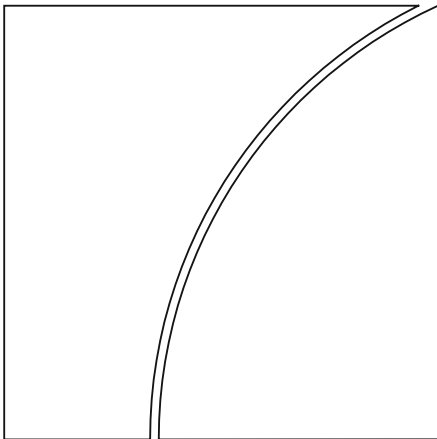


Basel Committee on Banking Supervision



Supervisory and bank stress testing: range of practices

December 2017



BANK FOR INTERNATIONAL SETTLEMENTS

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ISBN 978-92-9259-126-7 (online)



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Executive Summary

This report sets out a range of observed supervisory and bank stress testing practices.¹ It aims to describe and compare these practices and highlight areas of evolution. The practices observed in this report have been used to inform the Basel Committee's review and revision of its May 2009 publication: *Principles for sound stress testing practices and supervision*.²

This report primarily draws on the results of two surveys completed during 2016: (i) a survey completed by Basel Committee member authorities (banking supervisors and central banks), which had participation of 31 authorities from 23 countries; and (ii) a survey completed by 54 respondent banks from across 24 countries, including 20 global systemically important banks (G-SIBs). Case studies, and other supervisory findings, are also included to supplement the results of the surveys by providing more detail on specific aspects of stress testing.

Given the wide and varied application of stress testing, and rapid advances in its methodologies, the meaning of some commonly used stress testing terms can vary depending on the context in which the terms are used across jurisdictions. As a result, a stress testing taxonomy was developed and is set out in Annex 1 of this report. The aim of the taxonomy is to provide common set of definitions for stress testing terms as a way to encourage a common language to aid the dialogue among banks and supervisors in this rapidly evolving area.

The report is divided into two main sections: (i) a section on supervisory stress testing frameworks (Section 2); and (ii) a section on bank stress testing frameworks (Section 3).

Key findings

- In recent years, there has been significant advancement and evolution in stress testing methodologies and infrastructure at both banks and authorities.
- Supervisory authorities and central banks continue to devote more resources to enhance the stress testing of regulated institutions, with most supervisory stress testing exercises being carried out on at least an annual basis. This is resulting in significant progress in how the exercises are performed and how they are incorporated into the banking supervision process.
- Banks have been making improvements to their governance structures, with banks' boards, or delegated committees of boards, taking active roles in reviewing and challenging the results of stress tests, in addition to providing oversight of the overall framework.
- Banks are increasingly looking to leverage the resources dedicated to stress testing frameworks to inform the risk management and strategic planning of the bank. Stress testing frameworks are increasingly integrated into business as usual processes.
- Key challenges that remain for banks include finding and maintaining sufficient resources to run stress testing frameworks, and improving data quality, data granularity and the systems needed to efficiently aggregate data from across the banking group for use in stress tests. For national authorities, greater coordination of stress testing activities across authorities is needed, eg via the exchange information on stress test plans and results through supervisory colleges.

¹ The report was prepared by the Basel Committee's Working Group on Stress Testing, formerly known as the Stress Testing Network.

² The consultative document that sets out the proposed new principles is available at www.bis.org/bcbs/publ/d428.htm.

Supervisory stress testing frameworks

Governance of supervisory stress testing frameworks

Scope and objectives

- Authorities use stress tests to meet different objectives, including capital adequacy assessment or to inform macroprudential policies. Well governed stress testing frameworks include objectives that are clearly articulated at the outset.
- The majority of authorities provide internal guidance on stress testing, but only about one quarter of authorities have published supervisory guidance for their supervisor-run stress tests.

Roles and responsibilities

- Authorities are at different stages of clearly defining the roles and responsibilities for their supervisory stress testing exercises, which in part reflects that countries are at different stages of their overall development of stress testing frameworks.
- Some authorities maintain documentation that articulates, at a high level, the contributions of various participating groups across the organisation. However, a significant number of authorities take a more informal approach, and do not have internal documentation that formally articulates roles and responsibilities for staff involved in supervisory stress tests.

Resourcing

- Nearly all authorities consider obtaining adequate resources to be one of the greatest challenges in implementing a supervisory stress testing framework. Nevertheless, authorities note that they have made significant improvements in this area in recent years.
- Personnel and technical resources are seen by many authorities as the most important drivers to ensure a successful supervisory stress testing process. Staff are required to have skills in a number of areas, including liquidity, credit risk, market risk, capital rules, financial accounting, macroeconomics, supervision, modelling and project management.
- It is difficult to benchmark staff resources given the different organisational structures across authorities, and in particular the fact that many authorities do not have employees whose sole job function is stress testing but instead combine the efforts of staff across many different areas during the stress testing cycle. However, it is clear that resources devoted to stress testing have increased in recent years.

Validation and review

- A number of authorities have identified a quality assurance process as one of the most important drivers of a successful stress testing framework, after planning and resourcing.
- Regarding data availability and quality issues that arise during the validation of supervisory stress tests, authorities have made efforts in recent years to ensure that the lessons learned are also applied more broadly, such as to make improvements to regular internal management reporting.

Feedback and communication

- Communication is a key driver cited by authorities to ensure a successful supervisory stress testing exercise. The type of information that is officially communicated to the participating banks by supervisors typically consists of: the quantitative results; the supervisory

methodologies; and the assessment of the banks' risk identification, measurement, management and governance capabilities in carrying out the stress testing framework.

- While many supervisors publicly disclose aggregated results of stress test exercises and high-level methodology and scenario features, a sizeable minority does not publish any results at all, and very few supervisory authorities disclose bank-specific details or announce follow-up actions.
- There are divergent views and practices among authorities as to whether the individual bank results should be published. Bank-level disclosures can be used to restore confidence in the system in times of crisis, but publication could be counterproductive if undue management attention is diverted towards managing public relations issues associated with stress test outcomes.
- The majority of the supervisory authorities do not have a formal process for coordinating supervisory stress testing frameworks with other domestic authorities. The survey revealed a mixture of formal and informal approaches to coordination.

Use of supervisory stress tests

Microprudential use of supervisory stress tests

- Supervisory stress test results are primarily used by supervisory authorities for reviewing and validating the Internal Capital Adequacy Assessment Process (ICAAP) of banks and their liquidity adequacy assessments.
- Since the global financial crisis, an increasing number of countries assess capital ratio levels under adverse scenarios and use the resulting assessment for evaluating capital adequacy or required capital. However, a wide variety of practices exist.
- Certain supervisor set capital add-ons for banks by using rules-based methods based solely on stress tests (eg by benchmarking against formal hurdle rates). Those authorities which require add-ons based on stress tests mostly employ a combination of formal process and supervisory judgment. A few jurisdictions have a more rules-based treatment.
- It is less common for supervisors to use outputs from stress tests for other purposes than those related to capital/liquidity assessments. Nevertheless, some supervisors review and challenge banks' business plans or banks' recovery plans on the basis of stress test findings.

Macroprudential use of supervisory stress tests

- Stress tests are increasingly used to calibrate macroprudential measures and supervisory policy changes. Other macroprudential uses are early warning exercises to identify potential weaknesses of the system and enhance crisis management plans.
- Macroprudential stress tests are increasing in importance as a way of assessing the financial resilience of banking systems, as they can allow for a more direct assessment of feedback loops, amplification mechanisms and spillovers. These important effects are most frequently assessed via top down approaches.

Supervisory stress testing methodologies

Scenario design and risk coverage

- Stress testing methodologies used by supervisors vary in terms of objectives, time horizon, risks analysed, models, level of granularity, among other aspects.

- The number of scenarios included in supervisory stress testing exercises varies considerably across jurisdictions. Approximately, four out of ten use one adverse scenario, three out of ten use two adverse scenarios, and three out of ten use three or more adverse scenarios.
- The scenario narrative is seen as a useful device through which authorities can communicate the risks that they are exploring through the scenario, and help banks to generate additional variables that are not specified in the scenario.
- Almost all authorities include both credit and market risks in their stress tests, and more than half of the authorities incorporate stresses for liquidity risk. Coverage of other risks including operational risk, interest rate risk, concentration risk, sovereign risk, foreign exchange risk, counterparty default risk and business risk varies across jurisdictions. Approximately half of authorities design a scenario or apply a methodology that incorporates some interaction between credit risk, market risk, and liquidity risk.
- The typical time horizon used by supervisors for a stress test scenario is two to three years. A small minority use a four to five year test horizon.
- For supervisor-run stress tests, the majority of authorities use data at the portfolio level, drawing on the supervisory reporting system. A significant minority use a mixed approach combining portfolio and transaction level data.

Methodology and guidance

- For institution-run supervisory stress tests, more than half of the authorities provide primarily high-level guidance to banks. Others provide prescriptive and constrained instructions, while the least common approach is to allow methodologies determined completely by banks.
- Regarding the projection of banks' balance sheets, authorities are split between the use of static and dynamic balance sheets. Fewer than half of the authorities provide guidance to banks on the requirement to model feedback effects.
- Most authorities allow banks to report their projected capital position including management actions, or require stress test results including and excluding management actions.

International coordination

- The BCBS principles for Supervisory Colleges specifically encourage the sharing of stress testing information. However, survey results indicate that coordination of stress testing across supervisors in different jurisdictions is currently not common.
- Supervisors do not routinely exchange information on stress test plans and results through supervisory colleges, with less than one in five authorities indicating that this practice is common.

Bank stress testing frameworks

Governance of bank stress testing frameworks

Scope and objectives

- Capital adequacy and liquidity adequacy are two of the main objectives identified by banks, but expansion to objectives seeking to enhance the understanding of risk and improve business practices is a reflection of growing maturity of stress testing in banks.
- Banks stress testing frameworks cover a wide range of risks. All banks include credit risk and market risk, and virtually all also cover interest rate risk and liquidity risk.

- Some institutions have made progress in developing an integrated, enterprise-wide approach to stress testing rather than performing silo-based stress tests by risk type, with about two-thirds of institutions carrying out enterprise-wide stress tests more frequently than annually. However, full integration continues to be a challenging issue. The majority of banks run capital and liquidity stress tests separately, with the results often assessed jointly.

Organisation and resources

- The boards of institutions frequently delegate responsibility for stress testing to their risk committees. In over half of institutions the chief risk officer (CRO) is responsible for stress testing; however, variation was noted in terms of both geography and size of institution.
- Broad engagement across institutions in the stress testing process is beneficial, given the diverse set of skills and perspectives required. Boards prioritise their discussion time on stress test results, scenario design and the use of stress test results/outputs.
- The majority of banks run their stress testing in a centralised fashion with some variation seen for the mid-sized to large banks. The benefit of a centralised process is that it facilitates ensuring consistency across the organisation. A drawback is that it might hamper incorporation of valuable insights from the business for example on scenarios.
- Resources have been an important issue at many banks, with challenges reported in maintaining adequate staff with suitable skill sets. Where banks operate in multiple jurisdictions, greater resourcing is often required.

Validation and review

- Most banks undertake a regular review of their stress testing frameworks. Broadly, most aspects of stress testing frameworks are reviewed at least every two years with a significant proportion reviewed annually.
- Internal audit is a key component in banks' stress testing frameworks. All banks surveyed have internal audit programmes that cover the major elements of the stress testing programmes. Furthermore, internal audit plays a role in lessons learned exercises, usually in partnership with the business functions.

Use of stress testing outputs

- The most important areas in which stress testing results are used are: business and capital planning; risk appetite setting, risk monitoring and limit setting; regulatory compliance; liquidity contingency funding planning; and recovery planning.
- As stress testing frameworks have matured, banks have increasingly looked for opportunities to integrate stress testing processes and results into broader business and risk programmes.

Bank stress testing methodologies

- All banks are imposing macroeconomic negative shocks in their internal stress test scenarios and about two-thirds also model sectoral or industry-specific shocks as well as bank-specific shocks. The most common source of scenarios are historical experience and expert judgement, followed by the use of supervisory scenarios and statistical methods.
- Nearly half of banks conduct stress tests with feedback effects, such as between funding and credit risks. Most banks either report stress test results in a way that allows the impact of management actions to be separately identified, or exclude management actions.

- Reverse stress testing is conducted as a complementary stress test by two-thirds of the institutions. Reverse stress testing is considered as risk management tool that helps banks to assess and understand key risks by identifying scenarios that may put the bank's business model at risk. Solvency stress tests are usually conducted with a time horizon of one to three years, whereas liquidity stress tests cover a much shorter time horizon, ranging for the majority of banks between one and three months.

Future improvements

- Data quality and availability is one of the highest priorities of banks for future improvements through additional investment. Data can influence which types of models and methodologies are used, the validation efforts and related model governance work, as well as the robustness of the overall outcomes.
- Integrating stress testing into business as usual processes is a high priority area for improvement. Banks have flagged the need to derive additional business benefits given the resources devoted to the process.

1. Introduction

Since the global financial crisis, the role of stress testing as a supervisory tool has risen to prominence in many jurisdictions. In May 2009, the Basel Committee on Banking Supervision published its *Principles for sound stress testing practices and supervision*, hereafter, referred to as *2009 Stress Testing Principles*.³ The Committee's Supervision and Implementation Group (SIG) conducted a peer review of supervisors' implementation of the 2009 Stress Testing Principles during 2011, which was published in April 2012.⁴ The review covered implementation of principles 16-21 (principles for supervisors). The results showed that jurisdictions were at varying stages of implementing these principles, and that even those jurisdictions that were considered to be at a more advanced stage of implementation could do more.

Since then, stress testing as a supervisory tool and its use and governance have rapidly evolved and matured. Much progress was made within stress testing frameworks. Many jurisdictions have established supervisory stress testing frameworks that go well beyond the stress tests envisaged in the 2009 Stress Testing Principles, and stress testing now represents a key component of supervisors' risk and capital assessment in a number of countries.

To better understand the development in stress testing range of practices, the Committee approved the establishment of the Stress Testing Network (STN) in 2014, which has since become the Working Group on Stress Testing (WGST). This report has been prepared by the WGST to identify, describe and compare the range of observed practices in supervisors' and banks' stress testing frameworks, highlighting areas of evolution of these practices, and providing concrete examples of practices in specific jurisdictions and institutions. This phase of the work comprises actual and observed practices, rather than aspirational practices. The report aims to cover both bank and supervisory stress testing practices, with a focus on issues such as governance, use and key methodological issues. The report is not designed to canvass all technical aspects of stress testing.

³ Basel Committee on Banking Supervision, *Principles for sound stress testing practices and supervision*. May, 2009. Available at www.bis.org/publ/bcbs155.htm.

⁴ Basel Committee on Banking Supervision, *Peer review of supervisory authorities' implementation of stress testing principles*. April, 2012. Available at www.bis.org/publ/bcbs218.htm.

The report draws on three main sources of information: the direct experiences of WGST members (banking supervisors and central banks) and the results of two surveys conducted by the WGST in 2016. One survey was completed by WGST members while the other was completed by banks. These two surveys cover a range of key topics of interest, including governance frameworks, use of stress test outputs, international coordination and methodologies. The supervisory survey had participation of 31 authorities from 23 countries. The survey completed by banks included 54 respondent financial institutions from across 24 countries, including 20 global systemically important banks (G-SIBs). While there are some challenges associated with consistent interpretation of the results, the responses provide a rich source of evidence on the current range of supervisory and banking industry practices.

To supplement the results of the surveys, WGST members also developed a set of case studies, based on their jurisdictions' and banks' practices. This work focused on providing more detail on specific challenges in stress testing. The case studies cover jurisdictions and banks from a variety of geographical regions and provide an understanding of the historical evolution of, and the degree of maturity in the development of stress testing approaches.

Finally, the WGST has developed a taxonomy of supervisory stress testing terminology. In addition to aiding comprehension of this range of practices report, the taxonomy aims to encourage a common language for stress testing terms to enhance communication in this rapidly evolving area, and thus aid the dialogue among banks and supervisors.

The remainder of this report is divided into the following sections:

- Section 2 focuses on supervisory stress testing practices. It examines governance of supervisory stress testing frameworks, the use of supervisory stress tests, international coordination among banking supervisors and supervisory stress testing methodologies. For the purpose of this report, supervisory stress testing covers both stress tests in which the supervisor uses its own models and scenarios to assess banks, as well as stress tests in which the supervisor provides scenarios and guidance to banks, which then run their own models and report the results to the supervisor.
- Section 3 focuses on banks' stress testing practices. It examines objectives and scope of stress testing frameworks, roles and responsibilities, methodological issues, use of stress test outputs and areas for future improvements.
- Annex 1 sets out the taxonomy of stress testing terms.

2. Supervisory stress testing frameworks

2.1. Overview

There are two fundamental types of supervisory stress tests: (1) those in which the supervisors collect data from the firms and then use their own models and scenarios to assess the performance of the firms under stress (referred to in this report as either "supervisor-run" or "top-down" tests), and (2) those in which the supervisors issue scenarios and guidance to the firms, which then run their own models and report the results to the supervisor (the "institution-run" or "bottom-up" tests). In general, supervisory authorities and central banks continue to devote more resources to enhance one or both types of supervisory stress tests, and that increased focus has resulted in significant progress in how the exercises are performed and how they are incorporated into the banking supervision process.

The survey on which this section is based was completed by 31 distinct authorities from 23 countries. The survey results and case studies are used to highlight the range of observed practices and critical factors affecting the development and ongoing management and maintenance of supervisory

stress testing frameworks. As the survey was completed by both banking supervisors and central banks, it covers both microprudential and macroprudential stress testing practices. Certain elements of the survey were therefore not relevant for some authorities. For example, three surveyed central banks have no or limited powers to set microprudential measures.

In the seven years between 2009 and 2016, authorities conducted an average of four stress tests each, and all authorities conducted at least one stress test in the past two years. Most of the supervisory stress testing exercises are now carried out on an annual basis or more frequently. The macroeconomic environment and objectives of the stress test dictate both the frequency and scope (number and type of participating institutions) of the stress testing framework. Supervisor-run stress tests tend to be run more frequently, and the frequency of tests also tends to be higher in times of economic stress. Other factors, such as the annual frequency of the Supervisory Review and Evaluation Process (SREP) assessments, have also led to an increase in the frequency of supervisory stress tests in some jurisdictions.

Though the frequency and scope of both types of supervisory stress test can vary significantly across jurisdictions, the components of the stress tests are similar. Those components include the governance structures supporting the stress tests, the ways in which the stress tests are used within jurisdictions, the methodologies used to design the scenarios and the models used in the stress tests, and, for internationally active banks, international coordination between authorities. The remainder of this section reviews the range of practices observed across those four components.

2.2. Governance of supervisory stress testing frameworks

2.2.1. Objectives and scope

The governance structures supporting supervisory stress testing may not be as visible as the macroeconomic scenarios and outputs/results, but are an important part of any supervisory framework. Governance includes the articulation of objectives and scope, clarity on internal and external roles and responsibilities, the structure and resourcing for stress testing frameworks, and validation and challenge.

Stress tests aim to provide a forward-looking view of risks under stressed economic and financial conditions, and though authorities employ stress tests to meet different objectives, many use the stress tests to develop a horizontal view of banks' risk management practices (eg assessment of banks' risk identification, measurement and management capabilities). A number of authorities now use stress tests specifically for capital adequacy assessment or to inform macroprudential policies such as the countercyclical capital buffer. In some cases, stress testing frameworks aim to address multiple objectives. For example, in Canada the macroprudential stress test outcomes inform ongoing supervisory work, such as capital adequacy assessments and risk identification, prioritisation, and measurement, as well as financial stability policy initiatives. Stress testing can also be used to facilitate communication with relevant domestic and foreign parties regarding the stability of the financial system. The range of uses of supervisory stress testing frameworks is discussed in more detail in Section 2.3.

The scope (ie the population and definition of banks covered by the framework) of the stress test is linked directly to the objectives. For example, if an objective is motivated by financial stability considerations, the test may focus more on a smaller set of systemically important institutions. Whereas tests motivated purely by assessments of capital adequacy of individual institutions may have reason to include smaller, less interconnected firms that pose less of a risk to the system. Though objectives are important factors in determining scope, other factors such as the importance of foreign entities in a jurisdiction and concerns about proportionality can play a role.

Similarly, the definition of the legal entities subject to the stress test varies across jurisdictions. Many supervisor-run stress tests are based on the consolidated banking group (ie they cover all banking subsidiaries at the consolidated level, and in some cases non-banking subsidiaries will also be included as

part of the consolidated group). By contrast, other exercises cover banking subsidiaries on a stand-alone basis. Some of the differences in practices across jurisdictions are likely attributed to the objectives of the exercises and the legal environment in which the institution operates.

In some jurisdictions, regulation or legislation sets out requirements associated with the objectives and scope of stress tests. For instance, in the EU there is specific legislation on supervisory stress testing (article 100 of the CRD IV) and the EBA Guidelines. These provide guidance on the use of supervisory stress testing by authorities, describe different forms and objectives, cover issues related to organisation, resources and methodologies, and also address the use of the outcomes when assessing capital and liquidity adequacy under the SREP, in addition to national regulation. In the United States, legislation (the Dodd-Frank Wall Street Reform and Consumer Protection Act) requires supervisors and banks to run stress tests under scenarios designed by the supervisor. Implementation of regulations contains more details about the standards used in conducting stress tests.

Whatever the objectives, the better governed stress testing frameworks observed in the survey clearly articulated those objectives at the outset. They are often articulated as part of a formal process that also governs the timing, scope, types of metrics used, and decisions associated with the exercise. In many cases, the stress testing exercises are embedded in the regular decision making process used in other types of exercises.

2.2.2. Roles and responsibilities

Many authorities note that supervisory stress testing exercises are one of the most complex activities they conduct on a regular basis. Therefore, significant planning is required to identify and obtain the resources needed to ensure the timelines and quality expectations of the exercises are met. Such a process requires clear roles and responsibilities among the personnel and across the organisation, and between authorities where relevant.

Authorities have different approaches in this area, which may indicate some opportunities for improvement and reflects that countries are at different stages of their overall development of stress testing frameworks. A number of authorities do not have internal documentation that formally articulates roles and responsibilities for staff involved in supervisory stress tests. One country noted that the dedicated stress testing team has only been in place for a year; as such, the lack of formal documentation reflects that they are still in the early stage of the stress testing framework. In another country, the authority annually updates a document that articulates, at a high level, the contributions of various participating groups across the organisation. In yet other countries, stress tests are run by a dedicated team with clearly mandated roles and responsibilities.

The majority of authorities provide internal guidance and rules for supervisory stress testing frameworks. For example, the ECB has an internal coordination framework for all stakeholders involved in the process: Joint supervisory teams (JSTs, composed of ECB and staff from national authorities) for the respective significant institutions, macroprudential functions, horizontal functions within the ECB, horizontal functions at the national authorities, and additional national experts. This framework for stress testing defines the different actions to be taken by each of the stakeholders as well as objectives and timelines for the entire process.

Only about one quarter of authorities that participated in the survey have published supervisory guidance for supervisor-run stress tests. As an example, the EBA has published EU-wide stress test methodologies, templates and scenarios for the EU member states (2011, 2014, and 2016 exercises). Similarly, in the US, the Federal Reserve publishes a set of documents for each stress test cycle that contain details about the scenarios and methodologies used in the supervisor-run stress tests, and along with other US regulators have published formal data collection templates that are used to collect the information related to stress testing. In addition, the Federal Reserve published supervisory guidance on

issues related to capital planning and stress testing, including expectations for governance, risk management, internal controls, capital policy, scenario design, and projection methodologies.

Box 1 – Roles and responsibilities of the supervisory authority and central bank within Germany

The division of responsibilities between the Bundesanstalt für Finanzdienstleistungsaufsicht (Federal Financial Supervisory Authority, BaFin) and the Deutsche Bundesbank provides an example of coordination and articulation of roles and responsibilities. In general, BaFin and Deutsche Bundesbank share banking supervision in Germany. Their cooperation is governed by section 7 of the German Banking Act (Kreditwesengesetz – KWG). This stipulates that the Deutsche Bundesbank shall, as part of the ongoing supervision process, analyse the reports and requests, such as supervisory reporting requirements, that institutions have to submit on a regular basis. The analysis is used to assess whether the institutions' capital and risk management procedures are adequate. BaFin is responsible for the regulatory measures that apply to institutions, in particular general decrees and administrative decisions, including ordering inspections.

Regarding conducting supervisory stress tests, BaFin and Deutsche Bundesbank work closely together as set out in the German Banking Act. For that reason, BaFin and Deutsche Bundesbank have set up dedicated units as horizontal functions within their organisations, which are completely responsible for conducting supervisory stress tests at the national level. Additionally, there is close cooperation/involvement between these units, the EBA and the ECB when conducting supranational stress tests.

Due to the legal background, the decision making process within and between BaFin and Deutsche Bundesbank is generally based on the existing governance structure. Accordingly, no specific internal formal governance structure has been set up that articulates roles and responsibilities to cover supervisory stress testing (eg stress testing committees and parallel decision making processes have not been established).

The national supervisory stress test comprises around 1,600 institutions directly supervised by BaFin and Deutsche Bundesbank (ie excluding the German banking groups that are under the direct supervision of the ECB). These stress tests are currently carried out every two years. The dedicated stress test units of BaFin and Deutsche Bundesbank are separated from teams in the financial stability departments. Nevertheless, there is an information exchange with the financial stability department during the preparation phase of supervisory stress tests to consider potential macroprudential requirements. However, the main focus of national supervisory stress tests is on microprudential aspects, eg considering the results in the Pillar 2 guidance as part of the SREP (see section 2.3 "Use of supervisory stress tests").

In general, the dedicated stress testing units within BaFin and Deutsche Bundesbank are responsible for:

- (1) the planning and preparation phase of the whole exercise;
- (2) consideration of national specificities (eg national GAAP vs. IFRS used in the EBA EU-wide stress tests)
- (3) the information exchange within the two supervisory authorities (eg with the line supervisors that are responsible for specific institutions);
- (4) the external information exchange with institution and/or other national or supranational organisations (eg banking associations);
- (5) the development of the scenarios by considering the size, complexity and business model of institutions (eg use of sensitivity analyses for national supervisory stress tests and the use of stress testing scenarios in the EBA EU-wide stress tests);
- (6) providing and preparing personnel and technical resources;
- (7) quality assurance of the stress testing results (in close cooperation with the line supervisors);

- (8) preparation of the external and internal communication process; and
- (9) the publication of the main results (eg aggregated results vs. individual results published for the EU-wide stress tests).

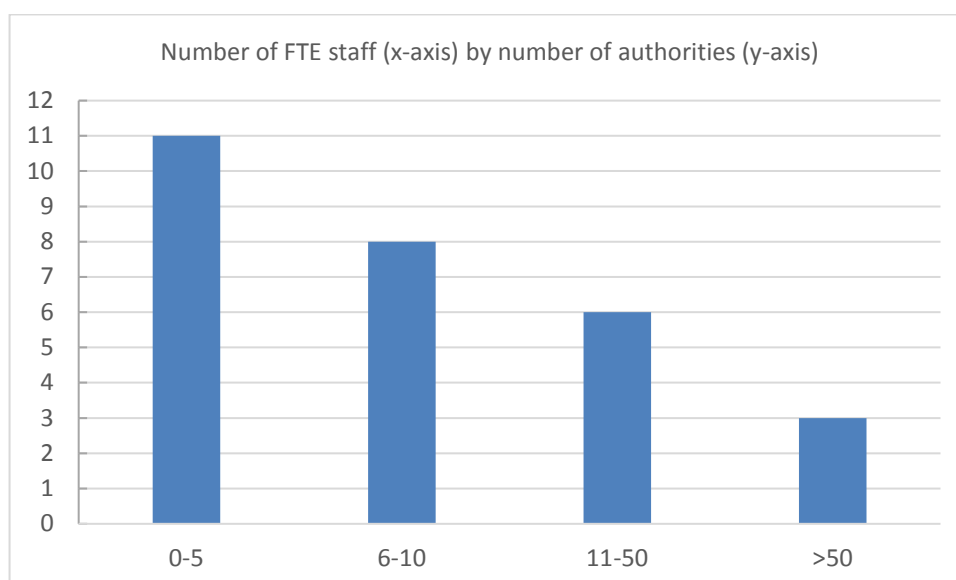
2.2.3. Resourcing

Supervisory stress testing exercises require specialised technical expertise. It is not surprising, therefore, that obtaining those technical resources is seen by authorities as one of the biggest challenges associated with running a successful supervisory stress test. Considerable time is necessary to develop capable stress testing resources, as these staff are required to have skills in a number of areas, including liquidity, credit risk, market risk, capital rules, financial accounting, macroeconomics, supervision, modelling and project management.

Though the different organisational structures make it difficult to fully compare resources across jurisdictions, it is clear that the number of people dedicated to supervisory stress testing has increased in recent years, both within the authorities and the institutions subject to the stress tests. The larger authorities that cover multiple G-SIBs usually have a large number of staff involved in supervisory stress testing exercises. These staff typically include risk specialists, modelling experts and examiners. The number of staff involved varies significantly depending on the scope of exercises. Three of the authorities in the survey have over 50 full time equivalent (FTE) staff exclusively devoted to stress testing (Figure 1). The highest proportion of these staff are risk specialists and modelling experts who have skill sets that are often in short supply in the market.

Running an industry-wide, institution-run stress test also involves coordination and communication with banks, data collection and validation and involvement of frontline supervision staff. For supranational stress testing exercises, like the EU-wide stress test, the coordination issues can lead to even greater resource requirements. For example, more than 250 FTE have been directly involved in the most recent EU-wide stress testing exercise.

Figure 1 - Resourcing for stress testing (distribution across authorities)



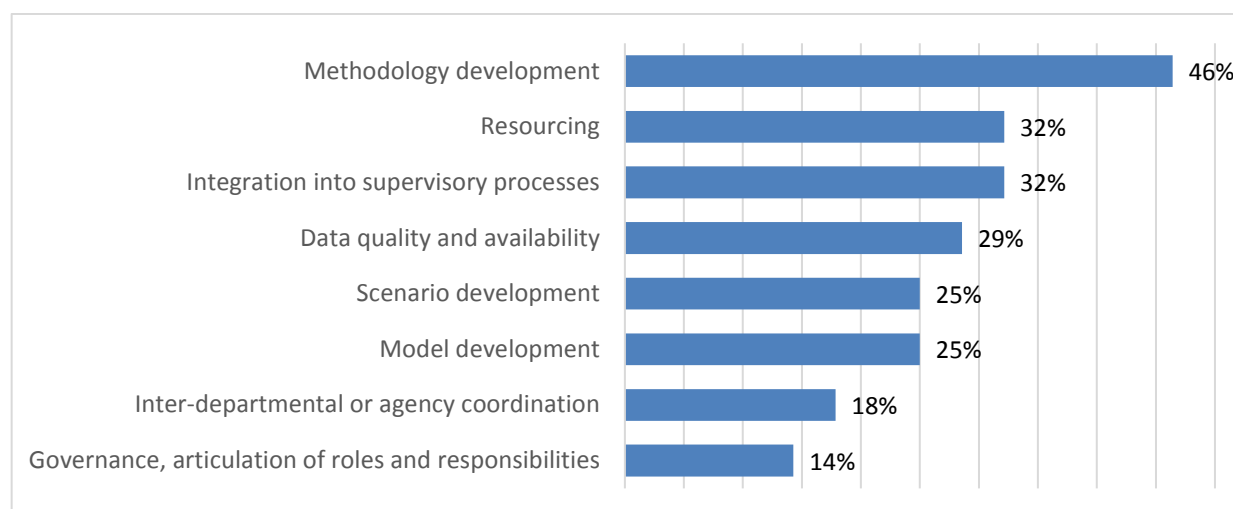
Source: BCBS survey of authorities. The question asked authorities for the number of fully time equivalent (FTE) staff involved in their most recent supervisory stress test exercise.

Although obtaining adequate resources remains a challenge, authorities note that they have made significant improvements in this area in recent years (Figure 2). For about two-thirds of authorities, supervisory stress tests are run primarily by a dedicated team. Though it is typical for a specific department

to be in charge of the coordination of stress tests, those departments often leverage contributions from other areas. For example, examiner resources in supervision departments or modelling resources from research/economic departments may contribute to aspects of the frameworks. The functions that the authorities rely on heavily for supervisory stress testing expertise are the macroprudential/financial stability function, risk area function, and frontline supervision function. Other functions that are often noted as important are the IT department to provide support to the infrastructure, the statistics function for data collection and checking, and the economics and the international functions, which contribute to the design of the stress test scenarios.

Figure 2 - Areas of greatest improvement in recent years

(% of authorities ranking each area in the top 3)



Source: BCBS survey of authorities. The question asked in which areas the authority's supervisory stress testing improved the most in the last four years. Authorities were asked to select the three most improved areas from a list.

Some examples of the structures used to resource supervisory stress testing exercises are:

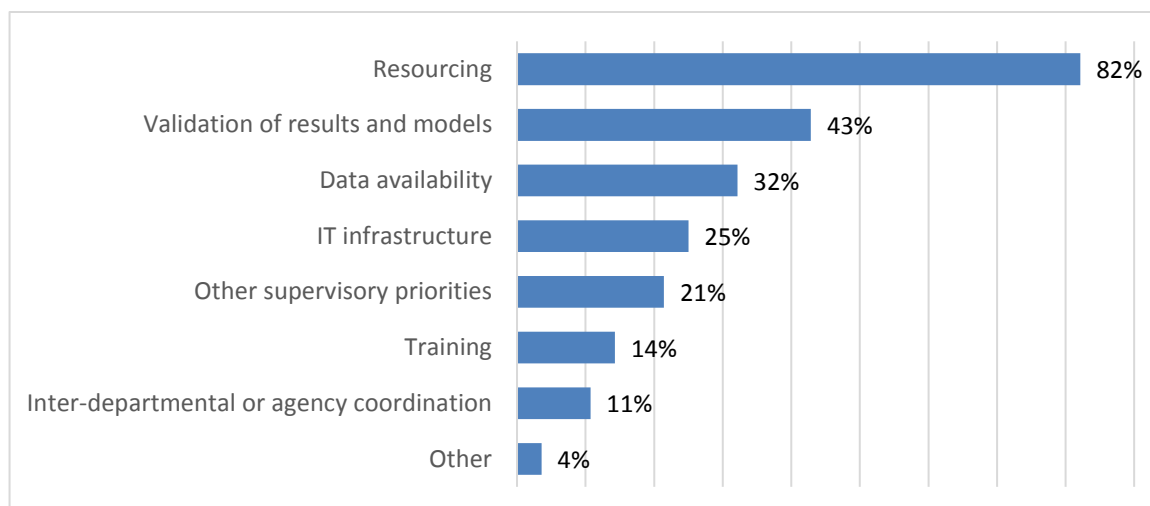
- OSFI and the Bank of Canada utilise a hybrid approach, with a dedicated team within each of authority responsible for coordination, project management, analysis and overall synthesis; these dedicated teams are supplemented with a stress testing working group comprised of supervisory and policy specialist groups as well as representatives from the central bank, with frontline supervisors providing additional assistance.
- In France, the stress testing exercises are run primarily by the research department in the supervision authority (ACPR). It is conducted by a horizontal team that supports the microprudential area and works in close cooperation with the financial stability division of the central bank (Banque de France) to run stress tests that capture macro-prudential risks.
- In Germany, the stress testing exercises are run by dedicated horizontal units (within BaFin and Deutsche Bundesbank), which are located in the microprudential area (see Box 1).
- The ECB resourcing for the EU-wide stress test exercise involved teams from the JSTs, ECB Banking Supervision (as the ECB's microprudential function), the ECB macroprudential and financial stability function, horizontal functions at the national authorities, and the IT and statistics departments.

The use of external consultants or contractors in supervisory stress testing exercises is not common. Only about ten percent of authorities surveyed use external contractors or consultants to assist

with the supervisory stress testing framework, but even when used, they generally comprise a small proportion of the overall stress testing staff.

In addition to obtaining the appropriate number of resources with the proper skill sets, the success of stress testing frameworks is also linked to the access to or availability of data and the quality of the data management infrastructure, which often takes time to develop. Data availability was cited as the third most significant impediment to implementing supervisory stress testing frameworks (Figure 3).

Figure 3 – Challenges in implementing supervisory stress testing frameworks
(% of authorities ranking each challenge in the top 3)



Source: BCBS survey of authorities. The question asked authorities to indicate the greatest impediments in their country to implementing supervisory stress testing programmes. Authorities were asked to select the three areas from a list of potential impediments.

Box 2 – Evolution of a supervisory stress testing framework in Mexico

The bottom-up stress testing framework in Mexico was implemented in 2009, and in 2013 a new team became responsible for it at the National Banking and Securities Commission (Comisión Nacional Bancaria y de Valores, CNBV). This new team developed the necessary skills to administer it in a short time, with scarce resources and a limited head count, through diverse means. Additionally, it addressed gaps that had been detected in the process.

The first step towards improving the supervisory stress test in Mexico was the creation of a detailed regulatory framework that added certainty to the supervisory stress test and aligned the incentives of frontline supervisors with becoming more involved in the process and taking specific supervisory actions accompanied by legal certainty. Although this created additional support from the frontline supervisors, the workload for the original stress testing team increased, since they were now responsible for testing more banks than in previous years.

To improve the process, the stress testing team created a tailored template to appropriately analyse the stress testing data, an internal validation tool, and a set of questions on specific issues that were of concern to the CNBV. These changes allowed for better-quality assurance tools that made the process more reliable, efficient and homogenous.

The CNBV lacked an internal projection model to assess the reasonableness of the banks' projections. The team determined that the optimal solution was to get external support with specialised knowledge to develop such a model. This approach faced fewer budgetary constraints than developing the model

in-house, and ensured a high-quality stress test model that would take account of best practices from around the world.

Solutions to resourcing and staffing challenges have varied according to the specific situation. When resource constraints were related to skills, external consultants or external experts were hired to join the stress testing teams. Other solutions to resourcing issues included: delegating certain tasks within the organisation to areas with specialised knowledge; improving the analysis tools and using IT solutions to help analysts increase their productivity; hiring additional people or getting other areas involved in the process by aligning their incentives; providing relevant training to analysts performing the exercise; detecting non-essential activities and removing them; and refocusing the available resources on the main sources of risks.

2.2.4. Validation and review of stress test methodologies and results

Validation of methodologies and quality assurance

In addition to the governance structures required to develop the models used in stress tests, both authorities and institutions need to have validation processes in place to assess the soundness of the models as well as the controls around data inputs, outputs, and models. Many surveyed view a sound validation framework that can appropriately challenge the models and control infrastructure as critical to ensure the credibility and usefulness of the stress testing framework. The process of validation is relevant for both supervisor-run and institution-run stress tests.⁵

In addition to validation, a number of authorities identify the importance of a quality assurance process. Quality assurance processes can touch all aspects of stress testing frameworks, from data gathering and storage to modelling to the production of results and disclosure.

Review of banks' models, methodologies, and projections

The importance of model, methodology and results reviews varies across jurisdictions. For example, Germany has noted that model validation is not the main objective of their supervisory stress tests; however, it is an integral part of the supervisory work, including examinations. The extent to which models are reviewed as part of a stress testing exercise may depend on whether the models are used by the banks for purposes beyond stress testing which subject them to a separate review. For example, in Canada, D-SIBs must have a robust, firm-wide model risk management framework more generally, which would also encompass stress testing. In Mexico, the institution-run supervisory stress tests do not include a review of the models used by banks since most banks have a regulatory standardised expected loss model. Rather, the supervisor in Mexico provides PDs and LGDs for each bank for all credit products based on the historical performance and the severity of the macroeconomic scenario. In contrast, the review of the institution-run stress test within the US CCAR is focused on the controls and methodologies used and how the stress test fits into the institution's capital planning framework.

Authorities often make considerable efforts to review banks' projections from the institution-run stress tests and the processes that support those projections. The approaches that supervisory authorities rely on most to assess the reasonableness of institution-run results are shown in Figure 4. The two most prevalent approaches are (i) consideration by supervisors of whether the results appear to be reasonable (ie a form of expert judgement); and (ii) comparison of the results against peer banks. About a third of the

⁵ The survey shows that: many of the authorities (nearly half) implement both supervisor-run (using internal models) and institution-run stress testing approaches, and have validation practices geared toward each; about one-third conduct only supervisor-run exercises; and about one-fifth only institution-run exercises. For instance, in the EU both types of exercises are covered. The bottom-up exercises are coordinated by the EBA and cover all EU countries while top-down exercises are developed by national authorities.

authorities surveyed compare banks' results to parallel results calculated by the supervisor, and in some jurisdictions that supervisory challenge is particularly rigorous. For example, the Swiss Financial Market Supervisory Authority (FINMA) runs sample calculations and uses those to cross-check stressed losses at individual banks.

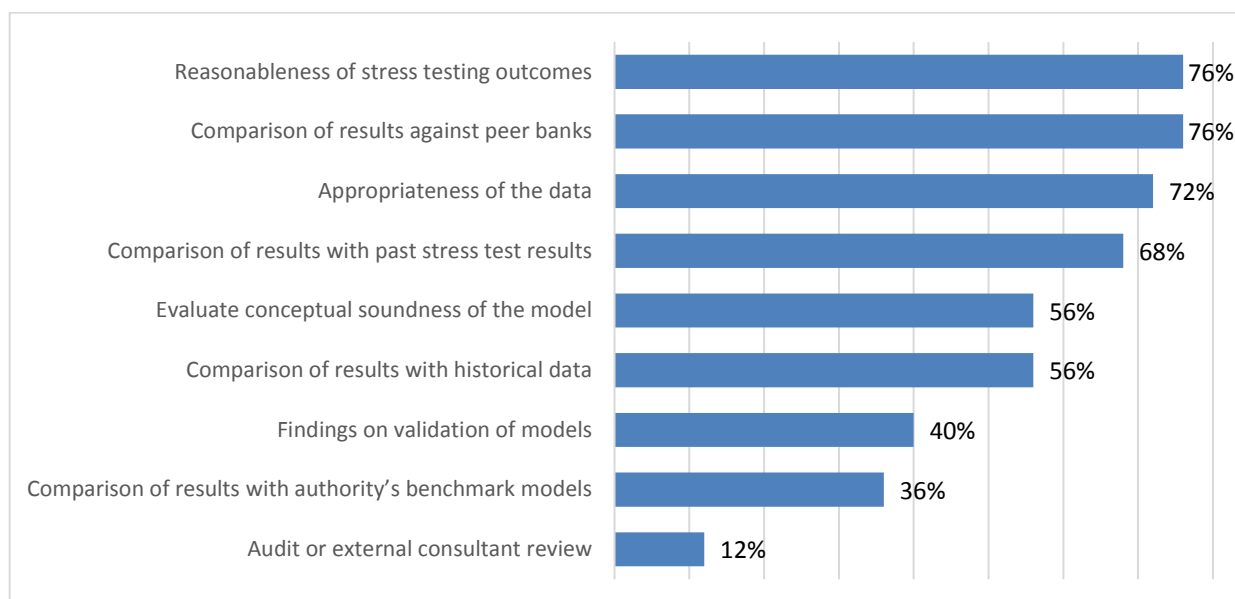
Box 3 – Validation practices: EU-benchmarks and descriptive statistics for consistency checks and quality-assurance

In the 2011 EU-wide stress testing exercise, and to a larger extent in 2014 and 2016, the EBA provided competent authorities with a common set of tools in order to ensure comparable and consistent outcomes across the EU. As laid out in the documentation for the 2016 EU-wide stress test, the process for running the exercise involves defining a set of minimum quality assurance guidance, and is followed by a direct engagement by EU competent authorities (the ECB in case of euro area countries) with the participating banks. The EBA coordinates the exercises, defines the minimum quality assurance guidance and hosts a central question and answer (Q&A) facility. The EBA also provides common descriptive statistics to competent authorities for the purposes of consistency checks. It includes not only credit risk indicators but also other risk areas and parameters (such as market risk, operational risk and interest rate risk).

The EBA minimum guidance for the quality assurance includes main steps, tools and principles to be carried out by competent authorities, which review banks' approaches, to challenge the results and to require banks to review their projections. The minimum guidance covers: (i) general quantitative information required from banks for all steps of the process; (ii) qualitative information required from the banks; (iii) data quality assessment; (iv) the assessment of consistency with the common methodology, particularly focused on checks for the correct application of constraints, many of which are already implemented in the templates; and (v) the EBA descriptive statistics including the variables for which EBA descriptive statistics are provided, and further quantitative assessments; among other aspects.

In addition, the ECB common EU-benchmark parameters are developed to provide additional guidance to the banks that participate in the EU-wide stress test exercises. These benchmarks concern the scenario-conditional evolution of Point-in-Time (PiT) Probability of Default (PD) and Loss Given Default (LGD) parameters. Other ECB benchmark parameters relating, among other things, to net interest income, market risk and operational risk, are also employed in the quality assurance process. The purpose is to serve as an input to the quality assurance process throughout the supervisory stress test exercises (ie validating banks' data and stress test results based on the bottom-up calculations, as well as reviewing the models used by banks for the stress testing exercise).

Figure 4 - Supervisory approaches to assessing banks results (% of authorities)



Source: BCBS survey of authorities. The question asked in what approaches the authority relies on to assess the reasonableness of supervisory stress testing results submitted by banks. Authorities were asked to select all approaches used from a list.

The differences in review approaches in part reflect differences in the objectives across jurisdictions, but also are influenced by the risk sensitivity and complexity of the methodologies and models used in the respective stress testing frameworks. Regardless of the approach, it is clear from the survey that there have been improvements in recent years in stress testing methodologies and models, and those improvements are likely related to efforts by authorities to internally validate the supervisor-run stress test methodologies and review the institution-run methodologies. The approaches listed above are also used in different contexts in addition to the validation of results.

2.2.5. Feedback and communication

Communication of the detailed parameters of a stress test (eg scenarios, supervisory expectations, etc.) and the results of stress testing assessments is a critical component of a successful supervisory stress testing exercise; however, there is not a one-size-fits-all communication approach. In general, communication methods employed can vary substantially across jurisdictions and exercises depending on the nature of the particular stress test and the economic environment. There are several dimensions of communication: communication of the authorities with institutions subject to the test; communication between multiple home authorities; and communication of the authorities and/or institutions with the public.

Communication between authorities and participating banks

Communication between authorities and participating banks is often divided into three timeframes: (1) in advance of the stress test; (2) as the authorities and/or banks are completing their tests; and (3) when the assessments are complete. Many authorities provide participating banks with detailed instructions prior to the exercise. For example, in advance of the EU-wide stress testing exercise, the EBA provides the participating banks with a detailed timeline of the exercise. This helps to manage expectations, as well as improve the planning, resourcing and data availability, which are three of the key drivers identified by supervisors for ensuring a successful supervisory stress testing process. The EBA has also hosted workshops with industry and national authorities as a way of improving dialogue and consultation. In the US, the Federal Reserve subjects formal data collections to a public review and comment process, provides

instructions to the participating institutions several months before the results must be submitted, and around the same time, publishes details about material supervisory model changes.

Questions often arise during the exercises, and about two-thirds of supervisors have a formal process in place for answering banks' questions regarding implementation of stress test methodology. There are different approaches for answering banks' questions: for example, one authority noted that they do not publish the responses to the questions, but instead distribute the responses among participating banks.

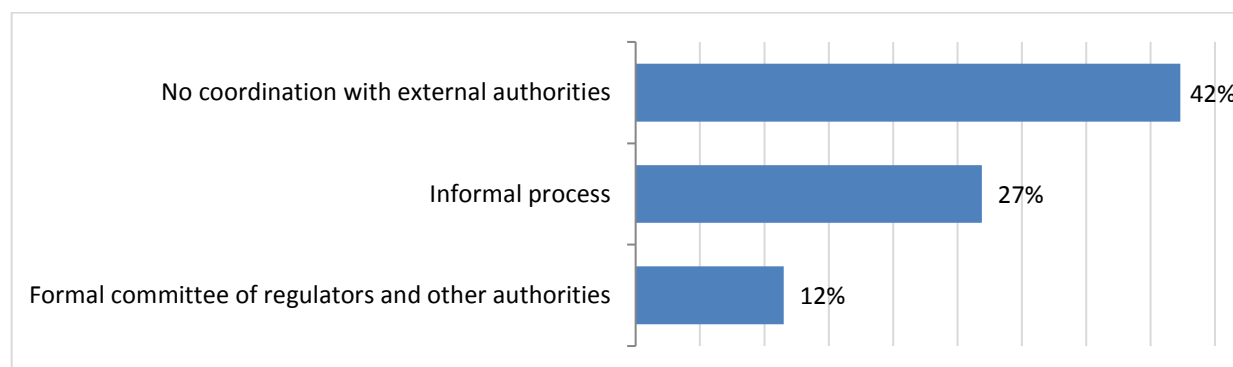
The type of information that is officially communicated to the participating banks by supervisors at the conclusion of the exercise often consists of the quantitative results, the supervisory methodologies, and the assessment of the banks' risk identification, measurement, management and governance capabilities in carrying out the stress testing framework. However, in a few cases, including the IMF's Financial Sector Assessment Program (FSAP) stress tests and some macroprudential stress tests, bank-level results are not communicated to the covered banks. Though some jurisdictions, such as the US, communicate results to banks and the public at roughly the same time, not all jurisdictions communicate results at the same time, as a supervisor can start communicating bank-level results with individual banks during the respective on-site examination process.

Communication between home authorities

The majority of the supervisory authorities do not have a formal process for coordinating supervisory stress testing frameworks with other domestic authorities (Figure 5). The survey revealed a mixture of formal and more informal approaches to coordination with other authorities, such as:

- OSFI and Bank of Canada have an informal process in which they frequently share stress testing practices and observations with other domestic authorities.
- The Federal Reserve coordinates with the other US banking regulators on stress testing regulations and on designing the supervisory scenarios, which are also used for the bank-run stress tests by the other US authorities.
- In the EU, the process is more formal with national authorities from the 28 EU countries and EU institutions and authorities being represented at the EBA Board of Supervisors. Macroeconomic scenarios are designed by the European Systemic Risk Board, whose members are central banks and supervisors of all EU countries as well as EU institutions. Euro area countries have an active role in the decision-making via their national authorities at the ECB's Supervisory Board, whose draft decisions are adopted by the ECB's Governing Council. Results of stress tests are shared with the colleges of supervisors.
- In Mexico, the CNBV creates a macroeconomic scenario that captures the main risks identified by the financial stability council, and sends them for approval of other authorities until a consensus in the stress test scenario is reached.

Figure 5 – Formal process for coordination with other domestic authorities (% of authorities)



Source: BCBS survey of authorities. The question asked authorities whether they have a formal process for coordinating supervisory stress testing programmes with other domestic authorities. Authorities were asked to select one answer from a list.

Communication with the public

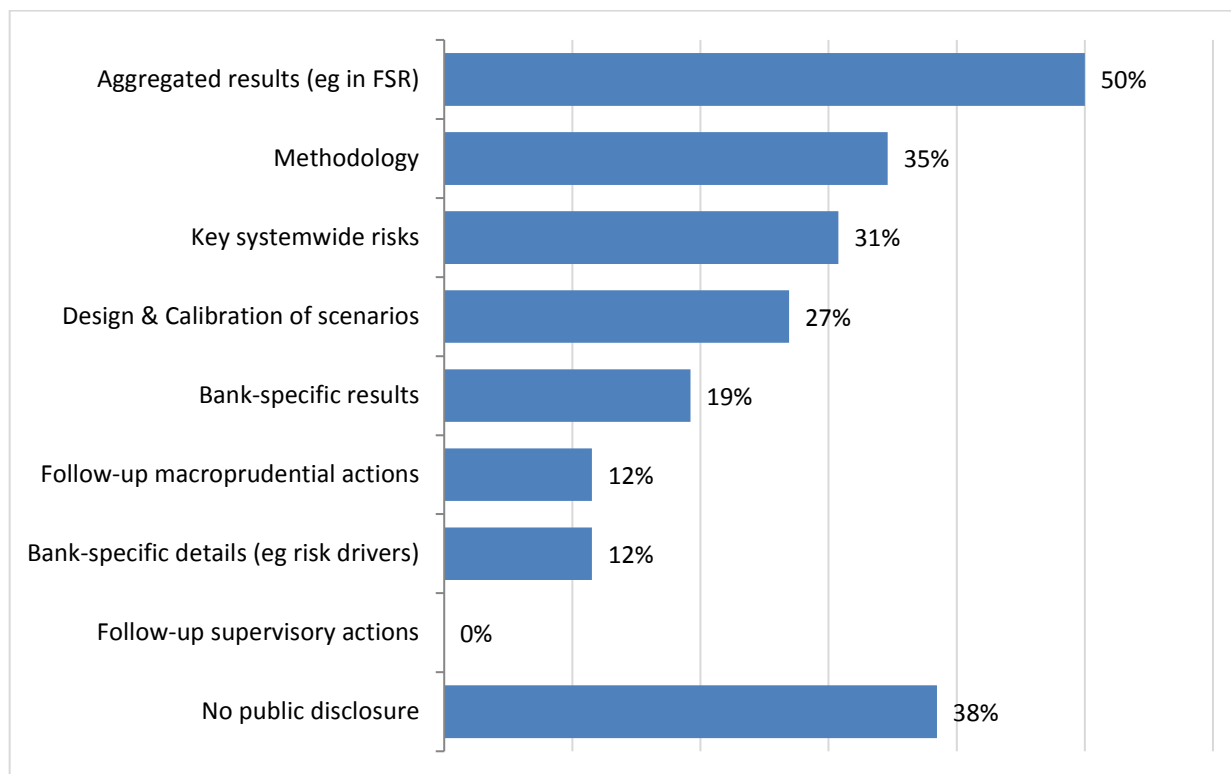
A range of practices have developed for public disclosure of supervisory stress testing. While many supervisors publicly disclose aggregated results of stress test exercises, commonly in the financial stability reports, a sizeable minority do not publish any results. Publication of high-level methodology and scenario design features is also a wide-spread practice (Figure 6). By contrast, very few supervisory authorities disclose bank-specific details, risks, or announce follow-up supervisory actions.

There are many considerations to take into account when deciding how much information to disclose publicly. Nevertheless, over time, market participants have increasingly demanded more in-depth disclosures and authorities have tried to enhance the transparency of stress testing exercises. Institutions providing a stress test outcome together with regular financial statements is becoming a routine task in some jurisdictions, while some regulators are considering making it mandatory.

In the US, supervisory estimates of post-stress capital ratios for each bank under adverse and severely adverse economic and financial conditions are publicly released along with detailed information on losses and revenues. In the EU, for all regular EU-wide stress test exercises hitherto, the EBA Board of Supervisors decided to publish the quantitative results at the bank-level and provide comprehensive granular data for several types of portfolios on a regular basis (eg sovereign portfolios and risk weights from internal models).

In contrast, for a number of countries, only aggregate-level results are published; often this is in the context of an FSAP review. For example, the Australian Prudential Regulation Authority (APRA) has traditionally disclosed only the aggregate results. In addition, a number of supervisory authorities do not publish any information regarding the scenarios and methodology applicable to the supervisory stress testing frameworks.

Figure 6 - Publication of stress test exercises (% of authorities)

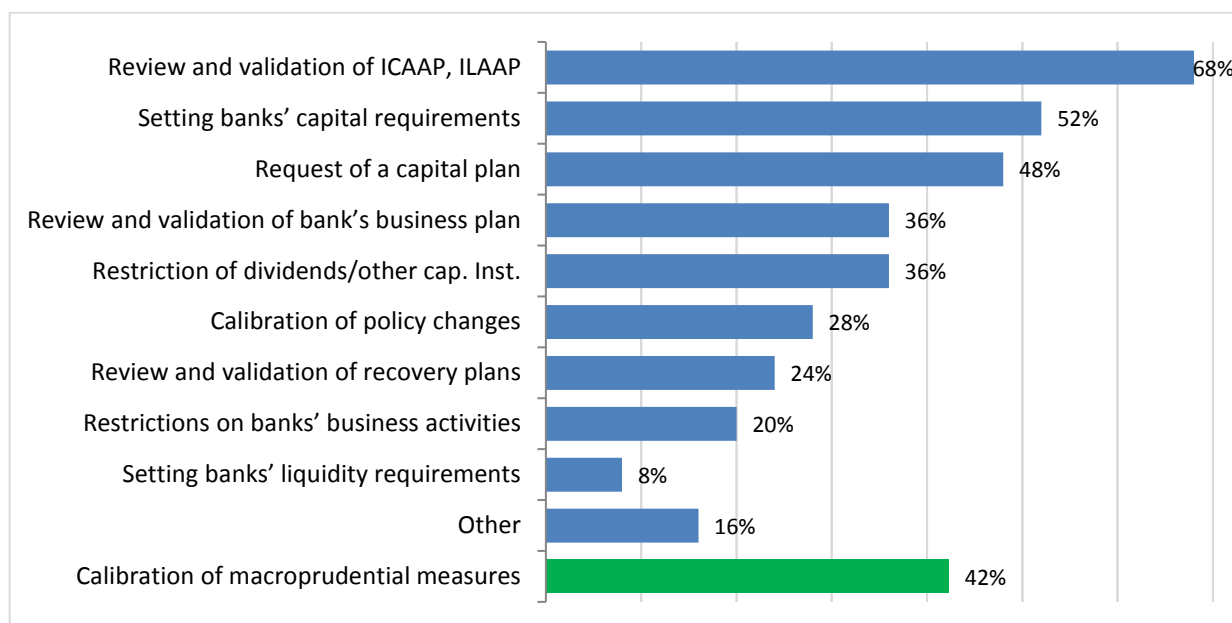


Source: BCBS survey of authorities. The question asked authorities whether any results or aspects of the stress test publicly disclosed. Authorities were asked to select all relevant answers from a list.

2.3. Use of supervisory stress tests

Supervisory use of stress test results is linked to the ultimate objectives of the specific stress testing frameworks. As noted in Section 2.2, there are a variety of different objectives of supervisory stress testing frameworks and so it is not surprising that the use of the stress test results vary across jurisdictions. They can also vary over time depending on the institutional, economic and financial context. This section focuses on the various supervisory uses of stress test results, grouped by microprudential and macroprudential uses, although it is important to note that there is often overlap between these two groups. For example, microprudential stress tests applied to systemically important banks can be considered to be an instrument within the macroprudential toolbox.

Figure 7 - Use of supervisory stress test results (% of authorities)⁶



Source: BCBS survey of authorities. The question asked authorities what they use (or have used in the past) bank internal stress tests for. Authorities were asked to select all relevant answers from a list.

2.3.1. Microprudential use of supervisory stress tests

Capital-related uses

Supervisory stress test results are primarily used by supervisory authorities for informing solvency and liquidity adequacy assessments. This can include using the results to sense check banks' own stress tests set out in their ICAAPs and their liquidity adequacy assessments. For example, supervisory models can be run with parameterisations tailored to individual banks, such that they can also be used to challenge individual elements of ICAAPs and liquidity assessments.

Since the global financial crisis, an increasing number of countries use stress tests as general supervisory tools to assess capital adequacy and/or to inform the setting of a specific capital buffer above which banks must remain.⁷ Australia and Germany are examples of countries that primarily use their stress tests as supervisory tools which, together with other tools, are a factor in assessing the adequacy of capital in the face of adverse macroeconomic conditions. The ECB, Bank of England, and the Board of Governors of the Federal Reserve System have or continue to use stress tests to formally inform or set capital buffers or capital requirements. For some jurisdictions, supervisors may review and assess the banks' own stress tests. For example, in order to avoid limitations on capital distributions, banks subject to CCAR must hold capital sufficient to meet the minimum regulatory capital ratios under the supervisor-run stress test, as well as pass a qualitative assessment of their own procedures for capital planning.

Certain supervisor set capital add-ons for banks by using rules-based methods based solely on stress tests (eg by benchmarking against formal hurdle rates), and those that do tend to employ a combination of structured methodology and supervisory judgment. Four jurisdictions that have a more

⁶ The charts exclude responses from central banks that are not regulatory authorities, except for those relating specifically to macroprudential measures. The blue bars highlight microprudential uses of stress testing, whilst the green bar highlights macroprudential use of stress testing by supervisors and central banks.

⁷ When a specific minimum is used, both the metric itself (eg CET1 ratio) and the minimum level of the metric can vary depending on the objectives of the exercise.

rules-based treatment are Mexico, Korea, Sweden and Georgia. For example, in the case of the National Bank of Georgia, the quantitative outcome of the exercise forms a stress test buffer in the Pillar 2 requirement, which combines with other buffers (ie the countercyclical capital buffer and capital conservation buffer).

Compared to the supervisory rules governing the setting of capital requirements, even fewer supervisors impose restrictions on dividends or on the payment of other capital instruments as a result of stress test outcomes, and yet an even smaller set restrict business activities.

In a number of cases, practices have evolved over time. The 2014 EBA-coordinated EU-wide stress test, institutions that failed to meet a predetermined capital threshold were required to submit a capital plan. In contrast, the 2016 EU-wide stress test did not contain a pass/fail capital threshold and was instead designed to be used as an inherent part of the supervisory review and evaluation process in the EU.⁸ The competent authorities (the ECB for euro area significant institutions and national authorities for other banks) could use those stress test results to facilitate the assessment of key elements of SREP, including business model, internal governance and institution-wide controls, risks to capital and capital adequacy (see Box 4).

The capital plan decisions made in US CCAR exercise in the United States have both a quantitative element based on the results of a supervisor-run stress test as well as a qualitative evaluation of the firm's capital planning processes. The supervisor-run stress test is the foundation of the post-stress capital analysis in CCAR, which evaluates the ability of a bank to maintain sufficient capital throughout a stressful period while executing their planned capital actions, such as dividend payments and share buybacks and issuances.⁹ Other stress testing requirements are outlined in the Dodd-Frank Act, which contains forward-looking quantitative evaluations of the impact of stressed economic and financial market conditions on capital by both the supervisor and the banks subject to the requirements of the Act.

One national EU authority has implemented an annual supervisor-run stress test that complements the EU-wide stress test and promotes compliance with the national requirements. The supervisor-run approach allows the application of multiple scenarios with embedded specificities for different business models. The final results of the supervisor-run stress test are discussed with the respective banking supervisors. While those results are neither published nor discussed directly with the banks, they feed directly into the SREP process and are an essential input to the final bank-by-bank risk assessment.

The Bank of England's supervisory stress test results inform a buffer requirement set by the Prudential Regulation Authority (the "PRA buffer") as well as the Countercyclical Capital Buffer (CCyB) set by the Financial Policy Committee. The PRA buffer is an amount of capital that an individual bank should have to cover losses that may arise in a period of stress. It is in addition to the bank's minimum capital requirements, their combined buffer requirements under the EU Capital Requirements Directive, and any sectoral capital requirements. The PRA buffers are set taking into account the results of supervisory stress tests, banks' stress tests and other supervisory tools but also seeks not to double count capital held in the CCyB.

In Germany, supervisory stress tests are currently designed to cover two objectives: first, the assessment of the institution's ability to cover risks arising from the ongoing low interest rate environment and second, the effect of macroeconomic shocks (via sensitivity analyses) to their credit and market risk positions. The results of the supervisory stress tests are considered in a Pillar 2 guidance as part of the SREP. The guidance is calculated on a gross basis and can be fully offset with the capital conservation

⁸ "Information update on the 2016 EU-wide stress test", EBA, (July 1, 2016).

⁹ In addition to the post-stress capital analysis in CCAR, supervisors evaluate the banks' processes around capital planning, which includes all facets of their stress testing frameworks.

buffer and the countercyclical buffer. The Pillar 2 guidance is primarily an internal early warning indicator for the national supervisory authority. Breaches will lead to intensified supervision, if necessary.

APRA do not impose capital requirements directly based on stress test results, but see stress testing as a strong tool to inform supervisors' judgments of capital adequacy. Stress testing is also expected to be reflected in banks' capital decisions, helping banks to set target surplus thresholds and fostering greater understanding of the dynamics between capital and risk.

Box 4 – Use of a supervisory stress test results in the EU-wide stress test

2014 exercise

The 2014 EU-wide stress test is an example of an exercise with a capital hurdle rate that banks passed or failed. The capital hurdle rate for the 2014 stress test exercise was set at a 5.5% CET1 ratio under the adverse scenario. If a capital shortfall was revealed by the exercise for a given bank, mitigating measures that the bank had taken after the cut-off date but during the execution of the stress test exercise were taken into account. For any residual shortfall, banks needed to submit a capital plan detailing the measures that would be applied to address it, such as a capital increase through a rights issue or other capital management actions such as the disposal of non-strategic assets. In addition, the exercise was part of a comprehensive assessment at the launch of the Single Supervisory Mechanism, under which direct supervision of the largest euro area banks was assumed by the ECB. For the comprehensive assessment, an asset quality review was undertaken to quality assure the starting point data, before conducting the actual stress testing exercise.

2016 exercise

The 2016 supervisory stress tests were designed with the objective of providing input into the SREP.¹⁰ The key purpose of the SREP is to ensure that institutions have adequate arrangements, strategies, processes and mechanisms, as well as capital and liquidity, to ensure a sound management and coverage of their risks. Supervisory capital demand resulting from the SREP consists of two parts: the Pillar 2 requirement (P2R)¹¹ and the Pillar 2 guidance (P2G).¹² The quantitative outcomes of the EU-wide stress test fed into the determination of P2G.

Competent authorities were expected to factor the results of the EU-wide stress test, together with other elements, into their assessment of banks' ability to meet applicable own funds requirements over the horizon of the stress test.¹³ Capital guidance to cover potential shortfalls in own funds was employed based on the quantitative outcomes of supervisory stress tests in a holistic manner. In the case of euro area banks, the ECB also used the qualitative outcomes to update conclusions of the SREP process, especially in the element of risk governance, which in turn influenced the determination of the P2R.

The 2016 stress testing exercises pointed to risks already identified through the ongoing supervisory assessment, but also to key vulnerabilities were an adverse shock to materialise. In particular, the stress tests shed useful light on:

¹⁰ Source: www.eba.europa.eu/-/eba-clarifies-use-of-2016-eu-wide-stress-test-results-in-the-srep-process

¹¹ P2R covers risks underestimated or not covered by Pillar 1. If a bank violates P2R, there will be automatic restrictions imposed on distributions such as dividends and bonuses, referred to as maximum distributable amount (MDA) as defined in Article 141 of Directive No 2013/36 (Capital Requirements Directive, CRD IV).

¹² P2G indicates to banks the adequate level of capital to be maintained in order to have sufficient capital as a buffer to withstand stressed situations, in particular as assessed on the basis of the adverse scenario in the supervisory stress tests. While P2R are binding and breaches can have direct legal consequences for banks, P2G is not binding. Nevertheless, the ECB certainly expects banks to comply with P2G.

¹³ Source: www.eba.europa.eu/documents/10180/1509035/Information+update+on+the+2016+EU-wide+stress+test.pdf

- the recent credit performance and portfolio composition of participating banks (asset class and country exposure) and how these may drive differences in loan losses across banks;
- margin decreases and the loss of income on defaulted assets as key contributors to a decrease in net interest income; and
- how lower credit quality impacts net interest income through multiple channels.

This information was used in SREP decisions and also triggered additional supervisory diligences, for instance in the form of targeted on-site inspections.

Furthermore, supervisory stress test results were used to inform macroprudential analyses, which were carried out by the financial stability function of the ECB. Notably, the macroprudential extension of the stress testing exercise involved an impact assessment of the dynamic evolution of banks' loan volumes that would be consistent with the macro-financial scenarios of the stress test, replacing the standard static balance sheet assumption. In particular, analyses were conducted to quantify second-round effects of stress via the reactions of banks to prospective capital needs under the adverse scenario of the stress test, as well as via contagion due to interconnectedness of banks with each other and with other economic sectors.¹⁴ Moreover, supervisory stress test results also helped to inform early warning models and supported the calibration of macroprudential instruments.

Other microprudential uses

Although the most common supervisory use of stress testing is for the assessment of capital adequacy, various other uses have been identified, including: review and challenge of banks' business plans; review and challenge of banks' recovery plans; assessments of banks' risk profiles; assessments of whether the bank has a sound culture of forward-looking risk management, reflected in its approach to considering adverse scenarios on particular businesses; and liquidity stress testing. The following are some practical examples:

- APRA has used stress tests results to evaluate the adequacy of banks' recovery planning. In particular, a bank's management actions in a stress test scenario should be consistent with and linked closely to a bank's recovery plan in order to be credible. Similarly, in May 2015 the EBA published guidelines asking institutions to include a range of scenarios in their recovery plans to test recovery options.¹⁵
- For the Hong Kong Monetary Authority (HKMA), stress testing provides a forward-looking assessment of a bank's risk exposures under stressed conditions, enabling it to develop appropriate risk-mitigating strategies and contingency plans across a range of stressed conditions, and also improving the banks' understanding of their own risk profile.
- The Bank of Japan uses its stress test results to inform supervisory activities such as on-site examinations and off-site monitoring of banks.

¹⁴ For more details, see Chapter 1 of the ECB Macroprudential Bulletin 2/2016, available at www.ecb.europa.eu/pub/pdf/other/ecbmbpu201610.en.pdf. For the underlying analytical framework see also Dees, Henry and Martin (2017) available at www.ecb.europa.eu/pub/pdf/other/stampe201702.en.pdf as well as Henry and Kok (2013) available at www.ecb.europa.eu/pub/pdf/scpops/ecbocp152.pdf.

¹⁵ See "Guidelines on the minimum list of qualitative and quantitative recovery plan indicators", EBA, (May 6, 2015), available at www.eba.europa.eu/documents/10180/1064487/EBA-GL-2015-02+GL+on+recovery+plan+indicators.pdf

- In the EU the latest draft EBA guidelines on stress testing¹⁶ suggest certain elements of the liquidity supervisory stress tests should be used as an input into setting specific liquidity requirements to institutions, especially in case a competent authority has not developed specific supervisory benchmarks for liquidity requirements.

Rectification of deficiencies identified through the stress testing process

Supervisory follow-up on identified deficiencies is important to improve current and future stress tests, but also because deficiencies in stress testing practices may indicate wider problems in a bank. The vast majority of authorities address weaknesses in such areas as data quality or governance arrangements by way of adopting qualitative supervisory measures. In some cases this is factored directly into the setting of quantitative (either capital or liquidity) requirements, mainly when deficiencies are severe or when the supervisor wants to give additional incentives for banks to address the deficiencies. Qualitative measures, in particular, may involve requesting corrective actions, improved work plans or more frequent reporting.

In the US CCAR exercise, qualitative factors are also considered, including the strength of the bank's capital planning process, which incorporate the risk management, internal controls, governance, and the stress testing required to be used in capital planning. The US Federal Reserve may object to a capital plan based on the quantitative test or based on qualitative concerns. In either case, the bank must rectify the concerns before increasing capital distributions relative to those previously approved.

As part of its stress test exercise, the Bank of England conducts a qualitative review and provides detailed feedback to participating banks, expecting to see clear improvements over time. Findings influence the intensity of supervision of individual banks and they can also have direct capital implications; for example, PRA may set a higher PRA buffer as a result of weaknesses in banks' stress testing processes and the quality of their data that reduce confidence in banks' own stress test results. The industry-wide findings of qualitative reviews are periodically summarised and published to serve as a guidance for future expectations.¹⁷

2.3.2. Macroprudential use of supervisory stress tests

An important development since the global financial crisis is the increasing use of stress tests in macroprudential analysis and in calibrating macroprudential measures as well as supervisory policy changes.¹⁸ Practices are still being developed, and there exist significant differences across countries.

The use of stress tests for calibration of macroprudential instruments raises a number of challenges. These include, for example, identifying the state of the financial cycle and choosing an appropriate level of severity for the stress test scenario; mapping stress test results to the desired instrument (capital buffer, lending restrictions, etc.), and dealing with the possibility that the timing of the stress tests may not align with the timing of the decision on the macroprudential instrument.

In the EU, supervisory stress tests and sensitivity analyses have been used to support the calibration of macroprudential instruments. Examples include:

- The risk-weight add-on for real estate exposures in Belgium.
- The calibration of the countercyclical capital buffer in the UK (see Box 5).

¹⁶ The EBA consultative document that sets out its draft guidelines on stress testing is available at www.eba.europa.eu/documents/10180/2006781/Consultation+Paper+on+Guidelines+on+institution%27s+stress+testing+%28EBA-CP-2017-17%29.pdf

¹⁷ See qualitative review of banks' stress testing frameworks, "Stress testing the UK banking system: 2015 results", Bank of England.

¹⁸ Note that the survey results may underestimate the role of stress tests in financial stability decision-making where responses were received only by a supervisory authority in a respective jurisdiction and not the central bank.

- The introduction of a risk-weight floor in Sweden.
- The capital surcharges for other systemically important institutions (O-SIIs) in Belgium.
- The design of a loan-to-valuation (LTV) cap in the Netherlands.

Other macroprudential uses include early warning exercises to identify potential weaknesses of the system and crisis management (eg for developing contingency plans). It is expected that the macroprudential use of stress tests, especially supervisor-run stress tests, will continue to increase as macroprudential instruments further develop.

Box 5 – Integrating micro and macroprudential stress testing at the Bank of England

The Bank of England’s approach integrates micro- and macro-prudential buffers. The results of the stress test are used also to inform the calibration of a system-wide countercyclical capital buffer, which is applicable to UK credit exposures and is to be met with Common Equity Tier 1 capital exclusively. Similarly, the results may be used to assess a sectoral capital requirement. For banks which are found to be more sensitive to the scenario than the aggregate system, the results are translated into additional bank-specific capital buffers (the PRA buffer). The calibrated buffers are subject to reconciliation with other capital requirements.

An interesting feature of the BoE approach is that stress testing scenarios are adjusted in line with the business and financial cycles to ensure that the countercyclical buffers are appropriately calibrated as *“The severity of this scenario will increase as risks build and decrease after those risks crystallise or abate. The scenario might therefore be most severe during a period of exuberance - for example, when credit and asset prices are growing rapidly and risk premia are compressed ...”*¹⁹

2.4. Supervisory stress testing methodologies

This section assesses the current approaches to supervisory stress testing at a high level and provides insights into the characteristics of stress tests that are currently run by authorities or international organisations, with particular focus on scenario design and risk coverage. Case studies are used to illustrate the methodological choices that authorities have, and in some cases reflect the advantages and disadvantages of the approaches used by different jurisdictions.

2.4.1. Scenario design and risk coverage

Scenario design is a critical aspect of supervisory stress tests, reflected in the considerable attention paid to the scenarios and their severity when authorities publish their stress testing results. Practices for scenario development and selection are an important part of the stress testing governance and methodology. Practices include selecting scenarios via a clearly defined process involving engagement with senior officials, developing a range of scenario options, with a process to select among them; and employing more explicit (though not rigid) criteria for scenario selection.

The main considerations in scenario design are relevance, severity and plausibility. Authorities generally do not gauge scenario severity in a statistical manner, but rather in the context of historical crises and current salient risks.

The number of scenarios included in supervisory stress testing exercises varies considerably across jurisdictions. More than a third use one adverse scenario, roughly thirty percent use two adverse

¹⁹ See Section 1.3 in Bank of England (2015), *“The Bank of England’s approach to stress testing the UK banking system”*, October 2015.

scenarios, and the rest use three or more adverse scenarios. The decision whether to include one or multiple scenarios seems to be related to the nature of shocks explored in the scenario. In general, authorities with scenarios that capture both bank-specific and system-wide shocks tend to design one scenario, while most authorities with scenarios focused on system-wide shocks use two or more scenarios.

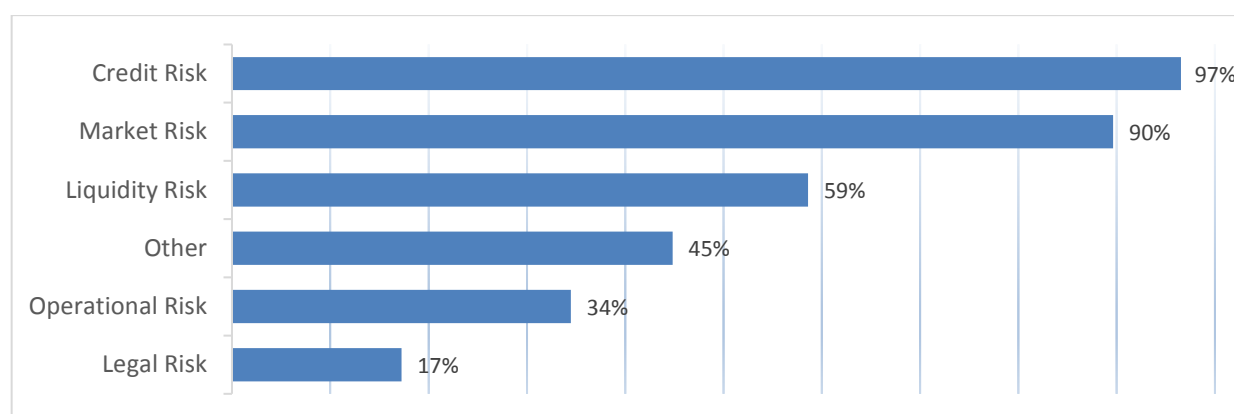
Authorities generally provide to banks a narrative description of the scenario for supervisory stress tests that the banks are required to run (institution-run stress tests). The narrative of the scenario is a useful device through which policymakers or bank risk managers can communicate the risks they are exploring through the scenario. The narrative is important to provide greater clarity to banks and support their efforts to generate additional variables that are not fully specified in the supervisory scenario. A few authorities focused primarily on calibrating key parameters and risk drivers, rather than on developing a fully fleshed out scenario.

Jurisdictions use different models to generate paths for key macroeconomic variables. Nearly all countries use macroeconomic forecasting models. While some jurisdictions use the same model used by central banks for monetary policy projections, others appear to rely on smaller and simpler macroeconomic models. In addition, about two-thirds of authorities use scenarios that are statistically generated. Specifically, one-fifth of authorities use various types of vector autoregressive models to project macroeconomic variables, while others use different macroeconomic models. A statistical-based approach is often used to calibrate shocks to market risk factors. On average authorities provide 25 economic and financial variables to banks for each scenario, although three authorities provide more than 100 parameters.

Almost all authorities stress both credit and market risks, and more than half of the authorities incorporate stress for liquidity risk. For example, the central bank of Brazil performs a supervisor-run stress test that stresses banks' liquidity coverage ratios. Also, stress tests in Korea incorporate contagion effects of funding liquidity risks. Over one-third of the authorities include operational risk in their stress tests with one-fifth of the authorities testing legal risk. For the EU-wide stress tests, the 2016 exercise included for the first time a dedicated stress for operational and conduct risk.

Nearly half of the authorities test various other risks, including interest rate risk, concentration risk, sovereign risk, foreign exchange risk, counterparty default risk and business risk.

Figure 8 – Risks covered in stress testing frameworks (% of authorities)



Source: BCBS survey of authorities. The question asked authorities which risks they stress in their scenarios. Authorities were asked to select all relevant risks from a list.

Box 6 – Interest rate risk stress testing at FINMA

The Swiss Financial Market Supervisory Authority (FINMA) has developed and applies a specific supervisory stress test on interest rate risk in addition to the international standard test of a parallel shift by 200 bps. Originally, the interest rates stress test was seen as an addition to the real estate stress test exercise typically run with domestic banks with a particular exposition to the Swiss mortgage market. FINMA now runs the interest rate risk stress test with a three-year scenario horizon on a stand-alone basis with a similar population of banks.

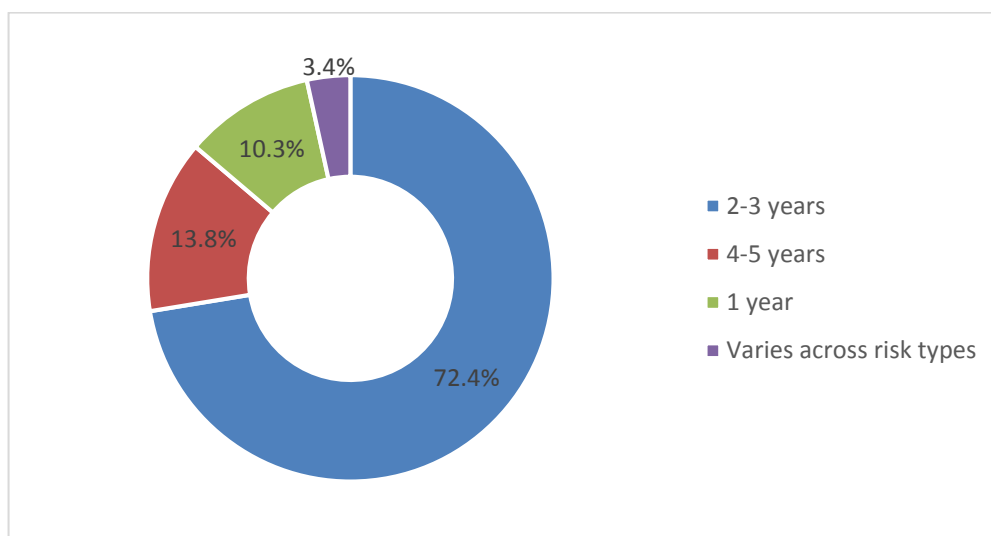
Due to the increased risks of rising interest rates caused by the negative interest rate environment, FINMA defines one major scenario where a significant increase in both long-term and short-term rates in a relative short time period is assumed. Additionally, FINMA provides another scenario with an even further decline in rates from current low levels. All interest bearing liabilities (deposits) and assets (variable and fixed term loans) are in-scope for this stress testing analysis. While FINMA defined the customer behaviour with respect to migrations between variable and fixed maturity contracts and time buckets, FINMA asks participating banks to define the client rates (margins) for the various products and maturities for both scenarios for the next 3 years. FINMA also asks the banks to include existing and expected future hedging activities.

The interest rate risk stress testing exercise has provided a very useful basis for a valuable supervision discussion. Moreover, the exercise can be used for benchmarking purposes, which can be leveraged for further questions towards banks within the supervisory process. Within such supervisory processes, further actions can be defined or required from banks, ranging from detailed reporting, up to additional capital requirements.

Although there is some variation among jurisdictions in the time horizons used in stress testing exercises, the time horizon most frequently used in the scenarios set by supervisors is two to three years. Less than one in five authorities use a four to five year horizon.

A relevant consideration in the design of a stress test related to the time horizon is the timing of the shocks within the horizon. For example, in the EU-wide stress tests conducted to-date, shocks were frontloaded, so that the adverse impacts materialise early during the stress test horizon. As bank losses follow macroeconomic stress with a lag, this feature increases the expected impact of the scenario. For market risk, the shocks are sometimes construed as instantaneous, in contrast to credit risk shocks that build throughout the time horizon of the exercise. Another relevant consideration is the reference date at which the shock occurs (or begins to occur). For the traded risk elements of stress tests, some authorities (eg the Federal Reserve Board and the Bank of England) specify a date to apply the shocks that is different to the period end date used for external financial reporting purposes. This can help to capture more typical levels of traded risk than, for example, applying shocks to the exposures of a bank at the year-end.

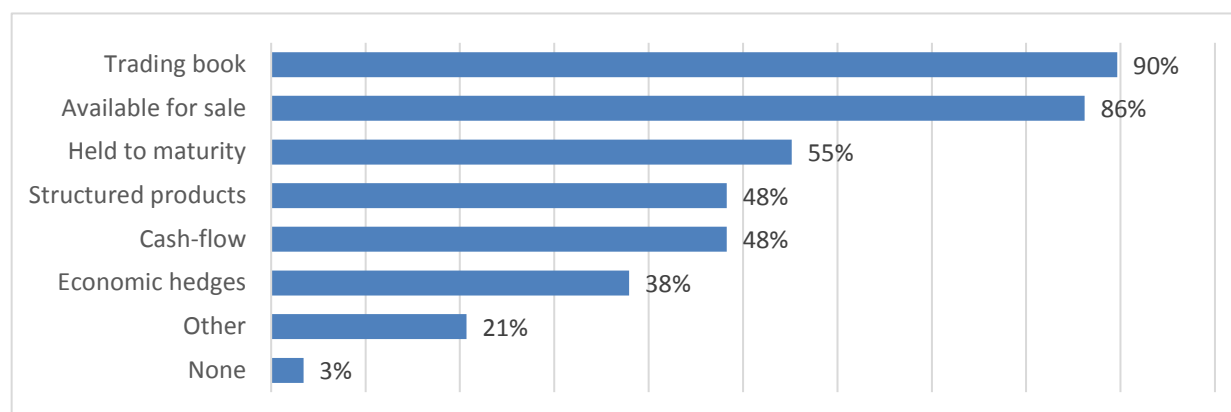
Figure 9 – Typical time horizon used for scenarios (% of authorities)



Source: BCBS survey of authorities. The question asked authorities for the typical time horizon of the scenario. Authorities were asked to select one relevant time range from a list.

Regarding market risk, a clear majority of authorities stress positions related to the trading book and the available-for-sale portfolio (Figure 10). Over half of authorities also stress held-to-maturity positions. This approach may be justified because banks in a crisis may be forced to sell held-to-maturity assets to address liquidity shocks, or because market analysts may use current market values rather than book values when calculating their own assessments of a bank's solvency. When assessing market risk, a majority of authorities also include concentration risk related to single obligors, interrelated borrowers, or any other significant interrelated asset or liability exposures.

Figure 10 – Positions related to market risk that are required to be stressed (% of authorities)



Source: BCBS survey of authorities. The question asked authorities for the positions related to market risk that they require to be stressed. Authorities were asked to select all relevant answers from a list.

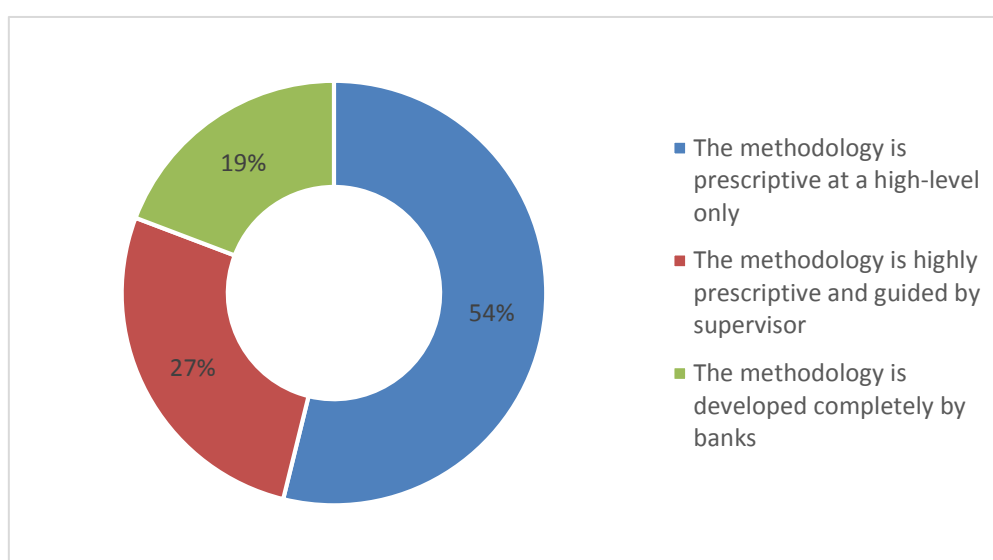
Half of the authorities design a scenario or apply a methodology that incorporates some interaction between credit risk, market risk and liquidity risk. Integrated liquidity and solvency stress tests are desirable as liquidity and solvency interactions can be material. Building an integrated stress test for liquidity and solvency risks is challenging, in part because of the difficulty in defining possible channels for interaction to occur. In addition to the more traditional well-known transmission channels between liquidity and solvency (ie the bank lending channel, the bank capital channel and the risk-taking channel),

the prevalence of high leverage, maturity mismatches in banks' balance sheets, mark-to-market accounting and asset fire-sales can exacerbate adverse dynamics and feedback effects.²⁰

2.4.2. Methodology and guidance

There are many assumptions that can be used by banks in conducting a supervisory stress test that may impair the comparability or credibility of results. As a result, most jurisdictions place some constraints on methodologies through instructions or guidance. This guidance can either be quite detailed and prescriptive, or more high-level. For institution-run stress tests, more than half of the authorities provide high-level guidance to banks. Others provide prescriptive instructions, while the least common approach is to allow methodologies determined completely by banks. Indeed there is a trade-off between having more- and less-prescriptive approaches. While more prescriptive approaches may enhance comparability across banks, less prescriptive approaches are more flexible to accommodate bank specific components (Figure 11).

Figure 11 – Level of prescriptiveness of the methodology (% of authorities)

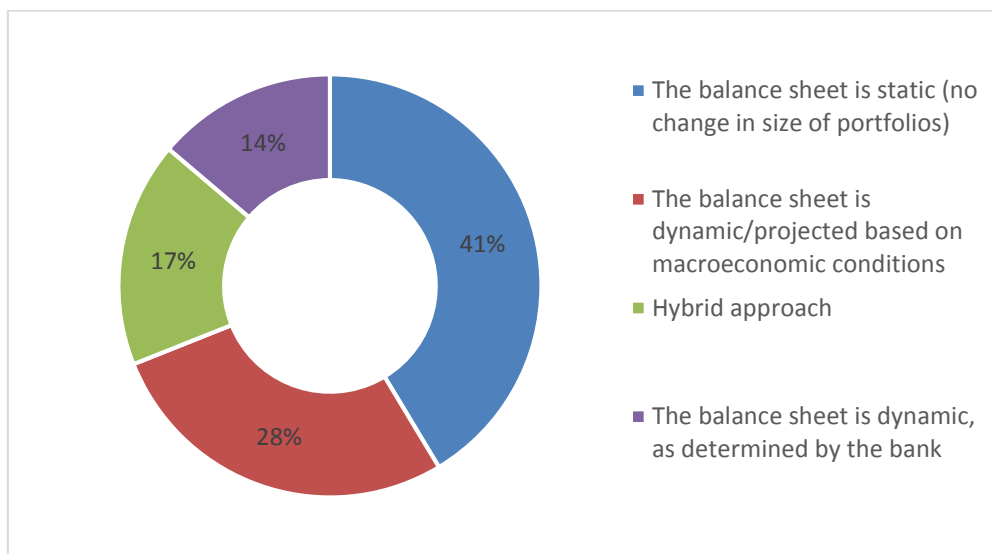


Source: BCBS survey of authorities. The question asked authorities how prescriptive is the methodology given by supervisors in bank-run stress tests. Authorities were asked to select one relevant answer from a list.

The assumption regarding a static or dynamic balance sheet is a key decision in designing an institution-run supervisory stress test. Holding the balance sheet static (constant) is artificial, but it allows the results to be interpreted free of subjective balance sheet compositional changes, and prevents improvement in the bank's financial position merely from reduction in business volumes. In practice, the approaches of authorities to the projection of banks' balance sheets is split between static and dynamic balance sheets (Figure 12).

²⁰ For further information, see Basel Committee on Banking Supervision (2015): "Making supervisory stress tests more macroprudential: Considering liquidity and solvency interactions and systemic risk", Working Paper no 29.

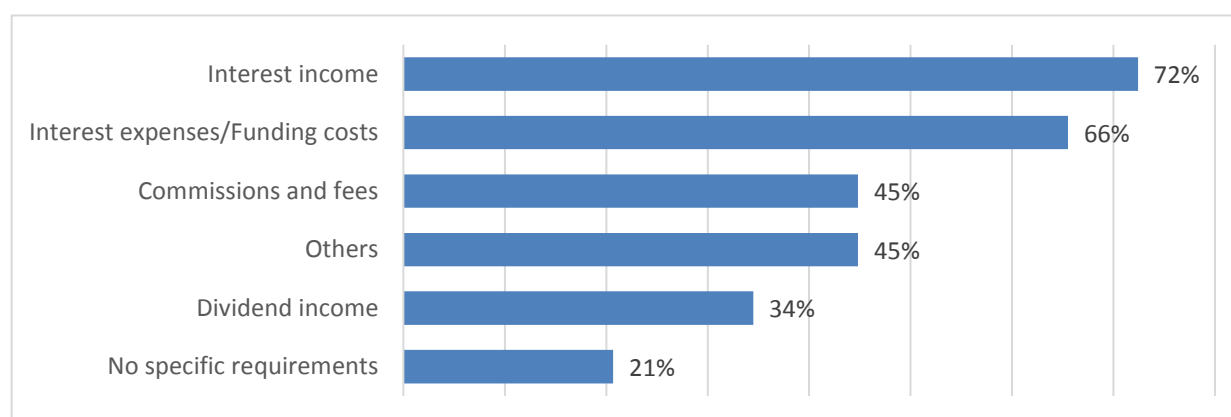
Figure 12 – Balance Sheet Assumptions (% of authorities)



Source: BCBS survey of authorities. The question asked authorities how banks' balance sheets are determined in stress tests. Authorities were asked to select one relevant answer from a list.

Most authorities model specific elements of the profits and loss statement, particularly related to interest income and interest expenses (see Figure 13), but just under half of authorities model non-interest income including commissions and fees. For supervisor-run stress tests, the majority of authorities use data at the portfolio level, drawing on the supervisory reporting system. Approximately forty percent use a mixed approach, combining portfolio and transaction level data, and less than ten percent rely on transaction level data.

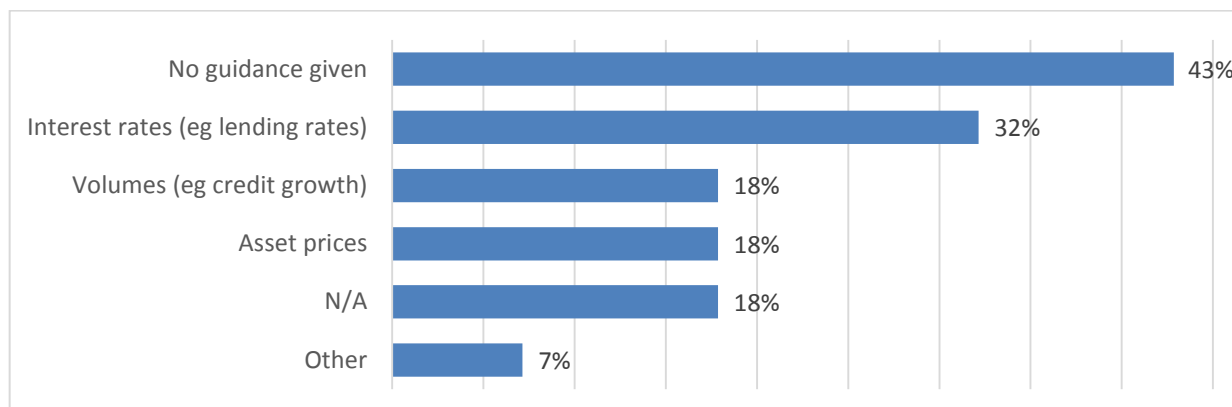
Figure 13 – Components of profits and losses modelled (% of authorities)



Source: BCBS survey of authorities. The question asked authorities whether their scenario or methodology requires specific elements of profits and losses to be stressed. Authorities were asked to select all relevant elements from a list.

Less than half of authorities provided guidance to banks on the requirement to model feedback effects, although in some jurisdictions, interest-rate guidance encompasses feedback effects. Some authorities design asset prices and credit growth paths to reflect feedback effects (Figure 14).

Figure 14 – Guidance on feedback effects (% of authorities)



Source: BCBS survey of authorities. The question asked authorities for bank-run stress tests which feedback effects are required to be explicitly modelled. Authorities were asked to select all relevant answers from a list.

Management or mitigating actions include steps (such as repricing, cutting dividends, hedging, asset sales, and capital issuance) that banks can take as a result of the stress to mitigate the impacts on their financial position. Some management actions that banks may project during a stressed period (eg capital issuance) may be considered overly optimistic. As a result, authorities may prohibit or limit their inclusion in the results of the supervisory stress test exercise, or subject to other specified limitations. For example, about forty percent of authorities reported that banks are required to provide results including management actions, while more than one third noted that banks report their projected capital position both including and excluding management/mitigating actions.

Box 7 – Methodologies: Country Experiences

Brazil. Banco Central do Brasil started running stress tests and publishing aggregate results in the Financial Stability Report around 2002. The chosen approach was top-down stress tests using daily and monthly information provided by banks, clearing houses, and trade repositories. The information covers liquidity, market exposures, accounting, credit operations, and regulatory capital.

The first type of stress test introduced was a sensitivity analysis simulation with shocks applied directly to risk factors such as interest rate yield curves, exchange rates, nonperforming loans, portfolio ratings, house prices, and deposit withdrawals. Impacts on capital through profits and losses were assessed for gradual changes in each risk factor, one at a time, allowing the identification of specific exposures and the vulnerabilities of each bank. Subsequently, stressed economic scenarios were introduced as a second type of stress test with scenarios working as drivers to joint changes in risk factors. This type of simulation allows for consistent assessment of impacts on profits and losses in hypothetical economic conditions addressing specific sources of risk. A third type of stress test which has now been introduced is a contagion stress test. It uses events in the real sector to trigger systemic effects. This test simulates the phenomena of the failure of large companies leading to other failures in the production chain due to economic dependence. The consequences are bank loan defaults by companies and employees, as well as potential defaults by banks in the interbank market, generating spill-over effects to other banks in a feedback loop.

A project to implement a bottom-up approach to stress testing is under way to access the view of the banks on their vulnerabilities in comparison to the view given by the top-down approach. Besides the publication of aggregate results in the financial stability review, individual bank results are used for supervision and the ranking of banks. Stress tests are mainly used as tools for supervision and systemic risk assessment.

Georgia. National Bank of Georgia (NBG) has adopted a supervisory approach, called "GRAPE," which integrates microprudential and macroprudential supervision in one process. The stress testing framework under GRAPE is designed to incorporate principles of risk sensitivity, simplicity, and comparability and is an inherent part of the supervisory cycle. Scenarios are adjusted counter-cyclically, complementing other macroprudential tools. Along with key macro variables, the scenario specifies a sectoral distribution of shocks (eg a drop in sales), allowing banks to stress exposures at transaction level (eg, analyse a sampled individual borrower's after-shock creditworthiness). This makes stress tests more forward-looking and less demanding of historical financial-sector data, captures the nonlinearity of results, reduces modelling errors, and increases comparability across banks. It ensures a high degree of transparency since the core of the methodology remains parsimonious, based on common creditworthiness analysis, which is well-understood by senior bank managers as well as frontline supervisors. It provides proper incentives and guidance to the industry on how to mitigate inherent risk, as, for example, by adjusting underwriting standards that have an explicit impact on stress test results. The NBG's approach could be of interest to other jurisdictions, where model risk is an issue or frequent structural changes occur in financial-sector data, making historical parameter estimates unreliable.

Japan. The Bank of Japan conducts top-down macro stress tests and publishes the aggregate-level results in its semi-annual Financial System Report. As of September 2017, the framework incorporates the activities of 370 banks, consisting of 10 major banks (including G-SIBs), 105 regional banks, and 255 *shinkin* banks (regional cooperative financial institutions).

Its main model, the Financial Macroeconometric Model, is a medium-sized macro model with two sectors, the financial and the macroeconomic. It models individual banks' activities with bank-level panel data. A notable feature is that it includes a mechanism reflecting the feedback loop between the financial and economic sectors, which can be roughly described as follows. Once the capital adequacy ratios of the banks deteriorate after the initial adverse shocks, funding rates rise, and the banks increase their loan interest rates and reduce their lending. This depresses household and firm expenditures and fuels deteriorated economic conditions, in turn leading to second-round negative effects on banks' profits and capital levels.

A satellite model calculates the effects of changes in market interest rates on lending and funding rates and on unrealised bond gains and losses. It produces individual banks' predicted paths of lending and funding rates based on the empirical pass-through estimated using dynamic panel models. It takes into account the heterogeneity in pass-through among individual banks.

Korea. As part of its efforts to fulfil its new mandate for financial stability since revision of the Bank of Korea Act in September 2011, the Bank of Korea has developed the Systemic Risk Assessment Model for Macroprudential Policy (SAMP), in a process that started with improvement of the macro stress test model (BOKST-07) developed in 2007. SAMP is an integrated systemic risk model framework comprised of six modules. The macro risk factor module estimates a joint probability distribution of macro risk factors and uses a BVAR, GARCH and EVT (respectively, Bayesian Vector Autoregression, Generalised Autoregressive Conditional Heteroskedasticity, and Extreme Value Theory) to capture time-varying fat-tailed marginal distributions. Designed to detect systemic crisis, SAMP measures not only the first-round direct effects of macroeconomic shocks on the financial system, but also second-round effects amplified and propagated by interbank contagion, fire sales, credit crunches, and deleveraging.

In order to reflect the unique features of the Korean domestic economy and financial system, SAMP models the mechanisms behind the amplification and propagation of various risks. According to the Bank of Korea, SAMP has several comparative advantages vis-a-vis other models, including: enhanced accuracy in tail risk evaluation; estimation of the contagion effects of funding liquidity risks; estimation of credit crunch losses from macro-financial feedbacks; and the setting up of multi-period models. The Bank of Korea also plans to further improve SAMP and expand its coverage of financial institutions.

Mexico. Banco de México currently conducts top-down stress tests to assess the resilience of the Mexican financial system to exogenous shocks from several risk factors. Specifically, the methodology is based on scenarios generated by a VAR model that considers changes in major macro-financial variables. The exercise assesses the effects on banks' balance sheets, profits and losses, and capital ratios for a set of 4,000 adverse scenarios. The current model forecasts major macro-financial variables, defines the paths of capital levels by incorporating credit losses and portfolio performance, and projects nonfinancial income and expenses. Also, market risk is assessed and contagion among financial entities is incorporated by using Network Analysis.

Banco de México started to perform top-down stress tests in 2007 using a simple model that addressed only credit risk and solvency. Since then, progress has been made and the model has evolved considerably. In particular, the methodology has been extended by adding satellite modules. The model improvements include: enhanced and refined modelling of macro risk factors; increased portfolio granularity; inclusion of non-banking entities; incorporation of market risk along with joint estimation of credit risk; increases in the number of simulations; yield curve modelling; analysis of large exposures among firms to address concentration risk; specific shocks on products or international contagion; and improved scenario design to address external shocks. Macroeconomic scenarios have been based on a three-year horizon since 2017.

Turkey. Stress testing in the Banking Regulation and Supervision Agency of Turkey has been performed since 2002 using historical scenarios and sensitivity analysis. Top-down macro stress testing studies began in 2011 and cover credit risk, interest rate risk, exchange rate risk, and contagion effects. GDP growth, the interest rate, exchange rate, unemployment rate and inflation rate are all used as macro variables. A baseline scenario is formed using market expectations and expert judgment. Adverse scenarios are designed as either historic or hypothetical. Panel regression satellite models are used to estimate loan growth and non-performing loans (NPL). The consideration of all shocks simultaneously in all risk parameters, income effects from loan growth, temporary revenues/costs, dividend payments, and tax rates are included. Primary final outputs are summarised for capital adequacy ratios. The stress test time horizon is two years, and all banks are included in the exercise.

Additionally, sensitivity and "what if" analyses are performed. Interest rate, foreign exchange rate and NPL shocks are applied to each bank to determine the effects on capital adequacy ratios. Several what-if analyses are conducted in the form of reverse stress tests. Stress testing is reported internally for supervisory assessment, with aggregated outputs used for industrial and systemic risk analysis.

United Kingdom. The Bank of England (BoE)'s concurrent stress testing framework allows its Prudential Regulation Committee (PRC) and the Financial Policy Committee (FPC) to assess the capital adequacy of individual institutions and the resilience of the banking system as a whole. The BoE runs a cyclical scenario annually and an exploratory scenario biennially (starting in 2016 and 2017 respectively). The annual cyclical scenario is calibrated to reflect imbalances in financial and credit markets, while the biennial exploratory scenario allows for an assessment of bank resilience to a wider range of potential threats. The annual cycle scenario stress test spans a five-year period and includes three types of stresses: a macroeconomic stress scenario, a traded risk stress scenario, and a misconduct risk stress. The first biennial exploratory scenario has a seven year horizon and explores a structurally low growth and interest rate environment. The BoE's stress testing methodology allows banks to develop and use their own internal models to project balance sheets, profitability, and capital under highly prescribed guidance. The BoE employs a suite of models to challenge the banks' stress testing results and to assess uncertainties and sensitivities around the outcomes.

Since 2014, the BoE has run concurrent stress tests of the largest UK banks and building societies to assess the banking system's capital adequacy. The BoE has also adjusted its stress test hurdle rate framework to improve consistency with the capital framework (including a leverage ratio threshold), increase transparency around Pillar 2 requirements, and hold G-SIBs to higher standards.

2.5. International coordination

The BCBS principles for Supervisory Colleges specifically encourage the sharing of stress testing information. However, the information gathered by the survey indicates that coordination of stress testing across national supervisors is currently not common. This includes both the sharing of stress test results among home and host supervisors of internationally active banks, as well as the international coordination of stress testing activities across jurisdictions. There are exceptions to this general finding, such as the coordination that takes place between the national and various EU authorities participating in the EU-wide stress tests (see Box 4), and the Australia/New Zealand cross-border stress testing exercise (see Box 8).

Greater coordination could have a number of potential benefits. Within an interconnected global financial system, nationally focused stress tests may only give a partial view of banking sector risks. Jurisdictions that host foreign banks are, on their own, unable to gain a complete picture of the resilience of those banks and their likely behaviour under stress, and may have less visibility into group structure or management actions by parent companies that could affect the resilience of subsidiaries. These arguments are particularly true for smaller supervisors or those with higher resource constraints. Jurisdictions that are home to banks that have significant foreign operations could also benefit from coordination with the host authorities of the foreign subsidiaries/branches. For example, the host authorities may be better placed to provide information on local risks that could impact the subsidiaries and branches and ultimately impact the parent of the group, or the group as a whole.

The survey of banks provided some information about the extent to which banks conduct stress tests in multiple jurisdictions, and therefore the potential efficiency impact of greater coordination. Of the 42 bank respondents on this question, more than half reported that they undertook supervisory stress tests in only one jurisdiction. However, eight reported conducting stress tests in 2-3 jurisdictions and nine reported they were subject to supervisory stress tests in four or more jurisdictions. The banks reporting four or more jurisdictions were, for the most part, the largest G-SIBs with extensive international operations. For these entities, both supervisors and banks may see efficiency gains from greater coordination.

2.5.1. Sharing of bank-specific results

Outside of the EU context, there appears to be fairly limited sharing of stress test results among home and host supervisors. This may be due to the high barriers to sharing sensitive information, or the relative lack of benefit perceived by supervisors. In some cases it may also be due to the fact that the results are made available to everyone through publication.

Supervisors generally do not routinely exchange information on stress test plans and results through supervisory colleges, with less than one in five authorities indicating that this practice is common. Nearly half of authorities are not in favour of further formal exchanges of information on stress test plans and results through supervisory colleges, but the reasons for not favouring further exchange vary. Some jurisdictions indicated that they would share results with home supervisors upon request or based on a 'need-to-know' basis. Several jurisdictions already publish detailed results at the bank-level (eg the US, Europe). While such detailed disclosures may largely obviate the need to share more details on the stress test results with other supervisors, several authorities such as the US regularly communicate about stress testing frameworks with other official organisations outside the US. In another case, the OSFI noted that where applicable and appropriate, information regarding supervisory stress testing is shared, for instance, through the supervisory colleges.

2.5.2. Data reporting

The level of data reported on supervisory stress tests reflects the differing objectives and areas of focus across supervisors. A review of several stress testing reporting templates (EBA, US CCAR and APRA)

indicates significant divergences in approach to their design, content and level of detail. The CCAR template was the most detailed, with quarterly data for a large number of balance sheet items in addition to trading book, CVA, and IRB parameters, and ancillary templates on various detailed topics (eg capital composition, operational risk losses, etc.). The EBA reporting template is also quite detailed, based on annual data with about 20 summary items and additional detail in areas such as sovereign exposures; however, there are additional, much more granular templates for credit risk exposures and net interest income. In comparison, the template from the Australian stress test was quite summarised, with the most detail on risk parameters, but substantially less on capital composition, trading book, and loan categories.

2.5.3. Coordinated stress tests

One area of potential cross-border coordination is on scenarios. A single scenario could be articulated across multiple countries in the stress test. The adverse macro-financial scenario for the EBA 2016 EU-wide bank stress testing exercise, for example, considers country-specific vulnerabilities by country-specific shocks to sovereign credit spreads. It also takes into account country-specific economic cycle starting points and historical statistical distributions when calibrating shocks and incorporates so-called national add-ons (to accommodate for country-specific stress factors outside the scenario narrative). However, the broader the scope of countries being considered, the less likely the scenario is able to capture country-specific risks due to the fact that the number of main risks identified that are relevant to all countries is typically limited. In practice, development of cross-border scenarios across jurisdictions is not common, although authorities typically have regard to scenarios being used in other countries and may use them for scenario severity comparison purposes.

Box 8 - Cross-border stress testing: Australia/New Zealand

In 2014 and again in 2017, the Australian and New Zealand supervisory authorities completed a coordinated banking industry stress test. Although both countries had worked together for previous banking industry stress tests, the level of engagement increased in 2014 with close coordination and collaboration on scenario design, templates, analysis and outcomes.

There is a strong link between the banking sectors in Australia and New Zealand; the four major Australian banks have significant exposures to New Zealand and their subsidiaries dominate the New Zealand banking system.

APRA was responsible for the overall coordination and execution of the stress test. There was a common scenario and set of reporting templates covering Australia and New Zealand. Timing of all stages was closely coordinated. The Reserve Bank of New Zealand (RBNZ) provided challenge and input into the scenario and determined the specific economic parameters for New Zealand, which focused on additional agricultural risks. The RBNZ was responsible for analysing the results for New Zealand banks. Each authority engaged directly with the banks within their jurisdiction on queries and feedback throughout the process.

Ongoing engagement and communication was critical to the success of the exercise. Particular consideration was given to issues that differed between the two jurisdictions. At the highest level this involved ensuring that the economic parameters between Australia and New Zealand were realistic and consistent in a stressed environment. For example, there was discussion and challenge as to the relationship between interest rates in Australia and a corresponding level for interest rates in New Zealand.

The benefits to both authorities included more credible results, deeper analysis of results and a group-wide perspective on each bank. There was also better engagement with the banks and a more efficient, streamlined process for them relative to conducting two separate stress tests. By working together, the authorities were able to combine resources and capabilities and share knowledge, resulting in greater efficiencies and some cost savings.

3. Bank stress testing frameworks

3.1 Overview

This section reviews the range of stress testing practices within banks. In their own internal stress test exercises, banks are able to tailor the stress scenarios to their individual business strategy, portfolio mix and risk profile, and to investigate their institution-specific vulnerabilities. Such stress tests can form a key part of a bank's risk management and can help guide its business strategy. The effectiveness of a stress testing framework is particularly influenced by the related governance and control arrangements, which is the focus of this section. There is some discussion of methodologies at a high level, but the report is not intended to catalogue technical approaches.

The range of practices defined below was gathered through a survey of 54 institutions across 24 countries (including 20 G-SIBs), as well as direct input from supervisory authorities with responsibility for reviewing and assessing bank stress test processes. The size and complexity of the respondent institutions was captured as part of the survey data to help inform the range of practices identified below, as some practices were found only in certain jurisdictions or sizes of institutions.

3.2. Governance of bank stress testing frameworks ²¹

3.2.1. Objectives

As with supervisory authorities, objectives define and drive stress testing frameworks in individual institutions. Objectives are key in informing the governance structure of the program, its scope, the degree to which different lines of business and support functions are engaged, the overall resources and budget and even the appropriate methodologies used. Clearly defined objectives have been identified by supervisors as an important component of successful stress testing frameworks, while objectives that are inadequate (eg overly broad) have resulted in less robust stress testing frameworks and, ultimately, results.

Objectives can vary significantly across institutions and geographies. For around three-quarters of banks, capital adequacy assessment is their highest priority objective, and liquidity assessment typically the second highest priority.

However, regulatory compliance is identified as an important objective for a substantial segment of institutions. Nearly one-fifth of institutions rank compliance as the highest or second highest objective. This suggests that for a sizeable minority of banks, stress testing continues to be seen as primarily a compliance exercise, which is disappointing. This may reflect relative maturity in stress testing across jurisdictions. Over time, supervisors have seen a trend away from a singular focus on regulatory compliance to objectives that include risk and business planning elements. The expansion from capital and liquidity adequacy to objectives seeking to enhance the understanding of risk and improve business practices is a reflection of the growing maturity of stress testing in institutions. It is also a reflection of the significant resources being devoted to stress testing and institutions' interest in maximising its value as an integrated process.

²¹ As governance structures differ among countries (eg one-tier versus two-tier structures) the term "board" should be interpreted according to the applicable law within each jurisdiction.

Table 1 – Objectives of stress testing frameworks (% of respondents)

Objectives	Rank			
	1	2	3	4
Capital adequacy assessment	77%	13%	4%	4%
Liquidity adequacy assessment	13%	51%	15%	4%
Regulatory compliance	11%	8%	21%	23%
Risk bearing capacity determination	9%	9%	28%	17%
Risk identification	6%	13%	17%	15%
Risk exploration	6%	4%	8%	6%
Recovery planning	4%	4%	13%	19%
Assessment of strategy	2%	0%	9%	11%

Source: BCBS survey of banks. The question presented a list of possible objectives of internal stress testing frameworks and asked banks to rank the objectives in order of priority. Rows and columns do not sum to 100% because only the top 4 ranks are shown and some banks provided the same rank for multiple options.

Almost all institutions indicated that they have revised their internal stress testing objectives over time. While around a fifth of the institutions surveyed have a regular programme of reviewing and revising their stress testing objectives, a large proportion of the institutions make revisions on an ad hoc basis. The frequency of the regular revision of objectives tends to be annual. In some jurisdictions, the annual review process is designed to follow the completion of the stress testing exercise, allowing the institution to take stock of its progress and gaps identified in the exercise.

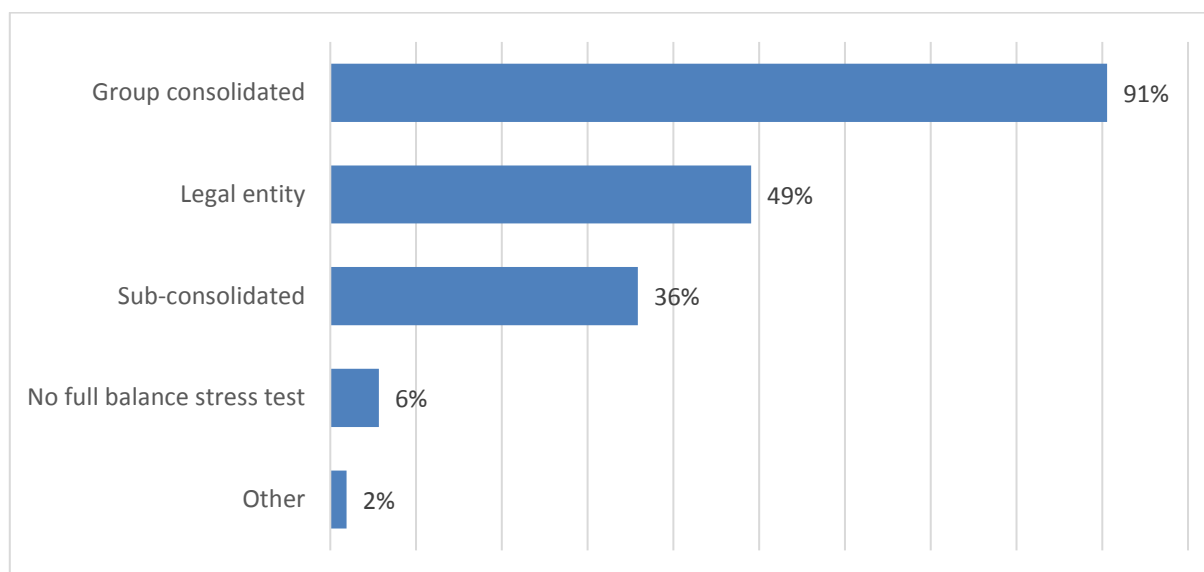
3.2.2. Scope

The objectives of an institution's stress testing programme are key in defining its scope. There are a number of ways in which scope can be considered, including:

- Institutional level - consolidated versus solo or sub-consolidated
- Portfolio level
- Line of business
- Risk type

A key decision is the level of consolidation at which the stress test is being undertaken. As can be seen from Figure 15 below, almost all institutions undertake stress testing at a group level. Around half of institutions also undertake stress testing at sub-consolidated and at legal entity (solo) level. Only a few institutions reported conducting stress testing at a sub-consolidated or legal entity level and not at a consolidated level, although potentially this could be due to exclusion of subsidiaries engaged in specialised business lines, or insurance (which may be subject to separate stress tests).

Figure 15 – Level of consolidation at which banks’ own stress testing is undertaken



Source: BCBS survey of banks. Regarding enterprise-wide, full balance sheet stress testing, banks were asked to select from a list all applicable approaches used.

Institutions commonly undertake stress tests of particular business lines or portfolios. For example, as oil and commodities prices fell in early 2016, a number of institutions undertook stress tests of their commodities exposures to better understand their exposure and the associated risks. These exposures are typically located across a number of portfolios and business lines – from the trading book to corporate loan books. This complicates the ability to conduct the stress test, but also highlights the need to ensure that all exposures, regardless of where they are located, are appropriately captured. In another example, an institution undertook a full balance sheet stress of its legal entities as part of the group-wide stress test with the express objective of understanding intra-group cash flows and which entities were capital constrained within the group. However, more generally the identification and aggregation of risk data within organisations continues to be one of the major challenges for institutions, which impacts their stress testing capabilities and operations.

Institutions also need to decide the scope of risks that will be stressed in a given stress test. For example, capital stress tests typically cover credit and market risks, but fewer consider a stress to operational losses (as institutions see little relationship between economic conditions and operational losses). However, operational risk management can also involve the use of scenarios to quantify and understand the impact of operational risk on operations, controls, and the business.

Some institutions have made progress in developing an integrated, enterprise-wide approach to stress testing, reflecting not only isolated effects on single risk types but also inter-linkages between risk factors. However, the full integration across the firm continues to be a difficult aspect of stress testing. Regarding the integration between capital and liquidity stress testing, over two-third of institutions run solvency and liquidity stress tests separately, or run them separately but assess the results jointly. At less than a third of institutions liquidity stress testing is fully integrated within enterprise-wide stress testing.

Depending on the scope of the stress testing exercise, the stress tests may be run at different frequencies. About two thirds of the respondent institutions carry out enterprise-wide stress tests more frequently than annually.

3.2.3. Responsibility for stress testing

One of the most fundamental elements of governance over any project or process is clearly defined roles and responsibilities and accountability for the success or failure of the stress testing framework. For

example, in about one in five banks, the full board takes responsibility for stress testing; more commonly the board delegates responsibility for stress testing to the board risk committee. A common alternative approach is delegation to the asset and liability committee. Some institutions indicated that responsibility is delegated to more than one board committee, which perhaps reflects different ownership for solvency and liquidity stress testing. It is worth noting that the range of practices regarding the governance of stress testing may ultimately be attributed to differences in governance structures at banks more generally.

Some supervisors have noted that with the increasing scope of responsibilities for the full board, delegating to a sub-committee may be necessary so that sufficient time can be spent on reviewing and providing feedback to management on the stress testing process. Some supervisors have observed that institutions in their jurisdictions use a hybrid approach in that the board has delegated responsibility to the board risk committee, but other board members that are not on the risk committee routinely attend the meetings where stress testing is discussed.

The role of the board is to provide oversight and challenge of the executive management team. So it is important to consider who is responsible for leading stress testing within institutions. The chief risk officer (CRO) is responsible for stress testing in over half of respondent institutions. However, practices vary across geographies. A practice that is notable within Europe and the Americas is joint ownership between the CRO and the chief financial officer (CFO) or a position that encompasses both sets of responsibilities. Where there is joint ownership, supervisors observe that there is division of responsibilities with few joint accountabilities. That said, joint ownership ensures that both finance and risk are engaged in the process which could result in a more integrated stress testing framework.

For mid to large size institutions, the CRO is most frequently the responsible executive. However, in the largest institutions, there is a wider range of practices where joint ownership reflects both scale and complexity of the institutions.

Over three-quarters of institutions make use of existing governance structures for stress testing. Institutions in the Americas are more likely to have created a new executive committee structure to support stress testing, with approximately half having done so. In Europe, Asia and Oceania, institutions are more likely to be making use of existing committee structures (over three quarters of institutions). Even where institutions are using existing structures, supervisors have noted that often structures and committee charters have had to be adjusted to ensure appropriate coverage of stress testing.

3.2.4. Training

Stress testing is a highly technical topic and not one that all board members are familiar with, which was particularly the case when stress testing was first being introduced by supervisors for capital and liquidity adequacy purposes.

More than half of institutions indicated that they provide training on stress testing to the board, either at least annually, on a periodical basis or to new members only. Approximately a fifth of respondents provided ad-hoc or on the job training. Some institutions noted there were extensive discussions regarding stress tests during board meetings, which helped to increase understanding. Notably, around a quarter of institutions do not provide training to board members on stress testing. Several supervisors noted that they have raised concerns with institutions directly when no training or insufficient information is provided to the board.

Table 2 – Board training on stress testing

Degree to which training is provided	Percentage of respondents
To all board members at least annually	24%
To all board members on a periodic basis	15%
To new board members only	19%
No specific board training	24%
Other	19%

Source: BCBS survey of banks. Banks were asked to select one of a list of possible answers on the frequency with which training is provided to board members on the subject of stress testing.

The level and extent of training for the board is likely to change in the future. Historically, it was rare to appoint board members with an understanding of stress testing. As stress testing has matured in their jurisdiction, institutions need to and are able to attract board members with prior stress testing experience.

3.2.5. Board priorities

Priorities of the board quickly become priorities for the senior management team involved in stress testing and generally drive the future work and improvements. One of the top board priorities is review and challenge of the stress testing results. Scenario development and the use of stress test results/outputs are also key priorities. Less important for many banks are model approval, and stress testing policies and procedures.

Regarding the assessments of inputs (scenario) and outputs (results and their use), boards often take a bifurcated focus, with significant focus on understanding the different aspects of the scenario followed by understanding the assumptions made that then drive the results. The level of detail that the boards spend on stress testing can vary significantly and there is a very wide range of practice.

The wide range of practices may be driven, in part, by maturity of processes. For example, some supervisors have noted that institutions with relatively mature stress testing processes are more focused on enhancements to models and model specific governance issues, and focus less on general governance, with the view that it is well-established and a “business as usual” framework. Whereas, institutions that are newer to the more robust stress testing expectations established by local regulators are spending more time within the board on developing the general governance framework.

Table 3 – Board priorities (% of respondents)

Board discussion topics	Rank			
	1	2	3	4
Review and challenge of results	34%	38%	9%	8%
Scenario Development	25%	19%	25%	8%
Use of stress test results/outputs	21%	25%	30%	11%
Governance	19%	8%	9%	28%
Stress testing policies and procedures	2%	6%	19%	17%
Stress testing model approval	2%	6%	8%	17%

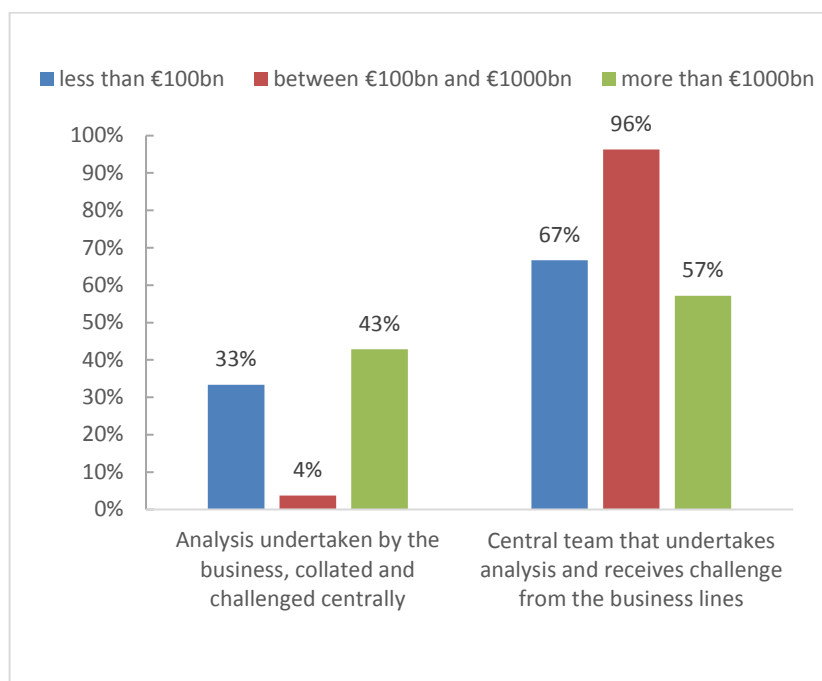
Source: BCBS survey of banks. The question asked banks to consider a list of activities related to stress testing and rank them in terms of the time the bank's board spends discussing each activity. Rows and columns do not sum to 100% because only the top 4 ranks are shown and some banks provided the same rank for multiple options.

3.2.6. Organisational approaches

The structure of institutions' stress testing activities can be an important factor in its success as a risk management tool. Supervisors have observed that institutions use both centralised and decentralised approaches. A centralised approach means that there is a central team that undertakes analysis and usually receives challenge from the business lines. In contrast, a decentralised approach means that the analysis is undertaken by the business lines and this is then collated and challenged centrally. The choice between a centralised and decentralised approach tends to be driven by the culture within the institution, as stress testing tends to follow the norms of how an institution generally operates its business. The majority of institutions use a centralised process to run stress tests. In contrast, approximately a fifth of institutions operate their stress testing in a decentralised way.

Differences in practices vary according to the size of the institution, as evidenced by the chart below. Almost all mid-sized to large institutions use centralised practices for stress testing. For very large institutions there is roughly an even split between centralised and decentralised practices.

Figure 16 – Degree of centralisation by total assets of institutions (% of respondents)



Source: BCBS survey of banks. Banks were asked to choose one of two options that best describes the interactions between lines of business and support functions in their stress testing activities.

As an example of institutional organisation, one large international institution reported that it has a central team that coordinates its global stress testing framework. This central team provides written instructions on the stress test to each local stress test team in order to ensure consistency of approach. The central team then challenges the results from local teams and aggregates the group level results. In contrast, another similarly internationally active institution has centralised much of its modelling with the front line business providing challenge.

There are benefits and drawbacks to both the centralised and decentralised approach. Anecdotal evidence from supervisors indicates that there is an increasing move towards centralised processes. The benefit of a centralised process is ensuring a certain level of consistency across the organisation through established group-level policies, procedures and controls. This allows institutions to provide a consistent engagement with regulators on supervisory stress tests as well. However, an overreliance on centralisation can raise concerns if the institutions move too far from the businesses, losing that direct contact which provides valuable insights around how stress scenarios can impact different portfolios and lines of business.

3.2.7. Functions involved in the stress testing process

Stress testing requires a diverse set of skills and perspectives, and as a result typically requires engagement across many business units with an institution. Table 4 shows for various aspects of stress testing the percentage of institutions that report the direct involvement of various business functions.

Table 4 – Functional involvement in stress testing processes (% of respondents)

	Risk	Finance	Treasury	Lines of business	Economics/ Research function	Internal Audit	External consultants
Development of the overall governance framework	100%	58%	43%	17%	15%	21%	17%
Scenario development	96%	51%	57%	53%	92%	6%	13%
Execution of the stress test	100%	81%	57%	42%	21%	6%	6%
Model development	100%	55%	42%	30%	17%	2%	23%
Review and challenge of the stress test results	96%	68%	53%	58%	15%	40%	2%
Reporting of the stress test results	94%	66%	40%	21%	9%	13%	0%
Validation of the stress test scenarios	81%	30%	25%	13%	34%	21%	13%

Source: BCBS survey of banks. For each stress testing activity listed in the first column of the table above the question asked the bank to indicate the bank functions (listed in the first row of the table) that are directly involved in that activity.

The involvement of the risk function across all areas of stress testing is consistent with strong ownership of the process by CROs and board delegation to the board risk committee. Also, consistent with supervisory observations, there is a high degree of engagement by the economics/research function in the scenario development process. The treasury function appears to be involved in about half the respondent population which may reflect differences in treasury responsibilities and organisation.

In about half of institutions the business was involved in scenario development or review of results. More advanced institutions are using the business lines' expertise to help consider plausible worst-case scenarios for their business. Business line involvement in scenarios as well as challenge of results can result in greater engagement around the organisation and as a result, more robust and valuable use of the results.

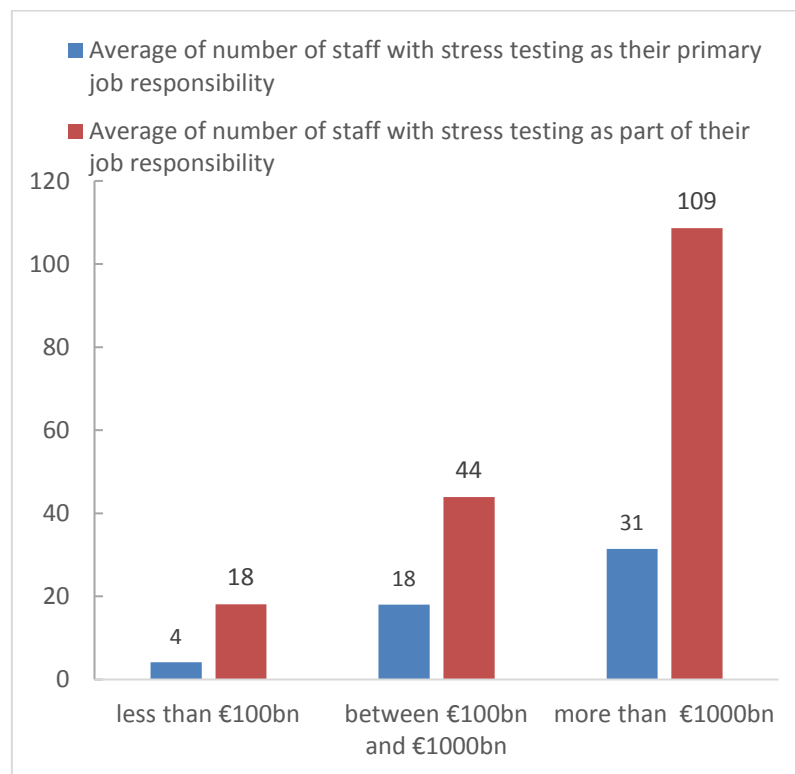
For less than half of banks, internal audit is involved in review of stress test results. This is an area where there may be room for strengthened practice.

3.2.8. Stress testing resources

There are a wide range of technical skills needed to complete all aspects of a stress testing project. Resources have been an important issue at many institutions, with challenges around getting the adequate number of staff with suitable skill sets, given competing demand across the industry. In addition, the sheer number of staff required is high regardless of the state of maturity of the stress test. As an example, one G-SIB had 550 people working solely on the regulatory stress test, with more than 2,000 employees contributing at the peak of the analysis.

There is some evidence that in jurisdictions with supervisory stress tests that are made public, resourcing tends to be higher than elsewhere. This is due to the higher expectations set by the supervisory authorities around the entire process, with few supervisors focusing on just the end results. Furthermore, where institutions operate in multiple geographies there is also a higher level of resourcing, reflecting greater demands in terms of data, modelling, controls, oversight, and challenge.

Figure 17 – Stress testing resourcing: average number of staff split by total assets of institution



Source: BCBS survey of banks. Banks were asked to state how many full time equivalent staff have stress testing as part of their primary job responsibility and as part of their job responsibility.

Generally resource needs differ across liquidity and solvency (capital) stress testing, with solvency stress testing requiring significantly more resources. Liquidity stress testing covers only one risk, typically managed within the Treasury function, and tend to be short-term, whereas solvency stress tests cover many risks and requires involvement across many business units. One institution noted that liquidity stress tests tend to be performed more frequently and regularly and tend to be more idiosyncratic in nature, with shorter time horizons and more sensitivities. Solvency stress tests tend to be performed less frequently with much larger teams, as there are multiple inputs and data sources.

Several supervisors have identified the need for additional skilled staff at some of the institutions in their jurisdiction. There are a number of potential reasons for this:

- Stress testing processes are still very manual at some institutions and without investment in data and infrastructure it is hard to reduce reliance on staff.
- Pressure on profitability at some institutions has restricted the hiring of new staff.
- For institutions that operate in multiple jurisdictions, there may be the need to conduct stress tests for multiple supervisory authorities simultaneously, resulting in greater demand for specific skills.
- The sophistication of the stress testing exercises has increased over time, increasing the need for specialised staff to cover the diverse technical aspects and to ensure effective collaboration of different experts across the institution.

Supervisors have seen instances where institutions began building their stress test frameworks using only existing staff, but quickly realised that they lacked the requisite skills, particularly modelling expertise. As a remedy, many institutions used external consultants to build the framework and facilitated

the initial stress testing cycle(s). Subsequently, the focus shifted to building the skills of internal staff and knowledge transfer to internal staff, as well as hiring personnel with specialised stress testing skills. As these resource changes occurred and the frameworks matured, the consultant's role has changed. Rather than executing the stress test, consultants are understood in some cases to be brought in to target specific areas and/or supplement internal resources.

3.2.9. Data quality and availability

Data quality and availability impacts all facets of institutions operations including stress testing.²² In the early stages of developing stress testing frameworks, there was an initial assumption by many institutions and supervisors that the existing data used for a wide array of banking practices (finance, audit, risk, etc) would be sufficient for stress testing. However, due to paucity of data, data retention policies creating data limitations, systems challenges, and other practices related to poor data governance, the premise turned out to be incorrect. At the outset of the development of stress testing frameworks, data quality and integrity were consistently identified as challenges. Even as processes and frameworks have matured, data continues to be a key focus for institutions to improve and enhance their stress testing frameworks.

Some of the common problems that supervisors have identified during the course of reviewing bank stress tests include:

- limited data by product or business lines;
- limitations on data due to past acquisition activity;
- data exclusions;
- data modifications;
- limited data on smaller portfolios or lower risk portfolios with limited loss experience;
- underinvestment in systems and infrastructure;
- inability of different data systems to work in a cohesive fashion to allow the data to be used for modelling and stress testing purposes (including as a result of inconsistent data concepts and definitions across the organisation); and
- reliance on manual processes.

One supervisor highlighted very strict local record retention regulations that require that all data over a certain age (eg seven years) is required to be destroyed; this has the effect of potentially excluding useful data, particularly around downturn periods. Supervisors have also seen instances where there is a significant reliance on external data; this is not inherently a bad practice, but it does require controls and processes that can differ from those used on internal data to ensure that the external data is fit for purpose and used correctly.

In the survey of institutions, data quality and availability was ranked as the second highest priority for future improvement by institutions, significantly ahead of improvements around governance, internal controls, and model risk management. Supervisory experience in several jurisdictions confirms that institutions are working to improve data quality and availability. These efforts are focused on investments in systems and infrastructure upgrades to make data more widely available within the institutions and on data integrity initiatives geared towards ensuring that the underlying data is accurate, comprehensive and

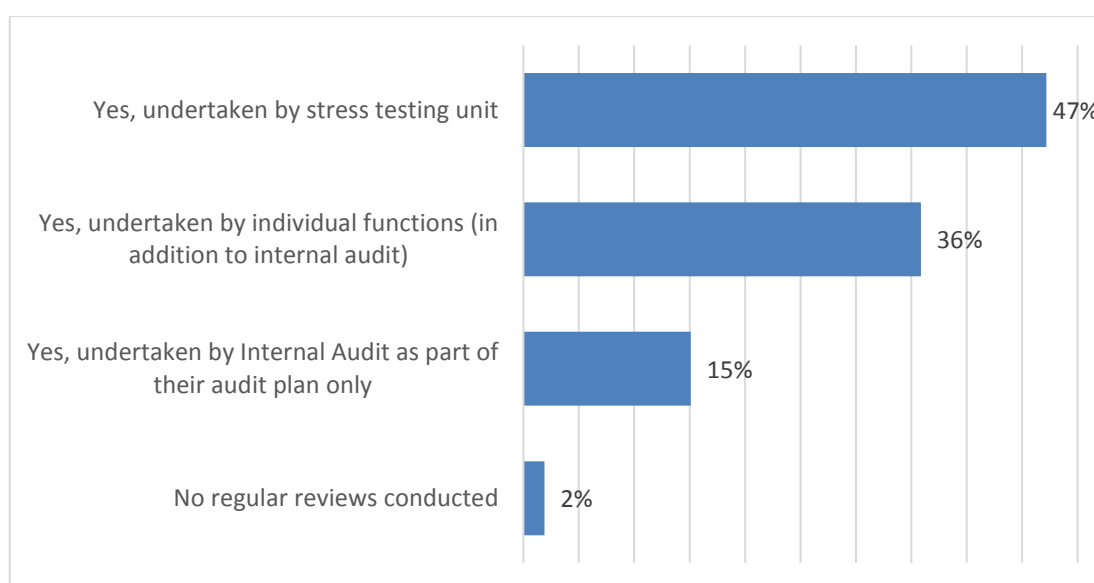
²² The Basel Committee has previously stressed the importance of good quality data. *Principles for effective risk data aggregation and risk reporting* was published in January 2013. G-SIBs were expected to have met the principles set out in this publication by January 2016, but many institutions are still working towards full compliance.

complete. Data quality and availability have material impacts on stress testing projections, so continued focus on controls and governance over data is critical to maintain integrity in the stress testing process.

3.2.10 Review of stress testing frameworks

One common practice observed in the industry is the use of 'lessons learned' or other hindsight review exercises to improve stress testing frameworks. Most institutions undertake a regular review of their stress testing frameworks. In some cases, institutions undertake lessons learned exercises within the unit responsible for undertaking the stress testing exercise, or the individual business functions included in the scope of the stress test. This indicates that the business areas are intimately involved in reviewing what they have done and how to improve for future exercises. However, others rely solely on internal audit for their lessons learned exercises, perhaps with the objective of achieving a more independent assessment.

Figure 18 – Lessons-learned exercises (% of respondents)



Source: BCBS survey of banks. Banks were asked to one answer from a list of possible options on the frequency of their lessons-learned exercise or similar reviews of their stress testing frameworks.

Broadly, most aspects of stress testing frameworks are reviewed at least every two years with a significant proportion reviewed annually. Not surprisingly, all institutions review their scenarios annually (as required by ICAAPs), but administrative aspects including documentation, as well as governance and control frameworks, are also subject to frequent review.

Suitability of data and infrastructure and conceptual foundation of models were both identified by institutions as being reviewed less frequently than other areas; around a fifth of institutions indicated that these two areas were reviewed less frequently than every two years or only on an ad hoc basis. For data suitability and infrastructure, these results are interesting in light of the finding that indicated that the institutions consider data to be a top priority for future improvements (see section 3.5). Some institutions do not review the effectiveness of management actions that are considered to mitigate impacts of stress scenarios, but this may be due to the fact that many jurisdictions do not allow management actions to be incorporated into stress testing results.

Table 5 – Frequency of review (% of respondents)

	At least annually	Every 1-2 years	Less frequently than 2 years or on ad hoc basis
Scenario choice and calibration	100%	0%	0%
Documentation	85%	8%	8%
Sensitivity analyses	86%	10%	4%
Governance and control framework	76%	16%	8%
Effectiveness of management actions	77%	4%	19%
Conceptual foundations of models	67%	22%	12%
Suitability of data and infrastructure	63%	17%	19%

Source: BCBS survey of banks. For each aspect of stress testing listed in the first column of the table above the question asked the bank to indicate the frequency (listed in the first row of the table) that the aspect of stress testing was reviewed by the bank.

3.2.11. Role of internal audit

Internal audit, the “third line of defence”, is a key component in the stress testing framework within institutions. Generally speaking, the audit activity does not duplicate the stress testing processes but reviews the integrity and effectiveness of the risk management processes related to stress testing. The survey questions focused on the internal audit programme elements, the extent to which internal audit is a factor in regular reviews of the stress testing framework, and whether internal audit is an area that management believes is a priority for future improvements.

For most banks, virtually all aspects of stress testing are covered regularly by internal audit. Four fifths of institutions cover all aspects of stress testing and almost all cover most areas. Most cover the key areas either annually or every 1-3 years. For example, framework design is covered by internal audit in all institutions that responded to the survey. Similarly, policies and procedures are covered by internal audit in most firms, as is board reporting.

There were areas that were covered by internal audit at fewer institutions, such as integration of stress testing across the organisation and management challenge and data integrity. These results may reflect the need for specialised resources but also in part a differing view on what internal audit should be covering. As set out in the previous section, internal audit plays a role in lessons learned exercises, usually in partnership with the business. Supervisors have observed that some institutions have outsourced the internal audit programme for stress testing for the first few years until expertise had been built up internally.

3.3. Use of stress test outputs

As stress testing frameworks have matured, institutions have increasingly looked for opportunities to integrate stress testing processes and results into broader business and risk programmes. While capital planning and regulatory compliance rank highly as key areas where stress tests are used, most institutions also use stress testing for risk appetite and limit setting and monitoring. Risk quantification and identification were considered secondary uses in most institutions.

Activities such as pricing and/or commercial policies, profitability measurement or performance management (including targets) were not seen as key uses at many banks. Institutions vary considerably in the degree to which they have incorporated stress test results into every-day business; however, some banks are observed to apply portfolio-specific stress tests to support and evaluate investment decisions.

As stress testing frameworks evolve from the genesis of a regulatory requirement, at least some institutions are starting to leverage their significant investments in stress testing to benefit their business more broadly. However, supervisory experience is that stress testing is still seen by some institutions as an expensive regulatory compliance exercise.

Figure 19 – Institutions use of stress testing results (% of respondents)



Source: BCBS survey of banks. Banks were given a list of activities and asked to select the five most important/prevalent activities for which the results/outputs of stress testing are used.

Box 9 – Uses of stress testing - examples

Limit setting

One Asian bank is using stress test results in its risk management framework. This institution takes the stress testing results into consideration to establish risk limits and to improve risk identification. For example, following the results of a stress test involving the oil industry, the bank reduced its internal limit for its oil and gas book.

Another example of how the bank uses the stress test results for limit setting involves structural foreign exchange positions limits. Structural foreign exchange positions are taken by the bank to protect its capital and they are non-trading and long-term in nature. The bank sets and reviews these limits annually. The bank incorporated elements considered in the limit setting process as part of the scenario design. This allowed the bank to determine if the limit that was set was appropriate. The bank was able to check the impact of the stress at the point at which the limit had initially been met. The results of this stress testing approach are reflected in the assessment of the limit and considered by the board's asset and liability committee and risk committee.

Finally, the bank takes a proactive approach to stress testing when risks begin to approach internally established limits. When liquidity stress testing results demonstrated that the bank would be close to its internal limits in a given scenario, the risk area of the bank took the results and discussed them with the business line to understand what other vulnerabilities could further affect the liquidity results. In this sense,

the bank not only accepts the results of the stress testing for risk management, but uses them as a starting point for a deeper discussion on risks and vulnerabilities.

Risk identification

Another UK bank is using stress test results as a risk identification tool. Over the course of 2016, this institution ran a number of scenarios based on potential outcomes of the US election results across the whole of its corporate loan portfolio. This allowed the institution to identify specific geographies and sectors that would be particularly vulnerable under different outcomes. As certain outcomes became more likely, they then ran more targeted stress tests of the vulnerable portfolios to better understand the dynamics of their business and plan ahead.

Investment decisions

At one bank the stress test results had a significant influence on the decision to refrain from an investment opportunity in a real property project. The bank did not only assess the consequences of the investment on its regulatory capital but also evaluated the riskiness of the real property investment in relation to its available internal capital by means of stress testing. As the stress testing results indicated that rental risks and the counterparty risk related to the involved property developer exceeded the risk appetite defined by bank's management, the board decided that the institution would not undertake the investment. Against this background, the bank records in its business strategy that ad hoc stress testing is mandatory if additional real estate investments are envisaged. The scenario to be applied assumes 20 percent vacancies and one month with 100 percent rent default.

3.4. Bank stress testing methodologies

3.4.1 Scenario design and risk coverage

As with supervisory stress testing, scenario design is one of the most crucial aspects of stress testing within institutions. An insightful scenario can uncover new vulnerabilities or demonstrate known risks in a new light, but scenarios also need to be plausible and sufficiently severe to be meaningful. Banks typically consider a range of different exceptional but plausible stress scenarios to test for its resilience against a broad range of sources of risk. Indeed, stress testing is recognised to be a tool that turns the risks and inherent uncertainty in the economic and financial environment into reasonable confidence about whether capital levels that appear strong in one scenario will also be sufficient in another. To develop the range of stress scenarios, banks typically make use of a regular scenario-selection process in which multiple experts from across the institutions are involved.

Box 10 – Scenario design

To ensure the scenario selection process is conducted imaginatively, one bank collects the scenarios proposed by different experts across the organisation in a so called "long list". This "long list" is updated regularly such that more up-to-date scenarios are added and older ones are deleted. The bank has developed some criteria to reduce the "long list" to a so called "short list", which contains those stress scenarios whose effects will actually be quantified. More specifically, the bank makes use of a heat map to classify, illustrate and discuss potential stress scenarios along the dimensions "expected loss potential" and "probability of materialisation". This classification of stress scenarios helps the bank to identify those scenarios with a reasonable trade-off between severity and plausibility as severe shocks are typically required to generate meaningful stress results, but perceived plausibility and relevance facilitate the communication and the implementation of management responses.

The survey shows that banks most often rely on expert judgement to calibrate scenarios. Indeed a number of banks are observed to make use of specific expert workshops or roundtable discussions with experts from across the organisation to qualitatively develop scenario narratives and specify quantitatively the risk factors and their interactions. As a starting point the macroeconomic outlook forecasts from the economic research department are used.

All institutions in the survey report using macroeconomic shocks in their scenarios and about two thirds also modelled sectoral or industry-specific shocks as well as institution-specific shocks. While a stressed macroeconomic environment is expected to affect a wide range of banking exposures, a significant majority of respondents also cover institution-specific shocks to capture vulnerabilities that are not particularly well captured by an enterprise-wide scenario analysis based on a stressed macroeconomic environment. Indeed, successful stress testing requires banks to generate individual stress scenarios that test the key risks germane to their business model and take into account the concentrations which are knowingly accepted by the strategic orientation of the banks' business activities. The most common sources of scenarios were historical experience and expert judgement, used by all institutions. About three-quarters also used the supervisory scenario or scenarios generated by statistical methods.

Institutions report covering a broader range of risks in their stress testing frameworks than do supervisors. All institutions cover credit risk and market risk, and virtually all include interest-rate risk and liquidity risk. About three-quarters include operational risks and concentration risks in their stress testing, which is more prevalent than reported by supervisors.

Box 11 – Use of expert judgement in the scenario selection and calibration process

One bank makes use of a macroeconomic statistical model to translate the scenario variables of the macroeconomic downturn scenario into PD risk parameters. In a second step, the estimates are assessed for their plausibility by an expert-based process. In this process, the centralised stress test unit consults the credit risk management experts via a web-based questionnaire and a follow-up teleconference. This process repeats on a yearly basis or on an ad hoc basis.

For the most part, liquidity and solvency stress tests remain relatively separate disciplines. About 20 percent of institutions run enterprise-wide stress tests that are fully integrated across solvency and liquidity or run solvency and liquidity stress tests together regularly.

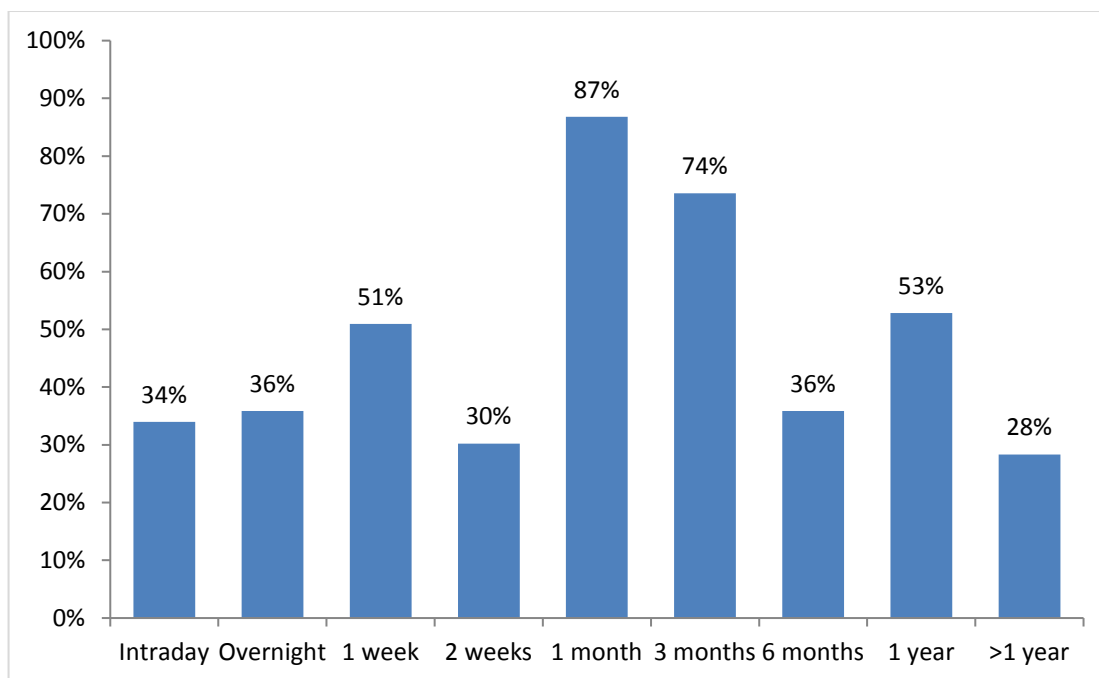
In a reverse stress tests, there is no explicit scenario but instead the objective is to produce a scenario that will cause a specified adverse outcome (such as a breach of capital requirements). Nearly three-quarters of institutions report that they regularly conduct reverse stress tests. This is surprising given that few supervisors conduct or mandate such tests. A capital or liquidity hurdle rate was the most common threshold for the reverse stress tests, with some institutions also modelling a liquidity crisis or breach of risk limits.

Box 12 – Reverse Stress tests

In practice, a range of banks make use of reverse stress tests to identify those events that would threaten the viability of the bank. One bank starts with an analysis of those risk factor variations that would lead to a breach of the regulatory minimum capital requirements. This reverse sensitivity analysis is performed for each material risk type and represent the starting point for the development of an enterprise-wide reverse stress test. Depending on the importance of the risk factors for the bank's business model, the identified risk factor variations are weighted and combined to parameter set(s) for an enterprise-wide reverse stress test covering all material risk types. This multivariate analysis includes a qualitative and critical evaluation of the events that would lead to such parameter sets.

The time horizon used for enterprise-wide capital stress tests is typically between one and three years. About 40 percent of institutions conduct stress tests of three years or greater, but only the largest institutions run stress tests spanning five or more years. For internal liquidity stress tests, between one and three months tend to be most common, with some institutions conducting intraday stress tests and others extending to one year.

Figure 20 - Time horizon for liquidity stress tests (% of institutions using each approach)



Source: BCBS survey of banks. Banks were asked to select from a list all relevant time horizons used for internal liquidity stress tests.

3.4.2 Methodological considerations

In their internal stress testing, institutions are not constrained by assumptions and guidance provided by supervisors. For example, nearly half of supervisors reported using a static balance sheet approach, but only about one in five institutions used this approach internally. Institutions were much more likely to incorporate dynamic effects (nearly half) or used different approaches depending on the scenario or other considerations. One institution noted that it applies the stress test to the forward business plan, which includes various forward-looking management actions.

Nearly half of institutions report conducting stress tests with feedback effects, such as between funding and credit risks, which is comparable to the responses from supervisors. Institutions on their own may have difficulty incorporating macroeconomic feedback effects, but may be able to consider how deteriorating credit quality in a particular market may make those exposures less liquid for trading or hedging purposes. One institution noted that this is an area where there is opportunity for improvement, while another indicated that feedback effects are taken into account in the scenario specification.

Supervisors typically require institutions to report stress test results excluding management actions, such as adjusting pricing or raising capital, or require them to separately quantify the impact of those actions. In their own stress tests, most institutions either report results both including and excluding management actions, or excluding management actions. Some institutions noted that this approach allowed them to test actions in recovery plans. A few institutions report that they include management

actions in their stress test results. This would not be considered good practice unless accompanied by strong analysis of the likelihood that the institution could execute those actions in the particular scenario.

3.4.3 Model management

Model management is a core part of the governance practices for stress testing since methodologies are frequently composed of models for projections and estimates. For example, the Bank of England have made various observations on model management capabilities of institutions.²³

Box 13 - Supervisory observations on model risk management - Bank of England report

Comments can be found from the Bank of England in 2014, 2015 and 2016:

2014

In general, model management frameworks for stress testing models lag behind those for regulatory models. The better performing banks had model inventories and clear, well-documented frameworks. At poorer performing banks, validation standards were not sufficiently robust, some key models were not validated and there were instances of models that had failed validation being used nonetheless.

2015

In 2015, the Bank undertook a review of banks' stress testing model management frameworks having found that they were weak during the 2014 exercise. For some banks, the coverage, scope and adequacy of model management standards were found to have improved. But others needed to make considerable improvements, including implementing and embedding model management policies more fully. Some banks lacked formal processes to approve stress testing models and had weak model governance. While the Bank recognises that improvements take time, banks are expected to continue to invest significantly to implement model development standards, maintain robust model inventories and strengthen their independent model review frameworks.

2016

Independent review of models: The Bank notes that independent review of models is standard practice in model development, with the independent review undertaken by a team not involved in the model development. The Bank's review identified the need for further improvement in banks' use of independent review for stress testing models. This is particularly the case for models outside of traditional risk modelling disciplines, where oversight tends to be more limited. Where models have not been through an independent review process this should be made transparent during the challenge and approval process and any adjustments to the outputs of these models should be subject to an appropriate level of challenge

Model risk management comprises a wide range of activities. It includes foundational components, such as clearly defining roles and responsibilities and processes that must be followed in model development. It also includes the more technically intensive tasks of ensuring that models are: developed using good data, sound assumptions and inputs; subject to testing and challenge; and properly validated by an objective and informed party. Because stress testing is typically model-centric, any weaknesses in the model risk management processes of the institution can negatively influence the stress testing framework and projections.

²³ www.bankofengland.co.uk/financialstability/Documents/fpc/results301116.pdf
www.bankofengland.co.uk/financialstability/Documents/fpc/results011215.pdf

Supervisors in several jurisdictions have noted that model governance standards applied for the general suite of models used for day-to-day management of the bank typically also apply to stress testing models. Some supervisors have, however, highlighted challenges in applying certain aspects of good governance to stress testing models. This is particularly the case where data is limited or modelling techniques are insufficient to represent more opaque links between the risk being modelled and the conditions in the scenario.

In instances where governance is seen as deficient, supervisors may introduce overrides on the results of the models or take other actions to reflect the uncertainty of the results. Some supervisors have also noted that because stress testing comprises a significant increase in the modelling activities for many banks, the resources needed to ensure sound model risk management sometimes lag the actual model development. This is particularly the case where technical skills are needed for tasks such as validation; several supervisors noted that institutions will use the available technical skills first on the model development, with resourcing for validation being a secondary priority.

The survey provides some insights into the model management element of the stress testing framework. The results indicate that model management and governance is principally the domain of the risk function in most institutions. The conceptual foundation of models is reviewed regularly by the majority of institutions, although the survey results show that some institutions review models less frequently than every two years.

All but 10 percent of institutions that responded stated that internal audit reviews model development and validation practices. Around half of institutions responded that audit coverage is provided at least once a year, while two fifth of institutions responded that it is provided every one to three years. Internal audit engagement on model development and validation is typically completed by reviewing the processes used by the model development team and the validators to ensure they meet internally established policies and procedures. Only one supervisor indicated that internal audit actually did separate model validation work; in this instance, the internal audit team had the skilled resources needed to complete validations and the bank made the determination to use audit for this work. However, this bank also had another group within internal audit check the work of the validation team to confirm that they were following internal practices.

3.5. Future improvements

Stress testing capabilities have been subject to rapid evolution across the global banking industry over the last 10 years. Both institutions and supervisors have noted the need to continually improve capabilities, refine methodologies and deepen the use of stress tests in the business.

An institution may determine where it wants to improve based on a gap analysis against a stress testing project plan, a review of its performance in a recent stress test or based on feedback from its supervisors. US and European authorities have observed that many institutions are undertaking stress testing enhancement frameworks and this is often in response to how they have performed during and in supervisory stress tests.

There are two key areas that institutions are commonly looking to improve. The first is the focus on integrating stress testing into business as usual processes. Institutions openly discuss the need to derive business benefits given the resources devoted to the process. Second, institutions are still looking to improve data quality and availability through additional investment. This is consistent with supervisory findings around risk data architecture and IT infrastructure and also observations from numerous external stakeholders.

Table 6 – Future improvements ranked by priority (% of respondents)

	Rank		
	1	2	3
Integrating stress testing into business-as-usual planning	30%	25%	8%
Data quality and availability	25%	9%	13%
Model risk management / governance	9%	9%	17%
Use of model outputs	6%	21%	4%
Board engagement (including training)	6%	8%	13%
Integrating liquidity stress testing	6%	6%	6%
Scenario selection	6%	4%	8%
Risk-specific models	4%	2%	13%
Internal controls	4%	2%	6%
Risk identification	4%	0%	6%

Source: BCBS survey of banks. Bank were given a list of areas and asked to rank the top five that represent areas that the bank has identified for further improvement with respect to their stress testing programme. Rows and columns do not sum to 100% because only the top 3 ranks are shown and some institutions provided the same rank for multiple areas.

4. Conclusion

This report finds that both bank and supervisory stress testing frameworks have evolved significantly since the financial crisis, and since the Basel Committee published the 2009 Stress Testing Principles. Changes have occurred in all aspects of stress testing, including methodologies, governance arrangements and the use of stress testing results.

Supervisory authorities and central banks continue to devote more resources to enhance the stress testing of regulated institutions, with supervisory stress tests typically carried out on at least an annual basis. This is resulting in significant progress in how the exercises are performed and how they are incorporated into the banking supervision process.

Banks have been making improvements to their governance structures, with banks' boards, or delegated committees of boards, taking active roles in reviewing and challenging the results of stress tests, in addition to providing oversight of the overall framework. Furthermore, supervisors have observed that banks are increasingly proactive in identifying areas for improvement in their stress testing frameworks.

Banks are also progressively looking to leverage the resources dedicated to stress testing frameworks to inform the risk management and strategic planning of the bank. Stress testing frameworks are increasing integrated into business as usual processes and it is encouraging that banks are now less likely to view stress tests purely as a supervisory compliance exercises.

Key challenges that remain for banks include finding and maintaining sufficient resources to run stress testing frameworks, and improving data quality, data granularity and the systems needed to efficiently aggregate data from across the banking group for use in stress tests. For national authorities, resources are also a key challenge, and more efforts are needed to improve coordination of stress testing activities across authorities, eg via the exchange information on stress test plans and results through supervisory colleges.

Annex 1 – Stress Testing Taxonomy

The term stress testing is broadly used to describe a risk management tool used by financial firms, as well as a tool for supervisors, central banks and international financial institutions/organisations to assess the impact of potential risks on the financial system, individual banks, or specific portfolios. Stress tests are designed to explore what may occur in a range of situations, including exceptionally severe but plausible circumstances. In banks, stress tests can be used as a risk management tool, eg to set operational limits, allocate resources, or evaluate strategic choices. Authorities can use stress testing to assess the risk profile/vulnerabilities of the supervised institutions, identify emerging risks, allocate supervisory resources and set additional regulatory requirements, actions or restrictions.

An implication of the wide and varied application of stress testing, and the rapid advances in theory and applications underlying stress testing methodologies, is that the meaning of some commonly used terms can vary depending on the context in which the term is used across jurisdictions. The aim of the taxonomy that follows is to provide common definitions for these terms as a way of further enhancing the dialogue and advancement of stress testing globally.

Core stress testing terms

Adverse (stress) scenario	<p>An adverse (stress) scenario is a set of economic and financial conditions (significantly more negative than a baseline scenario) which is designed to stress the financial performance of a financial system, sector, institution, portfolio or product (reflecting severe but plausible conditions). The design of the adverse scenario depends on the purpose of the test, availability of data and the time horizon chosen.</p> <p>See also “severe but plausible event” and “scenario plausibility”.</p>
Baseline scenario	<p>The baseline scenario is a set of economic and financial conditions that is generally consistent with the best (or average) estimate of future economic and financial conditions.</p> <p>The baseline scenario does usually not lead to a stressed result. One of the purposes of the baseline scenario is to provide a benchmark to compare results of other scenarios (eg adverse, historical and hypothetical).</p>
Capital hurdle rate	<p>The capital hurdle rate is the amount of capital requirements, presented in terms of capital adequacy ratios or leverage ratios, which is acceptable to supervisors, regulators, risk managers, or investors, after considering the impact projected by the stress testing exercise.</p> <p>The capital hurdle rate may be set at the regulatory minimum or higher, and it may also include additional surcharges and buffers, depending on the context and goals of the exercise. Capital hurdle rates do not typically have to be uniform for all scenarios or institutions.</p>

Capital planning stress test	<p>A capital planning stress test is a stress test developed and conducted by an institution as part of its capital planning process. An ICAAP stress test (internal capital adequacy assessment process) is a particular type of capital planning stress testing that is required under Pillar 2 of the BCBS standards and should be integrated with institutions' risk management and planning processes.</p>
Dynamic balance sheet	<p>Dynamic balance sheet refers to the assumption that the size, composition and/or remaining maturity structure of an institution's balance sheet (eg assets and liabilities) are allowed to vary throughout the stress testing time horizon due to changes in eg aggregate credit volumes, maturities, defaults or other scenario imposed restrictions and/or management actions.</p> <p>Under this assumption, an institution's management may react by taking actions that impact assets and liabilities, which could include, but are not limited to, changes in the credit portfolio mix, deleveraging, as well as changes in the composition of the trading book. However, actions that affect equity, such as issuance of new capital or restriction to the payment of dividends, may be treated separately within the capital planning process and might co-exist distinctly from the dynamic balance sheet assumption.</p> <p>See also "stress management actions", "capital planning stress test", and "static balance sheet".</p>
Enterprise-wide stress test	<p>An enterprise-wide stress test assesses the impact of shock on the institutional organisation as a whole, in contrast to focusing on individual business lines, sectors, portfolios or products. The term can also be used to indicate that only one firm is in scope of the stress test, to distinguish it from a system-wide stress test.</p>
Feedback (second round) effects	<p>Feedback or second round effects are shocks resulting from the transmission of initial shocks from institutions to parts of the real economy and also to the financial sector itself.</p> <p>A stress testing framework involves designing a scenario and mechanisms to simulate how a scenario affects a financial system, business line, sector, institution, portfolio or product. These initial or first order effects may affect the trajectory of the economy within the forecasting horizon (eg second round effects to the economy) or the solvency or liquidity of other institutions via contagion (eg second round effects to the financial sector). These transmission mechanisms may also arise from management actions taken by institutions. These effects can arise from some endogenous reaction and amplification mechanism within the financial system (eg fire sales). Liquidity stress testing is another area where the impact of feedback effects is important.</p>

Historical scenario	A stress test scenario that aims at replicating the changes in risk factor shocks that took place in an actual past episode. An historical scenario may also result from a combination of changes in risk factor shocks observed during different past episodes. Historically observed risk factor changes are transposed and if necessary adapted to the current market environment.
Hypothetical stress scenario	A stress test scenario consisting of a hypothetical set of risk factor changes, which does not aim to replicate a historical episode of distress. Generally they are aimed at trying to generate adverse scenarios. Such scenarios could be based on subjective estimates by risk managers collaborating with different senior experts within the institution (eg economists, business managers, traders) or generated by an economic/econometric model. See also "adverse scenario".
Institution-run stress test (bottom-up)	In this case there are two different definitions: (1) An institution-run stress test is a stress test performed by an institution using its own stress testing framework (eg ICAAP) or as part of supervisory/regulatory authority stress test where supervisors/regulators direct banks to run a stress test using or not a common supervisory framework (constrained bottom-up). These types of stress tests are often referred to as "bottom-up" stress tests in many jurisdictions, emphasising that the financial projections are produced by individual institutions within a jurisdiction and not by the corresponding supervisory or regulatory authority. Alternatively, on a systemic level, bottom-up stress tests amount to a stress test where the result (eg loan losses) for the entire banking sector are derived by aggregating the results from the micro level. The results at the micro level are usually derived by each individual institution using its own models to estimate its results following a specific stress test scenario and methodology (even if provided by authorities as a common framework). (2) In some jurisdictions, however, "bottom-up" may refer only to the disaggregated nature and origin of data inputs rather than on the entity that performs and estimates the results. Shocks are induced at a granular level, and their impacts are followed up at an aggregated level. It is necessary to describe the definition that is used in each context.
Liquidity stress test	A liquidity stress test is the process of assessing the impact of an adverse scenario on institution's cash flow as well as on the availability of funding sources, and on market prices of liquid assets.

	Outcomes can be measured as liquidity ratios, eg liquidity coverage ratio (LCR) and net stable funding ratio (NSFR).
Macroeconomic engine	A macroeconometric model used to generate the macro level shocks that are then fed into the stress testing models.
Macroeconomic stress test	A stress test that implements a link between stressed macroeconomic factors (taking into account macroeconomic relationships, eg a macroeconomic scenario) and the financial sustainability of either a single financial institution or the entire financial system.
Macroprudential stress test	<p>A macroprudential stress test is a tool that is designed to assess the system-wide resilience to shocks in the financial sector, which may include second round effects emerging from linkages with the broader financial system or the economy.</p> <p>Unlike microprudential stress tests, macroprudential stress tests generally take into account interactions between institutions (eg via interbank exposures).</p> <p>See also "microprudential stress test" and "feedback (second round) effects".</p>
Management actions	<p>Management actions refer to actions that would be taken by institutions in direct response to an adverse (stress) scenario that would otherwise not be taken in a baseline scenario.</p> <p>These actions typically include but are not limited to increases in capital (eg through equity issuance or asset sales), reductions in risk-weighted assets (eg through divestments or decreases in lending, tightening of lending standards), repricing, reductions in expenses (eg staff layoffs), hedging of exposures, or reductions in interbank lending. Management actions often mitigate the stress test impact and are not compatible with the static balance sheet assumption. Their feasibility during the stress test time horizon shall be subject to careful scrutiny by the supervisory authority.</p> <p>See also "capital planning stress test", "static balance sheet", and "dynamic balance sheet".</p>
Market price-based stress test	<p>A market price-based stress test is a methodology that uses primarily market data (eg share prices, volatilities, spreads) and statistical models to assess an institution's viability.</p> <p>This methodology can involve deriving solvency indicators, such as probabilities of default, from the prices estimated by the model.</p>
Microprudential stress test	<p>A micro-prudential stress test is designed to assess the resilience of an institution to macroeconomic and financial vulnerabilities and respective shocks.</p> <p>The instruments, mechanisms and measures available to supervisors are usually applied at the individual institution level (microprudential).</p> <p>See also "macroprudential stress test".</p>

Model overrides	Model overrides are modifications of modelled outcomes based on the use of expert judgement, alternative models, or other quantitative analysis.
Multi-factor stress test	A stress test applying a combination of two or more economic and/or financial vulnerabilities simultaneously. See also "scenario analysis".
Product-specific Stress Test	<p>A product-specific stress test is designed to assess the impact of an adverse scenario on an institution's positions in, or market for, a financial product/portfolio, rather than at the enterprise or other aggregate level.</p> <p>Product-specific stress test scenarios can include but are not limited to liquidity constraints, client behaviour, cash flows, credit ratings, or contract covenants. These stress tests can help identify and quantify risks associated with new or modified products/portfolios.</p>
Reverse stress test	<p>A reverse stress test is the process of assessing a pre-defined adverse outcome for an institution, such as a breach of regulatory ratios, insolvency or illiquidity, and identifying possible scenarios that could lead to such adverse outcome.</p> <p>A reverse stress test helps to understand underlying risks and vulnerabilities in institutions' businesses and products that pose a threat to its viability and helps to identify scenarios that could threaten resilience.</p>
Reverse-engineered scenario	A scenario designed to match a pre-defined outcome to be endured by the bank or the financial sector. For example, a reversed engineered scenario for interest rate risk would determine the size of an interest rate shock that would be sufficient to make the bank lose a certain amount of capital.
Risk-specific stress test	A risk-specific stress test is the process of assessing the impact of a stress scenario on a particular category of risk exposure of an institution, eg market, credit, liquidity, interest rate risk, etc.
Scenario analysis	<p>Scenario analysis is the process of applying historical and/or hypothetical circumstances to assess the impact of a possible future event on a financial system, sector, bank, portfolio or product.</p> <p>Scenarios are not necessarily forecasts; rather, they are coherent and credible narratives, describing potentially different paths to the current or expected conditions and their translation into calculating the scenario. Scenario analysis incorporates many economic and financial parameters in a consistent manner, in contrast to sensitivity analysis, which may focus on a subset of parameters.</p>
Scenario plausibility	Plausibility of a scenario is not only related to the likelihood of a certain scenario occurring. It is also related to the consistency of

	<p>the scenario, which concerns the relationship or dependency of shocks to the risk factors and other components characterising the scenario. For stress testing, it is often desirable that a scenario is severe but plausible. Plausibility is often associated with a probability, confidence interval or frequency of occurrence in time, but this is not a necessary condition for a scenario to be plausible, eg the likelihood can also be based on expert judgement. The forecast horizon also plays a role in determining the plausibility of a scenario. For example, market risks usually materialise in a shorter time horizon than credit risks. Furthermore, the reconciliation of these differing time perspectives is also a necessary consideration for scenario consistency.</p> <p>See also "scenario severity" and "severe but plausible event".</p>
Scenario severity	<p>The severity of a scenario is the magnitude of the shocks affecting the risk factors or other components that characterise the scenario.</p> <p>The analysis of historical behaviour of risk factors often helps identifying worst case scenarios and the probability associated with those scenarios, which can also serve as a benchmark for comparing the severity among scenarios. A severe scenario may not necessarily translate into material stress losses.</p> <p>See also "scenario plausibility" and "stress losses".</p>
Sensitivity analysis	<p>Sensitivity analysis is the process of assessing the impact of a change of a single or limited set of risk factors, variables, assumptions or other factors.</p> <p>Typically sensitivity analyses do not relate changes to a cohesive narrative or underlying event.</p>
Severe but plausible event	<p>A shock or combination of shocks that has a low but non-zero probability of materialising and has the potential of imposing severe losses to portfolios, banks or banking systems.</p> <p>Plausibility is not exclusively related to the likelihood of a scenario occurrence.</p> <p>See also "scenario plausibility".</p>
Single factor stress test	<p>Analysis of the impact of economic and/or financial vulnerabilities in a single risk factor.</p> <p>See also "sensitivity analysis"</p>
Solvency stress test	<p>A solvency stress test is the process of assessing the impact of an adverse scenario on an institution's capital (eg economic, regulatory, etc.). The outcomes of solvency stress tests are often measured in terms of capital adequacy ratios, which may entail a comparison to minimum regulatory requirements and/or pre-defined capital hurdle rates.</p>
Static balance sheet	<p>Static balance sheet refers to the assumption that the size, composition and remaining maturity of an institution's balance</p>

	<p>sheet (eg assets and liabilities) are invariant throughout the stress testing time horizon.</p> <p>This assumption is often made in order to provide greater comparability across institutions in a stress test, or to facilitate the quality assurance of banks' stress test results in the case of (constrained) bottom-up supervisory stress test. Under this assumption, an institution's management also does not change the balance sheet in response to the adverse (stress) scenario. Furthermore, actions that affect equity, such as issuance of new capital or restriction to payment of dividends, are treated separately within the capital planning process. Such issuances should only be allowed to occur during the stress test time horizon if decided and implemented before the start of the stress test.</p> <p>See also "management actions", "stress losses", "dynamic balance sheet", and "capital planning stress test".</p>
Stress loss rate	<p>Stress loss rate is a ratio or percentage representing losses projected from a stress test since initial position or baseline scenario.</p> <p>Stress loss rates are useful for comparing stress test impacts across different types of risks, eg credit and market risk, as well as classes of assets or risk factors. Typically, the numerator is a level of stress loss and the denominator is a measure of total exposures, exposure at default, average of exposures over stress test time horizon, or some other measure (eg Risk Weighted Assets).</p> <p>See also "stress losses" and "stress testing framework".</p>
Stress losses	<p>Stress losses are estimates of negative income that deplete capital resulting from the stress test. This can be calculated in terms of adverse-to-baseline or contribution to eg capital ratio under a given scenario.</p> <p>Stress losses depend on the assumptions and inputs of the underlying stress test and can be represented by different metrics, eg depletion of capital (regulatory or otherwise), reduction of revenues, and run-off of funding. Furthermore, stress losses are a key component in solvency stress tests. Other types of stress tests, eg liquidity stress tests, will likely have different outcome metrics.</p> <p>See also "stress loss rate", "stress testing framework", and "stress testing model".</p>
Stress policy response	<p>The modelling of the policymaker's (typically the lender of last resort) reaction to a stress testing results.</p>
Stress test	<p>A stress test is a forward looking risk management tool used to estimate the potential impact under adverse events or circumstances on a financial system, sector, institution, portfolio or product.</p>

	<p>A stress test is often used to assess and quantify vulnerability and resiliency to stress events or severe shocks, and to enhance decision making in the management of risks.</p> <p>The objective of the stress test can be to test the bank's capital adequacy or liquidity position in the face of a shock or a combination of shocks and it is an important part of the microprudential toolkit. Additionally, it is a relevant tool of the macroprudential analysis kit.</p>
Stress test horizon	<p>The stress test horizon is the amount of time which is covered in the forward looking part of the stress test. It should be in line with both the methodology and the hypothetical scenarios.</p> <p>See also "baseline scenario" and "hypothetical stress scenario".</p>
Stress testing framework	<p>A stress testing framework describes the context in which stress tests are developed, evaluated and used within the decision making process.</p> <p>A stress testing framework includes elements such as governance, resources, documentation, policies, processes, infrastructure and methodology that may be in place to guide and facilitate the use, implementation and oversight of stress testing activities. This framework may also be referred to as a stress testing programme in some jurisdictions.</p>
Stress testing methodology	<p>A stress test methodology is a set of tools and techniques that are necessary for carrying out a stress testing process. It includes stress testing models, scenario definition, results analysis, and all the tools and factors associated with them. It is the set of assumptions on which the tools and models rely.</p>
Stress testing model	<p>A stress test model is a tool built for the purpose of producing projections for a financial system, sector, institution, portfolio or product, under stress/different scenarios, and under other analytical assumptions.</p> <p>The definition of stress testing model encompasses all quantitative processes, methods and tools describing relationships and dynamics of the covered economic and financial variables.</p> <p>See also "stress testing", "scenario analysis", and "sensitivity analysis".</p>
Supervisor-run stress test (top-down)	<p>The meaning of this term varies according to the context in which it is used:</p> <ol style="list-style-type: none"> (1) A supervisor-run stress test is a stress test performed by a supervisor or regulatory authority using its own stress testing framework (data, scenarios, hypothesis and models). These types of stress tests are often referred to as "top-down" stress tests in many jurisdictions. (2) In some jurisdictions, however, "top-down" may refer to the aggregated nature and origin of data inputs for models used

	by supervisors, regulators or institutions rather than on who performs the analysis.
Worst-case scenario	A scenario where the most negative shocks over a certain time horizon are combined for a number of risk factors and the portfolio/institution is revalued for these shocks. This type of scenario may ignore correlations between risk factors and it may, thus, be implausible.