firms. The expansion of coverage and use of stress testing reflects the growing demands of senior management, business units and third parties such as investors. In an increasingly complex financial environment where firms are facing new risks and markets are becoming more global, stress testing benefits from its flexibility, comprehensibility and the onus that it puts on management to discuss the risks that a firm is currently running.

The expansion in the use of stress testing is clear evidence of the increased integration of stress testing into risk management frameworks at financial institutions. Increasingly, individual institutions are taking into account information about plausible worst case scenarios and, where it is deemed prudent, taking action to avoid the adverse consequences of these events. Given the link between financial markets and risk management practices, it is important that the overall consequences of risk management practices at financial institutions be well understood. This review of stress test practices is one part of that effort.

1. Introduction

In May 2004, the Committee on the Global Financial System (CGFS) initiated an exercise on stress tests undertaken by banks and securities firms. The exercise had two main aims. The first was to conduct a review of what financial institutions perceived to be the main risk scenarios for them at that time, based on the type of enterprise-wide stress tests that they were running. The second aim was to explore some of the more structural aspects of stress testing and examine how practices had evolved, particularly over the period since the previous CGFS survey, the results of which were published in *A survey of stress tests and current practice at major financial institutions* in April 2001.¹

There were two main parts to the latest exercise. The first part involved a survey of stress tests being conducted at banks and securities firms. The survey asked respondents to list details of the stress test scenarios and associated risk factors that were in use as at the end of May 2004. Sixty four banks and securities firms from 16 countries participated in the survey, with the reporting institutions selected by their national central banks.² Firms participating in the survey reported to their national central bank; the data were then submitted on a no-name basis to the BIS-based CGFS secretariat and entered into a database. Around 960 stress tests were reported and more than 5,000 risk factors were listed.³ Reflecting a desire to focus on the range of scenarios being employed and confidentiality concerns, survey respondents were not asked to report the results of any scenario runs.

In the second stage, national central banks conducted follow-up meetings with institutions that had participated in the stress test survey. National central banks met to discuss the results of the survey and these interviews. As part of this meeting, senior risk managers from several large complex financial firms were invited to discuss stress test practice. Both the follow-up meetings and the group discussion with risk managers made clear that risk measurement and the role of stress testing in risk management vary widely across firms, reflecting differences in both the complexity of risks faced by firms and the breadth and scale of the different businesses.

The output of the group is a synthesis of observations based on the survey, interviews with respondent firms and discussion with market participants. The exercise illustrated the wide range of practices and risk management frameworks at firms. This reflected, inter alia, the heterogeneous business models that are being employed by firms. The use of stress tests has expanded from the exploration of exceptional but plausible events, to encompass a range of applications. It has met with wider acceptance within firms because it is a flexible tool which can adapt quickly and efficiently to the changing environment and specific needs of a firm and provide important information on the risk exposures of firms. Notwithstanding this positive development, a number of challenges remain, most notably in the areas of stress testing credit risks, integrated stress testing and the treatment of market liquidity in stress situations.

2. The practice of stress testing

2.1 The role of stress tests

Stress testing is a risk management tool used to evaluate the potential impact on a firm of a specific event and/or movement in a set of financial variables. Accordingly, stress testing is used as an adjunct to statistical models such as value-at-risk (VaR), and increasingly it is viewed as a complement, rather than as a supplement, to these statistical measures. Stress tests generally fall into two categories: scenario tests and sensitivity tests. In scenarios, the source of the shock, or stress event, is well

¹ For previous CGFS-sponsored work on stress testing, see Committee on the Global Financial System, *Stress testing by large financial institutions: current practice and aggregation issues*, Basel, April 2000. This document can be downloaded from <http://www.bis.org>.

² A list of reporting institutions is reproduced in Appendix 3 of the report. The reporting form with instructions is reproduced in Appendix 4 of the report.

³ This compares with 43 reporting firms reporting 424 stress tests from 10 reporting countries in the survey conducted in 2000 (the results of which were published in April 2001).

defined, as are the financial risk parameters which are affected by the shock. In contrast, while sensitivity tests specify financial risk parameters, the source of the shock is not identified. Moreover, the time horizon for sensitivity tests is generally shorter - often instantaneous - in comparison with scenarios.

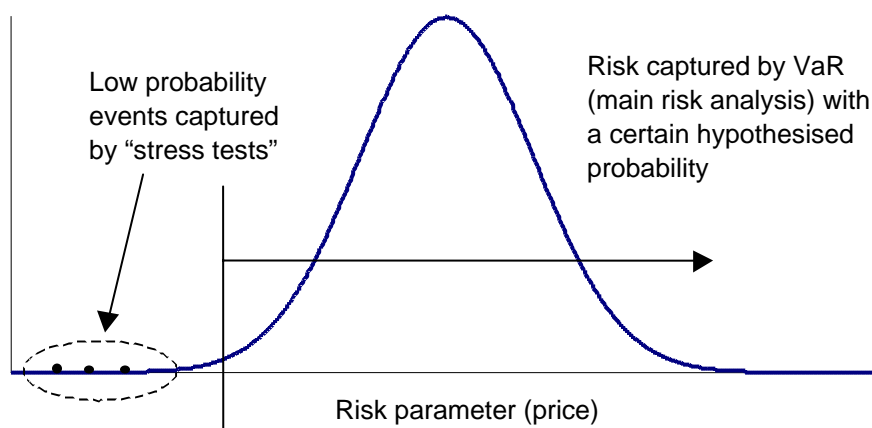
The survey and follow-up discussions revealed a wide range of uses of stress tests. These uses, which are not mutually exclusive, included:

- *Capturing the impact on a portfolio of exceptional but plausible large loss events*

Unlike VaR, which reflects price behaviour in everyday markets, stress tests simulate portfolio performance during abnormal market periods. Accordingly, they provide information about risks falling outside those typically captured by the VaR framework (Figure 1). These risks include those associated with extreme price movements, and those associated with forward-looking scenarios that are not reflected in the recent history of the price series that are used to compute VaR.

Figure 1

Stress tests capturing exceptional but plausible events



- *Understanding the risk profile of a firm*

Firms are using stress tests to better understand their own risk profiles. A stress test of a corporate customer, for example, may reveal exposures which at the individual business unit level are not significant, but which, in aggregate, may have a large negative effect on the overall business. Alternatively, it may highlight offsetting positions in other parts of the business.

In addition, firms are using stress tests - mainly sensitivity tests - to calculate the sensitivity of a firm's portfolio to changes in risk factors, such as an upward shift in a yield curve. Some institutions are using stress tests to verify the distribution assumed in their VaR models. If a loss computed by a stress test exceeds its VaR equivalent, the risk manager may need to modify the assumed distribution.

Firms are also using stress tests to evaluate risks where VaR is of limited use. Examples include markets where the price impact of shocks is non-linear, such as options. Stress testing is also used to set limits for markets with low historical volatility but which may be subject to large discrete movements, such as for pegged currencies. Risk managers have also found it useful for setting limits and monitoring new products where no historical data are available. Thus stress testing is considerably enhancing firms' overall risk management frameworks.

- *Limit/capital allocation or verification*

At some institutions, stress testing is used by senior management as a basis for informed decisions about how much risk they are willing to take and identifying where the

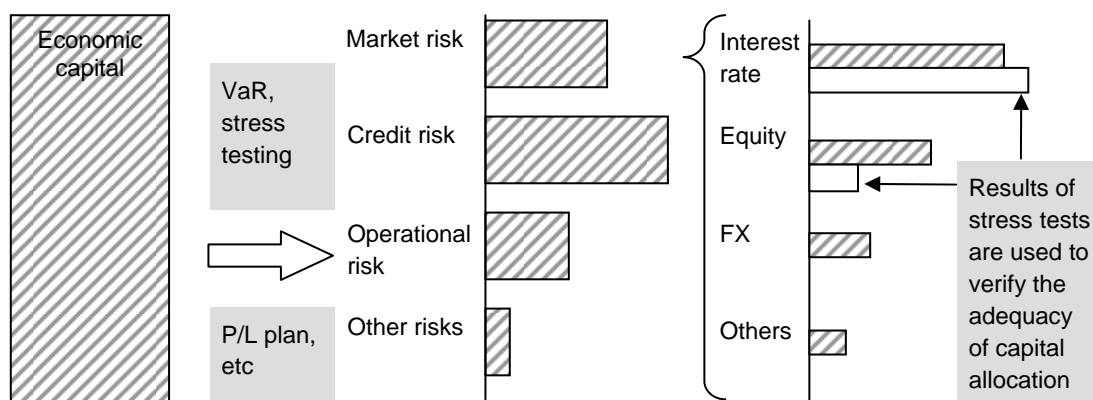
vulnerabilities in their portfolios actually lie. In other words, it helps them to evaluate their tolerance for risks - at both the firm and division level - and understand the combinations of risks that can produce large losses. This is then being linked, both directly and indirectly, to capital allocations.

The small number of firms which are using it as a direct input to the allocation of economic capital are generally adopting two different approaches. The first approach takes the form of constructing scenarios with the input of business units, and ranking them according to their relevance and plausibility. The output of this exercise then forms the basis for decisions about the allocation of economic capital (left-hand side of Figure 2). Alternatively, firms will focus on worst case scenarios, owing to concerns about the possibility of scenario manipulation and difficulties with aggregation and the distribution of the diversification benefit. This process is more objective, though judgments still have to be made about such things as the periodicity and span of the historical data. But even in this more quantitative exercise, the eventual allocation of capital is not formulaic, with a number of further judgments being made before capital is allocated.

A much larger number of firms are using stress tests as a diagnostic tool to verify the adequacy of established limits and assigned capital across portfolios and enterprises (right-hand side of Figure 2). Thus while some other methodology, such as VaR, is used in the initial allocation of economic capital, stress testing is employed to ensure that due consideration is given to the impact of a stress-type event. A number of reporting firms described how stress test reports had contributed in some way to changes in firm policy and/or modifications of risk exposures.

Figure 2

The allocation and verification of capital



Similarly, stress tests are also used as triggers or “soft limits”, whereby the breach of a predetermined level initiates a discussion among senior management, risk managers and the affected business units. The purpose of the discussion is to make sure that the relevant people are aware of the possibility of significant losses and to determine the appropriate actions, if any.

- *Evaluation of business risks*

One of the innovations in stress testing is its application to business plans. In some firms, a stress event is looked at in the context not only of changes in the value of on- and off-balance sheet items of the firm, but also of the effect that it has on revenue sources over subsequent years. This overlay assists management in deciding whether this type of event is a threat to their underlying business and whether the capital supporting the business is appropriate. One firm, for example, is testing the effect on its profitability of a long period of low interest rates. Stress tests are also being used to evaluate new business plans by stressing the scenarios which underpin these plans. This normally takes the form of examining the impact of an event on the net interest income of a firm.

In almost every interview, it was emphasised that stress testing is a very effective standardised communication tool between senior management and the business lines of a firm. In this context, stress tests have the advantage over VaR of explicitly linking potential large losses with specific events, rather than simply characterising large losses as a draw from a statistical distribution. Stress testing enables management to better understand the nature of risks embedded in the firm's business lines and, in effect, helps initiate a conversation in which stress testing can be used to quantify the effects of events perceived as risks by senior management, or even regulators.

2.2 Coverage of stress testing

As indicated by the various uses of stress tests, the coverage of stress testing has expanded beyond the evaluation of marketable instruments. On the assets side, stress testing tends to focus on the traded market portfolios. These portfolios include interest rate, equity, foreign exchange, commodity and credit market instruments and are well suited to stress testing because of the ability to mark them to market on a regular basis. Financial institutions will, however, largely confine themselves to areas where they have exposures or are active in making markets. For the global dealer firms, this means a large number of trading markets. Credit risk stress tests, particularly those associated with loan books, are conducted less frequently and by different areas of the firms (see below for a discussion of the stress testing of credit risks).

On the liabilities side, funding liquidity for individual institutions is tested at various levels by most institutions. Scenarios include changes in: client behaviour (eg the withdrawal of deposits or increased drawdown of commitment lines); own credit (eg a ratings downgrade); funding costs; and collateral requirements, such as how much collateral an institution has available and what haircut might be required. These tests may form part of an overall liquidity contingency plan and are generally conducted by the funding division of a firm's operations. Distinctly different assumptions about access to central bank facilities are made for scenarios involving system-wide problems and those for firm-specific ones. There is a general perception that important lessons on funding liquidity had been learned from historical events such as the failure of Drexel Burnham Lambert, and the Asian and LTCM crises - in particular, that firms can run out of cash before they run out of capital in a crisis of confidence.

Stress testing of operational risks also remains a work in progress owing primarily to data problems, although most institutions have established contingency plans. Firms currently employing operational risk stress tests are using internal databases.

2.3 The formulation of stress tests

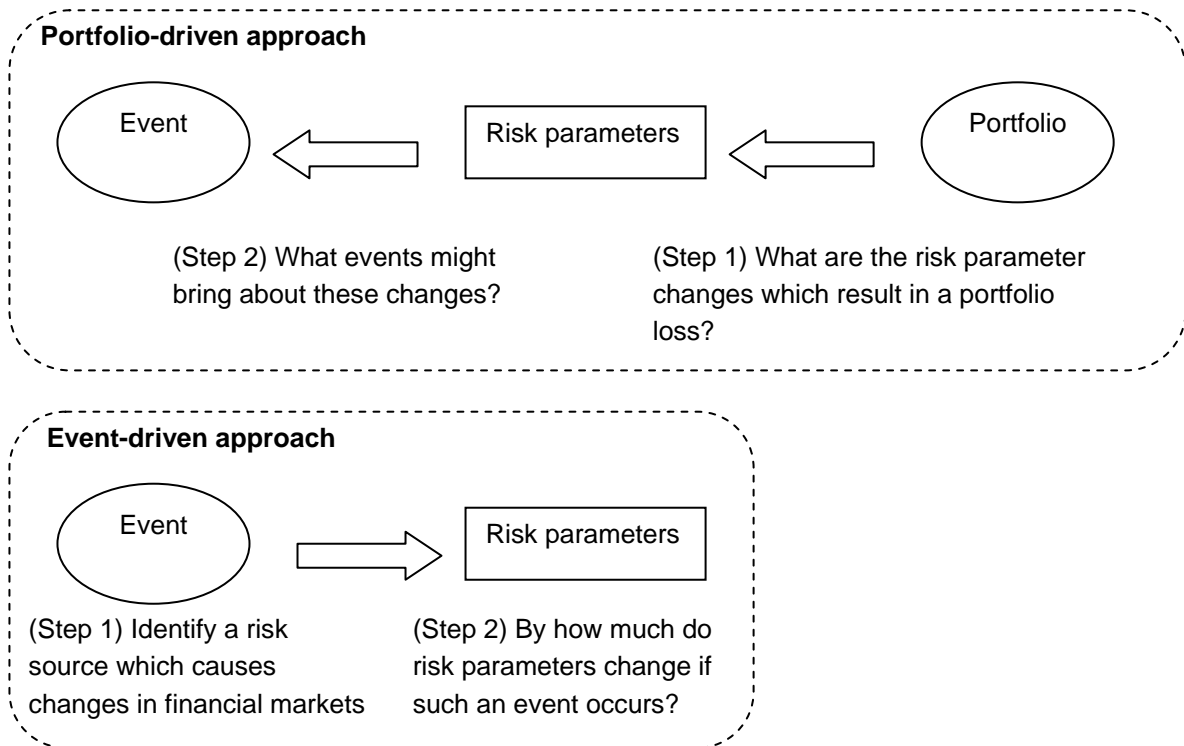
Scenario tests

As noted previously, stress tests generally fall into two categories - scenario tests and sensitivity tests. Scenario stress tests are generally based on either a portfolio-driven approach or an event-driven approach (Figure 3). In a stylised version of the portfolio-driven approach, key risk managers in a firm initially discuss and identify the vulnerabilities in the portfolio currently held by the firm. Having determined these vulnerabilities, risk managers work backwards 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 will be formulated around movements in interest rates.

In contrast, in event-driven scenarios the scenario is formulated based on plausible events and how these events might affect the relevant risk factors in a firm's portfolio. These scenarios are often formulated at the request of senior management and are sometimes motivated by recent news, such as a run-up in oil prices. Correlations across asset classes are normally implicit, although some firms will also examine the implied correlations in order to ensure that the results are not overly conservative.

Figure 3

Approaches to scenario formulation



Under either approach, events can be categorised as either historical or hypothetical scenarios. Historical scenarios rely on a significant market event experienced in the past, whereas a hypothetical scenario is a significant market event that has not yet happened. The choice of historical or hypothetical scenario depends on a number of factors, including the relevance to the portfolio of historical events, as well as the resources - particularly in terms of time and labour - that can be devoted to a particular exercise. Historical scenarios tend to be more fully articulated as they reflect an actual stressed market environment and therefore involve fewer judgments by risk managers. But they may not reflect the background of interest and the new ways in which financial risk is being packaged. In contrast, hypothetical scenarios are potentially more relevant to the risk profile of the firm, but they are labour-intensive and involve considerably more judgment. Accordingly, management- and business-level support for hypothetical scenarios is particularly important. With this in mind, some firms invite senior managers, front desks and economists to these discussions in order to secure objectivity and support for the scenario-setting process. Macroeconomic models are sometimes also employed. At the enterprise level, this broader participation also goes some way to ensuring that cross-business correlations are taken into account.

In practice, hybrids are quite common, ie hypothetical scenarios which are informed by historical market moves but which are not necessarily linked to a specific crisis. The use of historical episodes assists in the calibration of the size of price changes and other hard-to-set factors, such as the possible effects on market liquidity (see below).

More generally, practitioners repeatedly referred to the trade-off between realism and comprehensibility - the more fully articulated the scenario is, the more complicated and less comprehensible the contents may become - as well as the importance of a qualitative discussion to begin the process. Market practitioners were generally ambivalent about the need to assign probabilities. While it is necessary for some to attach probabilities to scenarios, such as those using hypothetical scenarios to allocate economic capital or those looking at the impact of scenarios on business plans, they emphasised that the use of stress tests was not mechanical.

Integrated scenarios covering multiple risks tend to be maintained for six to 12 months, as, in addition to the actual result, risk managers find considerable informational content in how the outcome

changes over time. A further factor arguing against more frequent changes to scenarios is that it is extremely time-consuming and costly - one firm referred to having to determine more than 1,000 settings for a scenario, which were then used to establish several thousand risk factors.

Notwithstanding the desire of risk managers to use stress testing to focus on regime shifts, such as a large unexpected shock which has a marked impact on the macroeconomic and financial environment, it was clear in a number of interviews that some firms have difficulty selecting “big picture” hypothetical scenarios. In this context, a number of firms noted the involvement of national authorities in the setting of macroeconomic risk scenarios. This was done either directly, at the specific request of authorities (such as tests involving macroeconomic scenarios and property prices, or IMF Financial Sector Assessment Program-type exercises), or indirectly via avenues such as financial stability and monetary policy reports where risks to the macroeconomic outlook were often listed.

Sensitivity tests

Firms also run a large number of sensitivity stress tests. The most straightforward type of test is a simple sensitivity test whereby risk parameters are moved instantaneously by a unit amount, such as a 10% decline or a 10 basis point rise. These tests can be run relatively quickly and are used by senior managers in a number of institutions to form a first approximation of the impact on the firm of a move in a financial variable. As a result, sensitivity tests are widely used at the trading desk and business line level. Firms also noted the usefulness of sensitivity tests between scenario runs, eg firms could estimate current losses (or profits) by scaling market moves to unit changes.

A second group of sensitivity tests examines historical movements in a number of factors.⁴ These tests can take several forms. One type is based on worst case movements for each risk factor over a set historical period, eg the worst change in the last 10 years for interest rates and equities. This 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.

Alternatively, some firms are using a historical dataset over a fixed period to determine the movement in risk factors that would have resulted in the largest loss for their current portfolio. In contrast to the previous method, this approach is based on actual market correlations. A variation on this technique is to specify a movement in one risk factor, but then derive movements in other factors using correlations observed during normal periods. These methodologies provide a less pessimistic assessment, but may not take into account the possible breakdown of historical patterns when financial markets are stressed. Reflecting this limitation, some firms are basing their correlation patterns on a recently stressed period.

3. Some survey results

3.1 Introduction

The survey of firms shed some additional light on these developments and provided more specific information about the stress tests that were being run. As noted previously, 64 banks and securities firms from 16 countries participated in the survey, with the reporting institutions asked to report on “firm-wide” stress tests that best captured important risks for their firm as at 31 May 2004.

These results, however, need to be interpreted with care. First, while a firm’s stress tests are related to its exposure, stress tests are not a perfect mirror image of the exposures of firms. Nor do stress tests reflect a firm’s perception of the likelihood of a given event.

There are also a number of possible reporting biases. At some firms, for example, the respondent is likely to be from the market risk management area, since market risk managers are most likely to be

⁴ To the extent that these tests are based on historical data, they are very similar to historical scenarios (and were reported this way by a number of survey participants). For the purposes of this survey, however, they have all been classified as sensitivity tests, as the source of the shock is not specified.

running portfolio-wide stress tests. Given the separation of risk management functions, such as between trading, credit and treasury functions, this runs the risk of missing some stress tests that are important for the firm as a whole. Similarly, “importance” is a subjective notion, and the number of tests reported by firms, as well as the number of risk factors, varied widely across reporting institutions.⁵

Third, in this report scenarios have been grouped into: dominant asset classes - interest rates, equities, foreign exchange, commodity, credit and property; and dominant regions - Europe, Japan, North America, Asia (excluding Japan), other emerging markets, other (including the Middle East and Oceania) and cross-border or global scenarios.⁶ For scenarios spanning more than one asset type and/or region, such a distinction can be artificial. Therefore, for tests covering multiple asset classes, reference was made to the title and detailed specification of the scenarios, in order to identify the most important asset class. Similar judgments had to be made with respect to the categorisation by region.

Finally, it should be noted that the latest survey cannot be directly compared with the 2000 survey, owing mainly to the expanded participation, differences in the way questions were asked, and changes in the categorisation of stress tests. As a result, comparisons with the 2000 survey are largely confined to some very broad observations. Nonetheless, in order to aid comparisons with the previous survey, the aggregate data have been split, where possible, into “Global dealer” firms and “Other” firms. Global dealer firms are banks and securities firms that are active worldwide across all market segments, including derivatives markets. This dataset is most directly comparable with the global dealer bank category in the earlier survey, although the firms included are not strictly comparable owing to mergers and acquisitions. Most of the banks and securities firms included in the “Other” category are internationally active, but do not cover all market segments.

3.2 Results

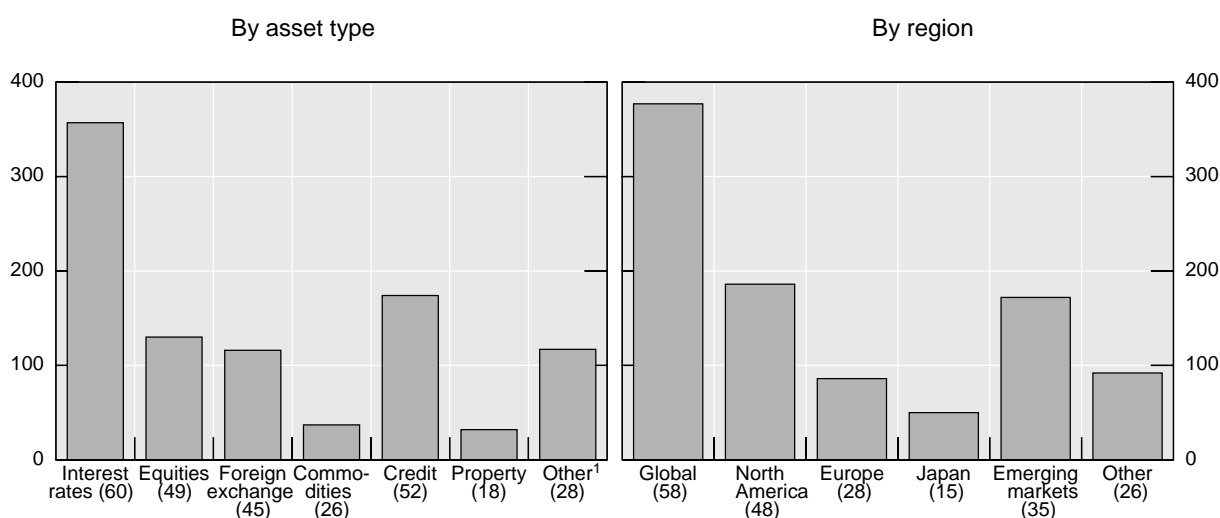
Overall

More than 80% of the stress tests reported in the survey were based on trading portfolios. Nonetheless, a number of firms also reported stress tests of their loan books, funding liquidity and net interest income. Stress tests based on movements in interest rates remain the dominant type of stress test, while those based on credit, equities and foreign exchange are much smaller (Figure 4; Table 1 in Appendix 1). In comparison with the previous survey, there was a greater focus on credit and less attention to equity markets. This is consistent with both the rapid evolution of traded credit markets and the fact that equity market valuations are now much closer to historical averages in a number of the major markets.

⁵ Given the variance in the level of detail for risk factors, analysis based on the number of risk factors has been omitted from this report. This information is, however, provided qualitatively throughout the report.

⁶ The latter category was used for sensitivity tests only, where it was impossible to discern the specific area of interest.

Figure 4
Stress tests
 Number of tests



Note: The numbers in parenthesis refer to the number of banks running these tests.

¹ Includes funding liquidity stress tests.

By region, there is a large concentration of global sensitivity tests (Table 2 in Appendix 1). Nearly half of these tests comprise data exercises involving the examination of historical movements of relevant risk factors across a range of global markets. The grouping also includes simpler exercises which examine the sensitivity of a portfolio to a unit change in a market parameter, such as a 10 basis point increase in interest rates in major markets. Region-specific stress tests are more likely to be US- or emerging market-based. Stress tests are well suited to the latter as markets in these countries can become illiquid very quickly and, as a result of a crisis, move in ways quite different from their historical pattern.

Reflecting the interaction between risk managers and senior management, respondents identified 123 one-off scenarios that had been requested over the preceding 12 months. The split between those requested by management and those requested by regulators was fairly even. These scenarios may be slightly outdated as they reflect the perceived sources of risks in the 12-month period up until May 2004. Management requests for one-off tests related mainly to real estate, commodity prices and credit spreads. Requests by regulators, some of which were in the form of sensitivity tests, cover issues such as a fall in property prices and generic macroeconomic events.

Historical and hypothetical scenarios

Some idea of the scenarios that firms felt were important enough to test is given in Tables 3a and 3b in Appendix 1. More specific details of the risk factors used in a number of topical scenarios are shown in Tables 4a-d; these tables group scenarios according to the way a particular issue is treated. In terms of historical scenarios, firms continue to focus on a number of major events such as Black Monday in 1987, the bond market decline of 1994, and the market turmoil associated with the collapse of LTCM and the Russian debt default in 1998. The latter has been particularly popular for interest rate and credit tests. Events surrounding the 1997 Asian financial crisis are also more common than in the 2000 survey, reflecting to some extent the wider participation of Asian institutions in the latest survey.

In the latest survey, the impact on financial markets of the terrorist attacks in the United States in 2001 has formed the basis for a number of historical and hypothetical scenarios. The tests concentrate on a number of asset types, including fixed income, equities and credit (Table 4a in Appendix 1). Of particular interest is how financial institutions are focusing on different aspects of the associated disruption to financial markets. For some institutions, the tested risk factors relate to domestic markets, while others have attempted to simulate virtually all aspects of the disruption. In some cases, this

includes quite detailed specifications, such as the term structure of implied volatility across the major asset markets. This may just reflect the increased ability of financial institutions to capture data. But more importantly, it may reflect the idiosyncratic nature of this particular event - in particular its impact on all aspects of the operation of financial markets - and therefore has highlighted the need to stress test at a sufficiently detailed level. The focus on 2001 also provides a recent example of how assets are correlated in a stressed environment that would have included a range of new instruments.

In terms of developing hypothetical stress tests, a large share of these tests are underpinned by scenarios based on changes in economic growth prospects. The majority of cases focus on a rise in interest rates, predicated on a stronger than expected pickup in economic growth in the industrialised countries. In contrast, a number of the emerging market scenarios consider an unexpected slowing in economic growth of the industrialised world, which then translates into widening sovereign credit spreads and a decline in stock prices. Aside from the slowing in economic growth for emerging market countries, other emerging market scenarios include the removal of currency pegs, the default of emerging market sovereigns, and developments in specific countries such as China (Table 4b in Appendix 1). A wide range of risk factors in emerging markets was listed, including domestic interest rates, exchange rates and credit spreads - mainly sovereign, but in some cases also local corporate spreads. For tied currencies, an interesting development has been the use of proxy markets to estimate potential changes in market volatility, such as the renminbi non-deliverable forward market.

High oil prices feature prominently in a number of stress test scenarios, including some of the economic outlook tests. The way most firms are choosing to look at the scenario of increased oil prices is to fit this into a macroeconomic framework and assess its impact on the broader economy, or, in the case of the loan book, on particular industries (Table 4c in Appendix 1). In a number of scenarios, the backdrop to the scenarios is rising geopolitical tension in the Middle East, or an act of terrorism. Oil-related historical events, such as the 1973-74 oil price shock, the Iraqi invasion of Kuwait in 1990, the subsequent Gulf war and the Iraq war in 2003, are sometimes being used to inform the development of these hypothetical scenarios. This is consistent with the more general development of an increase in the use of hybrid scenarios.

The running of property price scenarios was generally confined to markets that were either experiencing a property price boom, or had been subject to quite wide fluctuations in property prices in the past (Table 4d in Appendix 1). More generally, it is noticeable that, even among hypothetical scenarios with a common theme, the economic backdrops underpinning the scenarios are quite different, the parameters of interest vary, and there is a range of periods of interest.

Sensitivity tests

Consistent with the previous survey, movements in interest rates are the most common simple sensitivity test theme, with tests based on equities and foreign exchange much less evident (Table 5 in Appendix 1). In terms of interest rates, parallel shifts predominate, though there are a number of tests involving changes in the shape of the yield curve. Similar to the previous survey, half of all tests including interest rates as a risk factor specify an increase, compared with only 14% specifying a decline. The remainder test in both directions. The weighting towards increases may reflect the net long duration position that these firms tend to run. Half of the equity sensitivity tests that firms are running specify a fall in equity prices; only 12% of scenarios incorporated an increase. Tested movements in currencies against the US dollar were more evenly balanced, though they generally favoured a decline in the US dollar.

Frequency of running stress tests and frequency of revision

Test frequency statistics suggest that historical and sensitivity tests are run more frequently than hypothetical scenarios (Table 6 in Appendix 1): 92% of historical tests were run at least once a month; similarly, 74% of sensitivity tests were run over the same period. In contrast, a little more than half the hypothetical tests were run at least once a month, with more than one quarter of these tests run at an annual frequency. The lower frequency may reflect the more complex and situation-specific nature of hypothetical scenarios. Consistent with the observation that the performance of particular stress test scenarios over time is informative, the statistics on when the stress tests were last revised suggest that historical and sensitivity tests are revised relatively infrequently (Table 7 in Appendix 1).

Developments by firm type

As noted previously, in this survey firms were split into two categories - global dealer firms and other firms - in order to facilitate peer group comparisons. Each reporting firm was classified by its national central bank. Of the 64 firms participating in the survey, 21 institutions from six different countries were nominated as global dealer firms; the remainder were mainly internationally active firms, though they were not active across all market segments. The main distinguishing feature of global dealer firms was that nearly half of the stress tests reported by them were based on hypothetical scenarios, with the remainder split fairly evenly between historical stress tests and sensitivity tests. In contrast, more than half the stress tests being run by other firms were sensitivity tests (Tables 1b and 1c in Appendix 1).

Consistent with the greater complexity of their businesses (such as options trading) and their greater coverage across product lines and geographical regions, global dealer firms were more likely to be running global scenarios and include volatility and the term structure of volatility in different markets in their stress tests. (Tables 2b and 2c in Appendix 1). Global dealer firms were giving equal weight to credit and interest rate scenarios - both accounted for just under 30% of total stress tests run by global dealer firms - whereas stress tests of other firms predominantly related to interest rates (more than 40% of the total). In comparison with the 2000 survey, the most noticeable development for global dealer firms was a reduction in the share of equity market-related scenarios. A similar trend, though somewhat less marked, was also evident for other firms.

In terms of stress test practice, global dealer firms were more likely to be using stress tests as the basis for the assignment of economic capital and applying market risk stress testing techniques to all credit exposures (see below). Similar generalisations were harder to make for other firms, though it was noticeable that some firms were quite innovative in addressing problems specific to local markets, particularly in relation to emerging markets.

4. Specific issues

4.1 The treatment of credit risks

One area that arose repeatedly in discussions on stress tests with reporting firms and market practitioners was the need to develop better stress tests incorporating loan portfolios. The risks associated with loan portfolios represent the greatest threat to the viability of many banks, and it was felt that developments in this area lagged those in the market risk area by a large margin.

Stress testing of credit risks by firms is largely confined to two main types of testing: stress testing of credit spreads in trading books, such as swap spreads, corporate bond spreads and credit default swap (CDS) spreads; and the independent (and infrequent) stress testing of loan books and other credit exposures. The stress testing of credit spreads in trading portfolios is reasonably straightforward as the availability of a market price means that one variable - the credit spread - can be used to produce a mark to market value. In the separate stress testing of loan books, loan-related variables such as the probability of default, recovery rates, collateral values, rating migration probabilities and internal ratings assigned to borrowers are stressed. These scenarios are often underpinned by a shock to the macroeconomic environment.

Notwithstanding the common source of risk, efforts to develop integrated credit stress tests for both trading and loan books have been hindered by a number of factors such as: differences in accounting treatment; a lack of trading markets for certain products; and/or the organisational structure of firms, including differences in technology platforms. At the most basic level, some firms lack the system infrastructure to generate an integrated risk profile, or have an insufficient history of aggregated data.

One type of risk management exercise that is being undertaken in order to overcome such issues is based on a mark to market framework. This is a methodological extension of the market risk stress testing of trading portfolios to all credit exposures. But the marking to market of credit exposures, other than those associated with trading portfolios, is a difficult task. All credit exposures, including loans, counterparty risk for derivatives transactions and undrawn commitment lines, have to be quantified; a risk rating needs to be assigned to each obligor; and credit spreads have to be estimated in order to calculate present values. When this mark to market evaluation deviates from the disclosed accounting treatment - loans are normally accounted for on an accrual basis - a shadow set of accounts needs to

be kept for management purposes (managerial accounting). Accordingly, this technique requires substantial effort and IT resources.

In practical terms, the difficulty faced by commercial banks was evident when their practices were compared with those of securities firms. In contrast to commercial banks, securities firms are more able to rely on market prices to value much of their credit portfolios. These portfolios have a high proportion of traded credit instruments, such as corporate bonds and CDSs. On the other hand, most commercial banks have a large traditional loan portfolio, the majority of which is normally with unrated borrowers, including many small and medium-sized enterprises. The proportion of the portfolio which can be readily marked to market is normally very small.

For those firms pursuing a mark to market framework, various sources are used to value loan portfolios. For the credit risk attaching to larger corporates, firms may use CDS or corporate bond prices to obtain a reasonable estimate of credit spreads if loan prices are not available. For other listed companies, equity prices may be used to derive relevant credit parameters. For unrated and unlisted counterparties to whom they lend and/or with whom they have counterparty credit relationships, internal models are used to map internal credit ratings and other parameters to credit spreads of other corporates of similar standing, leading directly or indirectly to the estimation of credit spreads. Once this framework is established, it becomes relatively easy for the firm to run integrated evaluations as market-based credit spreads are readily available and easy to handle, particularly in comparison with estimations of the probability of default and loss-given-default.

This methodology, however, has a number of drawbacks. First, as noted above, there may be a difference between the accounting and economic treatment of credit risks embedded in loans. Second, in some markets information on credit spreads may not be readily available, or what information there is may be too volatile or transaction-specific - because of illiquid markets - to be of any use for producing meaningful results. In a similar vein, it is also not clear how common stress tests across both traded credit products and loan portfolios should be utilised given the varying time horizons for different assets.

4.2 Integration

In general, risk managers are striving for a more integrated risk management framework. At a very basic level, the separation of risk management functions has proved problematical for some institutions: the stress testing of trading portfolios, loan books, funding liquidity and operational risk is often undertaken in different areas of a firm, making internal consistency across integrated scenarios difficult.

As noted previously, even the integration of credit and market risks remains a long way off for many firms. A number of risk managers viewed it as an area that needs development over the medium term. Nonetheless, there is not universal agreement that stress tests should be common across all books, as some scenarios that are appropriate for credit books might not be appropriate for market books, and vice versa. This dichotomy also applies to the consistent application of stress testing by financial conglomerates across banking, life insurance and wealth management operations. Market practitioners noted that, in order to gain momentum on these initiatives, it was important to establish some form of shadow marking to market of non-traded portfolios across the firm. This would encourage a firm-wide focus on economic capital and would eventually promote broader management support.

The development of markets such as the CDS market and the secondary loan market has been very helpful in respect of data availability and transparency in a limited number of markets. This aids the marking to market of portfolios as credit risk factors are reduced to a credit spread. The increased integration of these markets into risk management frameworks may also have an added benefit of amplifying market liquidity by encouraging the use of these products.

Much of the increased coverage and complexity of stress tests since the last survey in 2000 was attributed by the market practitioners to enhanced IT capabilities. Nonetheless, the demands of integrated risk management on IT capacities remain intense, particularly in an environment in which interested parties - senior managers, business lines and risk managers - are seeking to incorporate more scenarios, an increased number of risk factors and a higher frequency of testing. At the same time, a practical problem for institutions remains the range of IT platforms within organisations. Some progress has been made, particularly in the area of data warehousing facilities, but it remains a significant issue for loan-related risks.

4.3 Market liquidity

The treatment of market liquidity was identified as a key issue in the stress testing survey conducted by the CGFS in 2000. It appears, however, that only limited progress has been made, reflecting significant challenges in this area. Some of the ways in which firms incorporate liquidity effects into stress test scenarios are:

- liquidity effects are incorporated to the extent that scenarios are based on historical moves - directly in the case of historical scenarios and historical sensitivity tests, and indirectly for hypothetical scenarios based on historical data;
- holding periods are extended; or
- historical moves are inflated by a factor so as to take into account illiquidity in particular markets. One firm, for example, spoke of a “general liquidity adjustment for shocks in order to account for re-balancing of derivative portfolios” and applied a larger change to illiquid product prices.

Some firms split risk factors into groups according to liquidity profile. An appropriate liquidity horizon is then attributed to each group. This is a particularly important distinction for those institutions involved in emerging markets. For those institutions covering very illiquid assets, such as property or unlisted equities, expected losses need to be covered by capital in the form of provisions (thereby obviating the need to sell the asset); as a result, a much longer period, such as half a year, might be assumed to verify that there is enough capital to cover the risk. Another variation is that for each scenario multiple periods are examined, such as a one-day move, a movement to worst and a movement until stabilisation. Some efforts are also under way which examine bid-ask spreads in particular markets and what could realistically be sold in a stressed market environment.

Feedback effects, such as the possible amplification of a negative market trend owing to loss-cutting transactions by the institutions themselves, are recognised by firms but are not yet explicitly incorporated in hypothetical scenarios. Implicitly, they may be folded into assumptions about market liquidity.

An unanticipated exit of a major market player is treated as one of the risk sources which could cause market turbulence. Not many institutions, however, are running this type of scenario. Those firms that are running these scenarios are mainly focusing on the withdrawal of the major market player from a particular market, rather than the failure of a major market-maker. A few firms mentioned the possibility of a central bank response when financial markets face crisis.

4.4 Funding liquidity

A little under one third of the firms reported running funding liquidity scenarios in the survey. However, follow-up interviews with risk managers suggest that most institutions are running this type of scenario, but because of a separation of risk management functions between asset and liability managers, some of these scenarios may not have been reported. Of the scenarios that were reported, most were well articulated, with the funding crisis coming from a variety of sources, such as a ratings downgrade or an expectation of a downgrade - leading to an increase in funding costs and/or a reduction in the availability of foreign currency funding - a sharp increase in the drawdown of commitments by borrowers, or a sudden change in the composition of deposits. Most of these scenarios were based around a firm-specific event, which does not necessarily have systemic implications.

Other stress tests of funding liquidity were more closely related to operational risks, with these stress tests ranging from a location-specific event in a major financial centre, through to the risks associated with an event that has an adverse impact on a firm-specific critical location. Some of these tests explicitly recognise that even a small amount of “trapped” liquidity can have a serious impact on system-wide liquidity and draw strongly from historical experience, such as the terrorist attacks in the United States in 2001.

5. Conclusions

Stress testing is becoming more integrated into risk management frameworks at firms, particularly the management of market risks. This has occurred because stress testing practice has evolved in a way which is meeting the demands of senior management, business units and third parties such as investors. Stress tests remain an important (and intuitive) tool for risk managers to communicate with senior management about risk exposure, and in turn an important way for senior management to communicate a firm's risk appetite with disparate parts of large financial firms. Details of stress test programmes now form an integral part of risk management practices that are outlined in the public releases for a large number of firms. Stress tests are often being used to set exposure limits, and in some cases allocate economic capital, particularly in markets where VaR is of limited value, such as markets with non-linear exposures, or markets subject to frequent price gapping. Nonetheless, even in cases where stress tests are being used to allocate economic capital, qualitative assessments are still being made. Stress tests are also being used to explore the risks associated with regime shifts, funding liquidity and the impact that a stressed environment would have on business plans.

There is no ideal framework or single exponent of best practice on stress testing, and industry practices still vary widely. This reflects not only the varying levels of sophistication across institutions but, more importantly, the different risk profiles of the firms, the availability of transparent data and, notably, the degree to which there is an alignment of interests between senior management and business lines. Some of the technological and data hurdles are being overcome, marked by progress on the introduction of common platforms within and across business units and the increased availability of transparent data. However, the cost and availability of data warehousing remain a hurdle, particularly in the area of credit risk management.

Of particular note, loan books are gradually becoming the subject of stress tests, although this development is at a relatively early stage compared with the stress testing of traded market portfolios. In addition to providing efficient risk hedging tools which enhance the management of credit risks carried by financial institutions on loan books, the gradual deepening of the credit default swap market has provided the wherewithal to value some loan portfolios, albeit for a limited range of countries. Nonetheless, the integration of market risk and credit risk embedded in loan books remains some way off for most firms, hindered by an inability to mark to market some portfolios, different holding periods and a division of risk management responsibilities within organisations. More generally, the work of the group supports the notion that the ongoing development of financial markets is an important building block for the further development of risk management capabilities.

The increased integration of stress testing into risk management frameworks at financial institutions has important implications for financial markets. At the institutional level, the incorporation of information about stress events should be leading to better informed decision-making by financial institutions. From a systemic perspective, the adverse consequences of these events may therefore be reduced. In addition, how the financial system (including financial markets) responds to variations in the likelihood of specific events occurring has changed since individual institutions are taking into account information about a wide range of possible scenarios and, where it is deemed prudent, taking action to avoid the adverse consequences of these events. Accordingly, it is important that the overall consequences of risk management practices at financial institutions be well understood. This review of stress test practices is one part of that effort.

Appendix 1: Tables

Table 1a

Scenario types - All firms

Number of tests

	Interest rates	Equities	FX	Commodities	Credit	Property	Other	Multiple	Total
Historical	92	50	30	2	32	1	5	na	212
Hypothetical	81	36	26	20	72	18	40	na	293
Sensitivity	184	44	60	15	70	13	21	51	458
Total	357	130	116	37	174	32	66	51	963

Table 1b

Scenario types - Global dealer firms

Number of tests

	Interest rates	Equities	FX	Commodities	Credit	Property	Other	Multiple	Total
Historical	17	5	12	0	17	0	3	na	54
Hypothetical	28	17	12	12	34	3	18	na	124
Sensitivity	24	14	7	1	27	1	5	5	84
Total	69	36	31	13	78	4	26	5	262

Table 1c

Scenario types - All other firms

Number of tests

	Interest rates	Equities	FX	Commodities	Credit	Property	Other	Multiple	Total
Historical	75	45	18	2	15	1	2	na	158
Hypothetical	53	19	14	8	38	15	22	na	169
Sensitivity	160	30	53	14	43	12	16	46	374
Total	288	94	85	24	96	28	40	46	701

Table 2a
Scenarios (by region) - All firms

Number of tests

	North America	Europe	Japan	Non-Japan Asia (NJA)	Emerging markets (excl NJA)	Other	Global	Total
Historical	73	19	12	27	25	7	49	212
Hypothetical	51	28	18	57	20	40	79	293
Sensitivity	62	39	20	40	3	45	249	458
Total	186	86	50	124	48	92	377	963

Table 2b
Scenarios (by region) - Global dealer firms

Number of tests

	North America	Europe	Japan	Non-Japan Asia (NJA)	Emerging markets (excl NJA)	Other	Global	Total
Historical	22	3	0	5	7	1	16	54
Hypothetical	21	15	1	14	11	15	47	124
Sensitivity	2	12	1	1	2	0	66	84
Total	45	30	2	20	20	16	129	262

Table 2c
Scenarios (by region) - All other firms

Number of tests

	North America	Europe	Japan	Non-Japan Asia (NJA)	Emerging markets (excl NJA)	Other	Global	Total
Historical	51	16	12	22	18	6	33	158
Hypothetical	30	13	17	43	9	25	32	169
Sensitivity	60	27	19	39	1	45	183	374
Total	141	56	48	104	28	76	248	701

Table 3a

Historical and hypothetical scenarios - by type of asset¹

Category	Historical²	Hypothetical
Interest rates (173)	1994 - bond market sell-off 1997 - Asian financial crisis 1998 - incl LTCM, Russia and Japan 2001 - terrorist attacks in the United States 2003 - bond market sell-off	US economic outlook, incl monetary policy (21) Global economic outlook (11) Increase in inflation expectations (8) China (6) Japanese monetary policy (6)
Equities (86)	1987 - Black Monday 1997 - Asian financial crisis 2000 - bursting of IT bubble 2001 - terrorist attacks in the United States	Geopolitical unrest (5) Terrorist attack (5) Global economic outlook (4)
FX (56)	1992 - EMS crisis 1997 - Asian financial crisis 1998 - incl Russia	Collapse of currency pegs (7)
Commodities (22)		Oil price scenario (11) Geopolitical unrest in the Middle East (6)
Credit (104)	1997 - Asian financial crisis 1998 - incl Russia 2001 - terrorist attacks in the United States	Emerging market economic outlook, incl default (10) Euro area economic outlook (7) Global economic outlook (6) Natural disaster (4) China, incl a change in currency arrangements (4) US government-sponsored enterprises (4) Terrorist attack (4)
Property (19)		Fewer than three per hypothetical episode
Other (45)		Bank funding (23) Global economy (4)

¹ Bracketed figures refer to the number of scenarios. ² Historical episodes with more than three references.

Table 3b

Historical and hypothetical scenarios - by region¹

Region	Historical²	Hypothetical
Europe (47)	1992 - EMS crisis	Euro area economic outlook (10)
Japan (30)	1998 - Japan	Japanese economic outlook, incl monetary policy (8) Japanese financial system (4)
North America (124)	1987 - Black Monday 1994 - bond market sell-off 2001 - terrorist attacks in the United States 2003 - bond market sell-off	US economic outlook, including monetary policy (23) US government-sponsored enterprises (4) Inflation expectations (4)
Asia, excl Japan (84)	1997 - Asian financial crisis	China (10) Change in currency arrangements (9) Geopolitical developments in Asia (8) Funding liquidity (7) Asian economic outlook (4) Natural disaster (4)
Other emerging markets (45)	1994 - Mexico 1998 - Russia	Emerging market economic outlook, incl default (12)
Other (47)	1990 - Gulf war 2003 - Iraq war	Geopolitical developments in the Middle East (12) Oil (7) Funding liquidity (4) Terrorist attack (3)
Global (128)	1994 - bond market sell-off 1998 - incl LTCM and Russia 2000 - bursting of information technology bubble	Global economic outlook (22) Terrorist attack (7) Funding liquidity (7) Inflation expectations (5) Capital flight (3)

¹ Bracketed figures refer to the number of scenarios. ² Historical episodes with more than three references.

Table 4a
Terror scenarios

Scenario background	Tenor	Interest rate					Equity					FX	Credit			Macro factor	Other factors	No of firms	No of scenarios
		US	Eur	JP	Asia	Other	US	Eur	JP	Asia	Other		Swap sprd	Credit sprd	Other factors				
Historical																			
2001-terror (shorter than 2 weeks)	Immediate to 2W	short ↓ long ↓	short ↓ long ↑	↓	↓		↓	↓	↓	↓		USD ↓	↑	↑			Vol ↑ YC flattens	25	26
2001-terror (longer than 2 weeks)	2W to 5M	short ↓ long ↓	short ↓ long ↑	short ↓ long ↑			↓	↓	↓	↓		USD ↓	↑	↑			Oil ↑ Emerging spread ↑	4	4
Hypothetical																			
NYC/major city terror	1D to 10D	↓	↓	↓		local ↓	↓	↓	↓		local ↓	USD ↓					Vol ↑ YC flattens	8	9
Local terror	1D to 3D, 3M (real estate)	↓				local ↓	↓				local ↓	local ↓					Real estate ↓ (3 months)	1	2
Middle East terror	n/a, 10D	↓					↓										Vol ↑ Oil ↑	2	2
Terror (long-term effect)	1Y											local ↓		↑	PD ↑ Specific country credit down	GDP ↓ Unemp ↑	Vol ↑	3	3

Notes to Tables 4a-d appear after Table 4d.

Table 4b
China

Scenario background	Tenor	Interest rate			Equity			FX	Credit		Macro factor	Other factors	No of firms	No of scenarios
		US	JP	Asia	JP	Asia	Other		Credit sprd	Other factors				
Hard landing	n/a, or 6M to 1Y	↓	↓	↑	↓	↓	↓ ¹	pegged ²	↑		GDP (US/EU) ↑ GDP (JP/Asia) ↓	YC steepens ³	4	4
Soft landing	n/a				↓	↓	↓ ¹				GDP (JP/Asia) ↑	Oil ↑	1	1
Currency revaluation	n/a, or 1D			↑		↓		JP/Asia ↑	↑			YC flattens	2	2
Currency devaluation	n/a			CNY ↑ ⁴									1	1
Corporate sector down	n/a, or 1Y									Drawdown of line of credit ↑			2	2

Notes to Tables 4a-d appear after Table 4d.

¹ Australian equities. ² Asian currencies pegged to USD. ³ For both non-Asian and Asian interest rates. ⁴ Short-term rises larger than long-term.

Table 4c
Oil price rise scenarios

Scenario background	Tenor	Interest rate				Equity					FX	Credit			Macro factor	Other factors	No of firms	No of scenarios
		US	Eur	JP	Asia	US	Eur	JP	Asia	Other		Swap sprd	Credit sprd	Other factors				
Combined with inflation	Immediate to 1Y	↑	↑	↑		↓	↓				USD ¹ ↓					YC steepens	5	5
Combined with recession	2M to 1Y	↓			↓						USD ¹ ↓				GDP ↓ Unemp ↑	YC flattens	2	2
Terror origin	n/a	↓	↓			↓	↓				USD ↓	↑	↑			Int vol ↑ Oil/Gas ↑	1	1
Credit scenario	n/a or 1Y												↑ ²	PD ↑ Country risk ³			4	4
Commodity scenario	Immediate to 10D															Oil ↑ Oil vol ↑	2	2

Notes to Tables 4a-d appear after Table 4d.

¹ Oil-importing country's currency down scenario included. ² Except for the oil producers. ³ Impact on specific countries such as Russia and South Africa.

Table 4d
Real estate

Scenario background	Tenor	Interest rate	Equity (domestic)	Credit				Macro factor		Property price ¹	Other factors	No of firms	No of scenarios
		Mortgage		Credit sprd	PD	LGD	Others	Unemp	GDP				
Residential/ mortgage	3M to 3Y	↑			↑	↑	Collateral value ↓ Rental income ↓ NPL ↑ Provision ↑	↑		↓		8	11
Regulator driven	6M to 1Y				↑	↑	Mortgage insurance recoveries ↑			↓		4	8
Real estate as collateral or real estate only ²	n/a, or 1Y						Collateral value ↓			↓		2	2
Loan parameter effect	n/a, or 2Y				↑	↑				↓		4	4
Loan accounting effect	3M to 1Y		↓				NPL ↑ Provision ↑		↓	↓	No of bankruptcy filings ↑	4	5
Effects on financial markets	Instantaneous		↓	↑							YC flattens	1	1

Notes to Tables 4a-d: ↑ = increase in variable of interest, such as interest rate, equity prices or widening of spreads; ↓ = decrease in variable of interest, such as interest rate, equity prices or narrowing of spreads; Unemp = unemployment rate; Sprd = spread(s); Vol = volatility; PD = probability of default; LGD = loss-given-default; YC = yield curve; Tenor = Y - year(s); M - month(s), D - day(s); n/a = not applicable; CNY = Chinese renminbi; NPL = non-performing loans; GDP = gross domestic product.

¹ The magnitude of the fall in property prices is generally set at between 10 and 40%, mostly at either 20% or 30%. ² These scenarios examine the effect of a fall in property prices on either collateral values or the effect on direct holdings of real estate.

Table 5
Simple sensitivity tests¹

Share of tests (%)

	↑	↓	↑↓	not specified
Interest rates (153 tests)	50	14	31	5
Equities (40 tests)	12	50	20	18
Currency - USD (47 tests)	15	26	51	8

¹ Excludes sensitivity tests using historical data.

Table 6
Frequency of running scenarios - All firms

Number of tests (share of total, %)

	Daily	Weekly	Monthly	Quarterly	Six-monthly	Annually	Ad hoc	Total
Historical	72 (34)	43 (20)	80 (38)	9 (4)	5 (2)	2 (1)	1 (0)	212 (100)
Hypothetical	63 (22)	44 (15)	59 (20)	26 (9)	5 (2)	69 (24)	27 (9)	293 (100)
Sensitivity	118 (26)	105 (23)	116 (25)	29 (6)	11 (2)	76 (17)	3 (1)	458 (100)
Total	253 (26)	192 (20)	255 (26)	64 (7)	21 (2)	147 (15)	31 (3)	963 (100)

Table 7
Last revised - All firms

Number of tests (share of total, %)

	Within 1 month	2-3 months	4-6 months	7-12 months	Longer than 12 months	Total
Historical	25 (12)	21 (10)	31 (15)	35 (17)	100 (47)	212 (100)
Hypothetical	93 (32)	51 (17)	47 (16)	32 (11)	70 (24)	293 (100)
Sensitivity	84 (18)	88 (19)	63 (14)	38 (8)	185 (40)	458 (100)
Total	202 (21)	160 (17)	141 (15)	105 (11)	355 (37)	963 (100)

Appendix 2: Additional tables

Table 8

Summary survey statistics

	2004	2000
<i>All firms</i>		
Number of participating central banks	16	10
Number of respondent firms	64	43
Number of stress tests	963	424
<i>Global dealer firms</i>		
Number of respondent firms	21	19
Number of stress tests	262	209

Table 9a

Historical scenarios - All firms

Number of tests

	Interest rates	Equities	FX	Commodities	Credit	Property	Other	Multiple	Total
Global	27	8	2	0	11	0	1	0	49
North America	30	29	2	0	8	0	4	0	73
Europe	4	2	11	0	2	0	0	0	19
Japan	8	2	1	0	1	0	0	0	12
Asia (excl Japan)	7	5	10	0	4	1	0	0	27
Other emerging	13	2	4	0	6	0	0	0	25
Other	3	2	0	2	0	0	0	0	7
Total	92	50	30	2	32	1	5	0	212

Table 9b

Historical scenarios - Global dealer firms

Number of tests

	Interest rates	Equities	FX	Commodities	Credit	Property	Other	Multiple	Total
Global	7	0	1	0	8	0	0	0	16
North America	7	4	2	0	6	0	3	0	22
Europe	0	0	3	0	0	0	0	0	3
Japan	0	0	0	0	0	0	0	0	0
Asia (excl Japan)	1	1	3	0	0	0	0	0	5
Other emerging	1	0	3	0	3	0	0	0	7
Other	1	0	0	0	0	0	0	0	1
Total	17	5	12	0	17	0	3	0	54

Table 9c

Historical scenarios - All other firms

Number of tests

	Interest rates	Equities	FX	Commodities	Credit	Property	Other	Multiple	Total
Global	20	8	1	0	3	0	1	0	33
North America	23	25	0	0	2	0	1	0	51
Europe	4	2	8	0	2	0	0	0	16
Japan	8	2	1	0	1	0	0	0	12
Asia (excl Japan)	6	4	7	0	4	1	0	0	22
Other emerging	12	2	1	0	3	0	0	0	18
Other	2	2	0	2	0	0	0	0	6
Total	75	45	18	2	15	1	2	0	158

Table 10a
Hypothetical scenarios - All firms

Number of tests

	Interest rates	Equities	FX	Commodities	Credit	Property	Other	Multiple	Total
Global	28	18	3	6	14	1	9	0	79
North America	24	8	3	1	9	1	5	0	51
Europe	3	1	3	0	12	5	4	0	28
Japan	11	2	1	0	1	0	3	0	18
Asia (excl Japan)	8	3	13	0	16	5	12	0	57
Other emerging	2	1	2	1	13	0	1	0	20
Other	5	3	1	12	7	6	6	0	40
Total	81	36	26	20	72	18	40	0	293

Table 10b
Hypothetical scenarios - Global dealer firms

Number of tests

	Interest rates	Equities	FX	Commodities	Credit	Property	Other	Multiple	Total
Global	12	12	2	4	9	0	8	0	47
North America	7	0	2	0	6	1	5	0	21
Europe	2	0	3	0	5	2	3	0	15
Japan	0	0	0	0	0	0	1	0	1
Asia (excl Japan)	3	2	4	0	5	0	0	0	14
Other emerging	2	1	1	1	5	0	1	0	11
Other	2	2	0	7	4	0	0	0	15
Total	28	17	12	12	34	3	18	0	124

Table 10c

Hypothetical scenarios - All other firms

Number of tests

	Interest rates	Equities	FX	Commodities	Credit	Property	Other	Multiple	Total
Global	16	6	1	2	5	1	1	0	32
North America	17	8	1	1	3	0	0	0	30
Europe	1	1	0	0	7	3	1	0	13
Japan	11	2	1	0	1	0	2	0	17
Asia (excl Japan)	5	1	9	0	11	5	12	0	43
Other emerging	0	0	1	0	8	0	0	0	9
Other	3	1	1	5	3	6	6	0	25
Total	53	19	14	8	38	15	22	0	169

Table 11a

Sensitivity tests - All firms

Number of tests

	Interest rates	Equities	FX	Commodities	Credit	Property	Other	Multiple	Total
Global	101	30	36	3	33	1	7	38	249
North America	36	7	3	8	6	0	1	1	62
Europe	17	3	4	1	10	0	1	3	39
Japan	6	2	6	0	3	1	0	2	20
Asia (excl Japan)	16	1	5	0	5	5	4	4	40
Other emerging	1	0	0	0	2	0	0	0	3
Other	7	1	6	3	11	6	8	3	45
Total	184	44	60	15	70	13	21	51	458

Table 11b
Sensitivity tests - Global dealer firms

Number of tests

	Interest rates	Equities	FX	Commodities	Credit	Property	Other	Multiple	Total
Global	15	14	6	0	21	1	4	5	66
North America	2	0	0	0	0	0	0	0	2
Europe	5	0	0	1	5	0	1	0	12
Japan	1	0	0	0	0	0	0	0	1
Asia (excl Japan)	0	0	1	0	0	0	0	0	1
Other emerging	1	0	0	0	1	0	0	0	2
Other	0	0	0	0	0	0	0	0	0
Total	24	14	7	1	27	1	5	5	84

Table 11c

Sensitivity tests - All other firms

Number of tests

	Interest rates	Equities	FX	Commodities	Credit	Property	Other	Multiple	Total
Global	86	16	30	3	12	0	3	33	183
North America	34	7	3	8	6	0	1	1	60
Europe	12	3	4	0	5	0	0	3	27
Japan	5	2	6	0	3	1	0	2	19
Asia (excl Japan)	16	1	4	0	5	5	4	4	39
Other emerging	0	0	0	0	1	0	0	0	1
Other	7	1	6	3	11	6	8	3	45
Total	160	30	53	14	43	12	16	46	374

Table 12
Historical stress tests

Event cited	Number of tests
Oil crisis in 1973-74	1
Black Monday, October 1987	23
Californian earthquake in 1989	1
Emerging market crisis in 1990	1
German unification in 1990	1
Gulf war in 1990-91	5
Nikkei stock price correction in 1990 in Japan	1
1991 coup attempt in Russia	1
Emerging market crisis in 1992	1
European currency crisis in 1992	8
Italian recession in 1992	1
European currency crisis in 1993	1
European recession in 1993	1
Global bond price crash in 1994	18
Increase in US official interest rates in 1994	2
Mexican peso crisis in 1994	5
Yield curve shape change in 1994	2
European bond price decline in 1995	2
US dollar rally in July-August 1995	1
Rate increase in 1995 in Japan	1
Latin American market in 1995	1
Improvement in economic outlook and official interest rate rise in United States in Mar 1996	1
1997 Asian crisis (currency devaluation and credit deterioration)	22
1997 - no specific event mentioned	1
Currency intervention to support HKD in 1997	1
Japanese financial system crisis, including bankruptcy of Yamaichi Securities and/or Hokkaido Takushoku Bank in 1997	1
Asian stock market crash in 1998	1
Sharp one-day sell-off of USD against JPY in 1998	3
1998 - no specific event mentioned	1
Financial crisis in Japan in 1998, including nationalisation of LTCB/NCB	2
JGB sell-off triggered by the news of halt of JGB purchases by Trust Fund Bureau in 1998	3
1998 10/7 - LTCM crisis	8
1998 August-Russian debt default and currency devaluation	15
1998 - combined LTCM/Russia event	13
Brazilian real crisis in 1999	1
Emerging market stock price decline in 2000	1
Stock price decline observed globally in 2000	4
Credit spread widening due to syndicated loan credit deterioration in United States in 2000	2
Argentine bond spread widening in 2001	1
Terrorist attacks in the United States in September 2001	30
ABS spread widening in 2002	1
Accounting problems in United States in 2002	3
EURO STOXX decline in July 2002	1
2002 - no specific event mentioned	1
JGB sell-off triggered by undersubscription at JGB auction in 2002	1
US interest rate rise observed in 2003	4
Smaller than expected US monetary policy change in 2003	2
Accounting problems of US government-sponsored enterprises in 2003	1
Hostilities in Iraq in 2003-04	3
Outbreak of SARS in 2003	1
Italian equity price fall in 2004	1
Terrorist attack in Madrid in March 2004	1
Unidentified	3

Table 13
Risk factors - Global dealer firms¹

	Historical		Hypothetical		Sensitivity		Total	
	Number	Share (%)	Number	Share (%)	Number	Share (%)	Number	Share (%)
Scenarios	54		124		84		262	
Risk factors	672		931		253		1,856	
Avg per scenario	12		8		3		7	
Scenarios, incl:								
– interest rates	40	74	63	51	29	35	132	50
– interest rate vol	12	22	21	17	7	8	40	15
– equities	39	72	47	38	14	17	100	38
– equity vol	17	31	19	15	13	15	49	19
– Fx	35	65	42	34	13	15	90	34
– Fx vol	11	20	15	12	7	8	33	13
– commodities	0	0	23	19	1	1	24	9
– comm vol	0	0	10	8	0	0	10	4
– credit	29	54	64	52	27	32	120	46

¹ “Global dealer firms” are banks and securities firms that are active worldwide across all market segments, including derivatives markets.

Appendix 3: List of financial institutions participating in the survey

The following institutions participated in the stress test exercise (in alphabetical order):*

ABN Amro Holding NV	Hang Seng Bank Ltd
ANZ Bank	Hongkong and Shanghai Banking Corporation Ltd
Banco Bilbao Vizcaya Argentaria	HSBC Bank plc
Banco Santander Central Hispano	ING Bank NV
Bank of America, NA	JPMorgan Chase and Co
Bank of China (Hong Kong) Ltd	Kookmin Bank
Bank of East Asia Ltd	Korea Development Bank
Bank of Montreal	Lloyds TSB
Bank of Nova Scotia	Merrill Lynch & Co Inc
The Bank of Tokyo-Mitsubishi, Ltd	Mizuho Bank, Ltd
Barclays Capital	Mizuho Corporate Bank, Ltd
Bayerische Hypo- und Vereinsbank AG	Mizuho Financial Group, Inc
Bear, Stearns and Co Inc	Morgan Stanley
BNP Paribas	NAB
Canadian Imperial Bank of Commerce	National Bank of Canada
Capitalia Gruppo Bancario	Nippon Life Insurance Company
Caxton Associates, LLC	Nordea AB
CBA	The Norinchukin Bank
CCF	Oversea-Chinese Banking Corporation Limited
Citigroup, Inc	Rabobank International
Commerzbank AG	Royal Bank of Canada
Credit Suisse Group	The Royal Bank of Scotland Group
Daiwa Securities SMBC Co. Ltd	SEB AB
DBS Bank (Hong Kong) Ltd	Shinhan Bank
DBS Bank Limited	Société Générale
Deutsche Bank AG	Standard Chartered Bank (HK) Ltd
Dresdner Bank AG	Sumitomo Mitsui Banking Corporation
DZ Bank AG Deutsche Zentral-Genossenschaftsbank	TD Bank Financial Group
Fortis Bank SA/NV	Tokio Marine & Nichido Fire Insurance Co, Ltd
The Goldman Sachs Group, Inc	UBS
Groupe Crédit Agricole	UFJ Bank Limited
Gruppo Banca Intesa	United Overseas Bank Limited
Gruppo Bancario Sanpaolo IMI	Westdeutsche Landesbank Girozentrale
Gruppo Unicredito Italiano	Westpac Bank
Gruppo Bancario Banca Nazionale Del Lavoro	Woori Bank

* Not all firms participated in the survey part of the exercise.

Appendix 4: Survey reporting form

Instructions

The survey consists of two tables. We would like you to base your answers on current stress tests as of the end of May 2004. Current stress tests include those conducted on, or close to, 31 May 2004, as well as those “one-off” stress tests thought to be of ongoing relevance to your firm’s management activities.

Part A asks you to list “firm-wide” stress test scenarios that capture material risks to your firm at present. Please provide the following information:

- list between five and 20 scenarios. Do not include business-level stress tests, worst case scenario stress tests that add each business unit’s exposure to its own worst-case scenario (rather than a common “firm-wide” scenario), and modified value-at-risk setups (eg VaR at the 99.9% confidence level). Note that we are not asking you to report the calculated results of stress tests conducted by your firm;
- a title for each scenario. If a scenario does not have a formal title, please provide a short description;
- list the type of scenario (historical, hypothetical, or simple sensitivity test);
- for “test frequency” and “last revised”, please state how often the test is conducted and fill in the date on which the scenario was last revised (such as the substitution of a risk factor or a change in the size of the shock or duration) or first introduced if the scenario has not been revised since its introduction;
- in discussing the motivation for a scenario, the Committee is interested in the extent to which each scenario is driven by developments in the real economy, developments in financial markets and/or other factors. In addition, the Committee would be interested in knowing how scenarios may have evolved over time in response to these factors;
- the five scenarios that have received the most attention from senior management (or the risk committee) over the past six months could include: scenarios that have been instituted at the request of senior management; scenarios that are not regularly presented to senior management, but have been presented recently; and scenarios in which senior management have sought variations, such as changes to risk factors. This need not necessarily reflect your firm’s actual exposure; and
- identify any “one-off” or “special” scenarios that your institution has conducted over the past 12 months that continue to be employed in risk assessment exercises. Please provide details of these scenarios if they have not been included in the main listing.

Part B asks you to identify the specific risk factor shocks in each scenario, as well as the size and period over which these shocks occur. It should be possible to determine from the information provided the market risk and liquidity aspects of market disturbances. The following should be observed:

- each risk factor should be listed, together with the direction and magnitude of the move, and the duration;
- provide a brief description for each risk factor; and
- please provide a comment on changes in asset liquidity. The Committee would be interested in knowing whether you model aspects such as the price impact of trades, bid-ask spreads and/or the time needed to liquidate a position. Include any additional comments which you think might help interpretation.

If you have any questions, please refer to the accompanying cover letter for the contact person at your national central bank.

Survey form

Part A

Name of reporting institution:.....

List the stress test scenarios that best capture material risks faced by your firm at present.

Scenario title	Type (Historical, hypothetical or simple sensitivity test)	Test frequency	Last revised*	Briefly discuss the motivation for the scenario

* If not applicable, the date when the scenario was introduced.

Of these scenarios, identify those that have received the most attention from senior management (or the risk committee) over the past six months. This could mean: scenarios that have been instituted at the request of senior management; scenarios that are not regularly presented to senior management, but have been presented recently; or scenarios in which senior management have sought variations, such as changes to risk factors. This need not necessarily reflect your firm’s actual exposure.

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Has your institution conducted any “one-off” or “special” scenarios over the past 12 months? If so, please list below and provide details of these scenarios (if these stress tests have not been listed above).**

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** Please identify those scenarios that have been instigated at the direction of regulators/supervisors.

Appendix 5: Members of the stress test exercise group

Chairperson Bank of Japan	Mr Hiroshi Nakaso
Reserve Bank of Australia	Mr Keith Hall
National Bank of Belgium	Mr Konstantijn Maes
European Central Bank	Mr John Fell
Bank of Canada	Mr Thomas Hossfeld
Bank of France	Ms Florence Verhille
Deutsche Bundesbank	Mr Frank Heid Ms Ingrid Stein
Hong Kong Monetary Authority	Mr Andrew Wu Ms Margaret Leong
Bank of Italy	Ms Antonella Foglia
Bank of Japan	Mr Mahito Uchida Ms Yuko Kawai Mr Takashi Nakayama
Bank of Korea	Mr Kunhyun Cho
Netherlands Bank	Mr Han van der Hoorn
Monetary Authority of Singapore	Ms Lily Chan
Sveriges Riksbank	Mr Patrick Nimander Mr Pontus Aberg
Bank of Spain	Mr Carlos Trucharte
Swiss National Bank	Mr Matteo Facchinetti
Bank of England	Mr Mathias Drehmann
Federal Reserve Bank of New York	Ms Patricia Mosser
Board of Governors of the Federal Reserve System	Mr Matthew Pritsker
Bank for International Settlements	Mr Chris Aylmer Mr Allen Frankel