



**Taking Control –
Managing the Pain Points in
Stress Testing**

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Introduction

The depth and duration of the financial crisis has led many banks and supervisory authorities to question whether stress testing practices were sufficient prior to the crisis and whether they were adequate to cope with rapidly changing market conditions. In particular, not only was the crisis far more severe in many respects than was indicated by banks' stress testing results, but it was possibly compounded by weaknesses in stress testing practices in reaction to the unfolding events. As the crisis comes to an end, there are already lessons for all market participants emerging from this episode.

Stress testing is an important risk management tool that is used by banks as part of their internal risk management and, through the Basel II capital adequacy framework, is promoted by supervisors. Stress testing alerts bank management to adverse unexpected outcomes related to a variety of risks and provides an indication of how much capital might be needed to absorb losses should large shocks occur. While stress tests provide an indication of the appropriate level of capital necessary to endure deteriorating economic conditions, a bank alternatively may employ other actions in order to help mitigate increasing levels of risk. Stress testing is a tool that supplements other risk management approaches and measures. It plays a particularly important role in:

- Providing forward-looking assessments of risk
- Overcoming limitations of models and historical data
- Supporting internal and external communication
- Feeding into capital and liquidity planning procedures
- Informing the setting of a banks' risk tolerance
- Facilitating the development of risk mitigation or contingency plans across a range of stressed conditions

Stress testing is especially important after long periods of benign economic and financial conditions, when fading memory of negative conditions can lead to complacency and the underpricing of risk. It is also a key risk management tool during periods of expansion, when innovation leads to new products that grow rapidly and for which limited or no loss data is available.

Pillar 1 (minimum capital requirements) of the Basel II framework requires banks using the Internal Models Approach to determine market risk capital to have in place a rigorous programme of stress testing. Similarly, banks using the advanced and foundation internal ratings-based (IRB) approaches for credit risk are required to conduct credit risk stress tests to assess the robustness of their internal capital assessments and the capital cushions above the regulatory minimum. Basel II also requires that, at a minimum, banks subject their credit portfolios in the banking book to stress tests. Lepus research has indicated that banks' stress tests did not produce large loss numbers in relation to their capital buffers going into the crisis or their actual loss experience. Furthermore, banks' firm-wide stress tests should have included more severe scenarios than the ones used in order to produce results more in line with the actual stresses that were observed.



A stress test is commonly described as the evaluation of a bank's financial position under a severe but plausible scenario to assist in decision making within the bank. The term 'stress testing' is also used to refer not only to the mechanics of applying specific individual tests, but also to the wider environment within which the tests are developed, evaluated and used within the decision-making process. In this paper, the term 'stress testing' will be used in this wider sense.

Finally, this paper, with the aid of secondary research and interviews with leading banks, will explore in further depth four key areas within stress testing, namely:

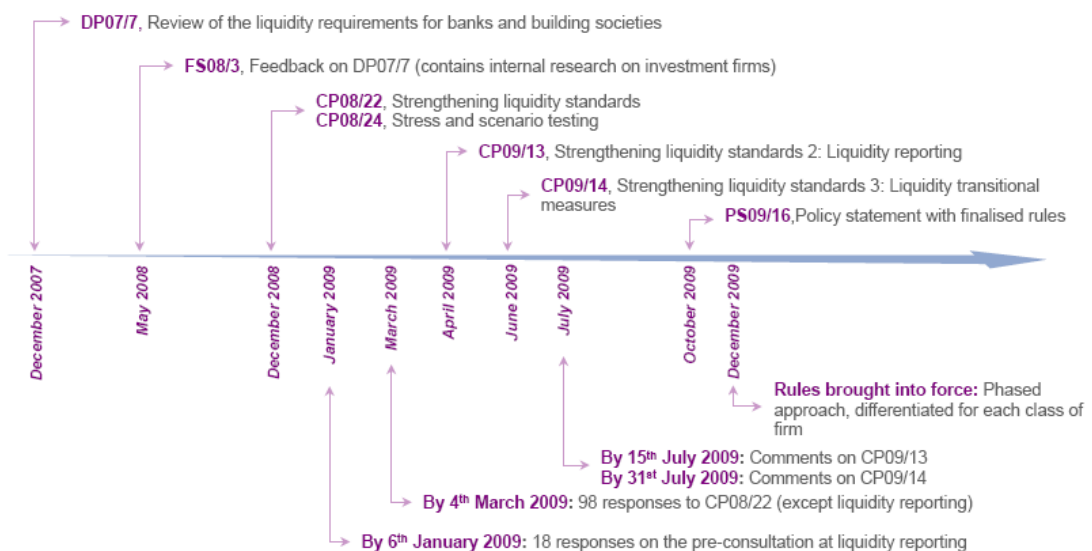
- **FSA's new liquidity regime**
- **Data**
- **Benchmarking and frameworks**
- **Reporting and transparency**
- **Business benefits**



FSA's New Liquidity Regime

As a result of this crisis, a leading regulator, namely the UK's Financial Services Authority (FSA) published a Policy Statement in October 2009 regarding a new liquidity regime including the final version of the rules and reporting requirements, after a thorough consultation process which started in December 2007. The illustration below highlights the key milestones in this consultation process.

Figure 1: FSA consultation process timeline



Source: [Lepus](#)

Although the timetable for implementation has slipped when compared with the original, somewhat unrealistic dates proposed in the Consultation Paper (CP) CP08/22, the time line is still tight with systems and controls requirements going live by October 2009. These requirements are extensive and include the need for firms to have in place:

- A robust framework to project cash flows arising from assets, liabilities and off balance sheet items over an appropriate set of time horizons;
- A contingency funding plan to deal with a liquidity crisis, which should set down how the firm will meet time critical payments, allocation of roles and responsibilities, escalation procedures and the impact of stressed market conditions on the firm's ability to sell or securitise assets;
- The ability to perform stress testing on an institution specific and market wide basis, and to assess the impact of these stresses on cash flows, liquidity position, profitability and solvency;
- Reliable management information systems to provide the firm's governing body, senior managers and other appropriate personnel with timely and forward-looking information on the liquidity position of the firm.



Banks will then need to be in a position to apply the quantitative and reporting requirements of the new regime and with the go live date for a large number of firms in April and July 2010. Half of Lepus interviewees, mentioned that many banks will take not take a proactive approach and that there will be a rush closer to the deadline for banks to implement the significant new reporting and more extensive stress testing requirements required for the Individual Liquidity Adequacy Standards (ILAS).



Data

Data management is and continues to be a key challenge within risk management. Issues caused by the quality of data are pronounced within the risk modelling and management departments. Furthermore, as data is derived from a variety of sources and in various formats, its quality in many instances can be called into question.

As a result of the economic crisis, risk measurement, stress testing and monitoring has become of paramount concern to data management which has been driven by the compliance requirements that came out of Basel II, Sarbanes-Oxley and other regulations.

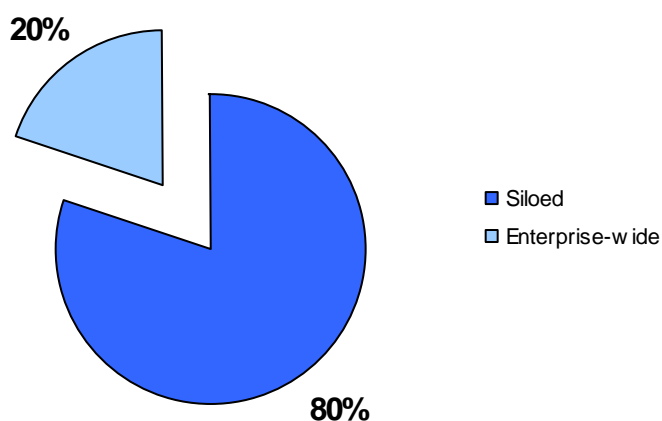
There are many critics in the industry who say that the idea of the 'golden copy' achieving 100% clean and accurate data, is not only a myth, but unworkable in practice. Data from external vendors is generally never completely clean and often delivered in different formats even within the same bank. Internal data from numerous legacy trading systems also presents a challenge.

All of the banks that were interviewed stated that clean data always presents a challenge and each bank has its own process of cleansing its data. For example, a tier-1 US bank stated that the business needs to have a strong interest in clean data and the charge (initial and ongoing costs) for poor quality data can be prohibitive. Although all banks have relevant tools and processes in place to ensure high quality data, this US bank went on to add that one method it uses is to match its data on a daily basis. Additionally, a tier-1 European bank stated that if they are comfortable from the outset with their data, they can maintain their accuracy by monitoring any significant changes.

Siloed versus enterprise-wide approach

As suspected, all of the banks viewed their data management procedures as an integral piece of their risk management policies. The chart below illustrates the results of how many banks currently have siloed risk data structures and how many utilise enterprise-wide data management approaches.

Figure 2: Siloed versus enterprise-wide risk data management approach



Source: Lepus



Although the majority of banks have siloed structures at present, there are initiatives in place in all of these banks to move them towards an enterprise-wide data management structure.

Practical implementation issues

Three of the interviewed banks also cited some practical implementation issues regarding the FSA's liquidity risk regime.

As the majority of the interviewed banks have siloed data structures, a key issue with the new regime is that of data capture as access to relevant data as well as identifying data gaps would be hampered as a result of the current structures in play.

Exploring this issue further highlights that data quality would prove to be another pain point as the new rules require extensive analysis to create reports to a high level of granularity by currency, legal entity, business, liquidity driver and so forth.

Although the ownership of data has always been a contentious issue, the FSA's new rules will require firms to implement clear responsibility for maintaining accuracy, approving modifications and permitting access to relevant data.

Another area that the new regime explores is that of data processing and it states that firms should look to have the following:

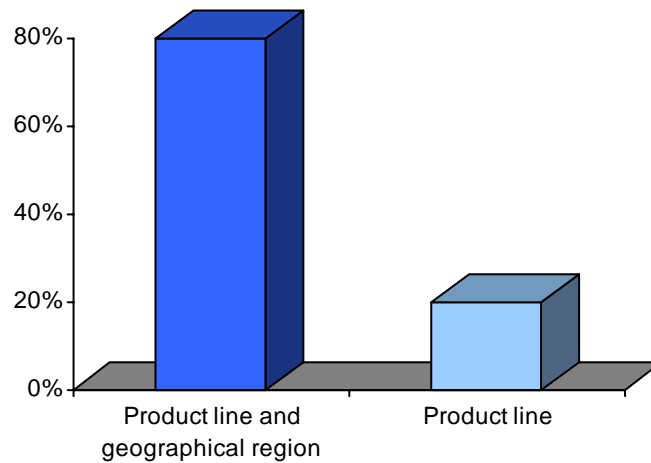
- Alignment between reference or static data required for analysis and unstructured data to supplement analysis;
- Speed of processing and ability to handle large volumes;
- Cut off where multiple time zones to meet end of day processing and reporting requirement.



Aggregation of risk scenarios

It proved interesting to note that not all of the interviewed banks aggregate their risk scenarios by product line and geographical regions. The chart below illustrates Lepus findings on this issue.

Figure 3: Risk scenarios aggregated by product line or geographical regions



Source: Lepus

Although one of the North American banks currently aggregates its risk scenarios on a product line basis, it did mention that it plans to combine these with its geographical regions in the near future.



Benchmarking and Frameworks

The financial crisis has highlighted weaknesses in stress testing practices employed prior to the start of the crisis in four broad areas: (i) use of stress testing and integration in risk governance; (ii) stress testing methodologies; (iii) scenario selection; and (iv) reverse stress testing.

Use of stress testing and integration in risk governance

Board and senior management involvement is critical in ensuring the appropriate use of stress testing in banks' risk governance and capital planning. This includes setting stress testing objectives, defining scenarios, discussing the results of stress tests, assessing potential actions and decision making. At banks that were highly exposed to the financial crisis and fared comparatively well, senior management as a whole took an active interest in the development and operation of stress testing, with the results of stress tests serving as an input into strategic decision making which benefited these banks. Stress testing practices at most banks, however, did not foster internal debate nor challenge prior assumptions such as the cost, risk and speed with which new capital could be raised or that positions could be hedged or sold.

The financial crisis has also revealed weaknesses in organisational aspects of stress testing programmes. Lepus uncovered that prior to the crisis, stress testing at some banks was performed mainly as an isolated exercise by the risk function with little interaction with business areas. This meant that, among other things, business areas often believed that the analysis was not credible. Moreover, at some banks, the stress testing programme was a mechanical exercise. While there is room for routinely operated stress tests within a comprehensive stress testing programme (e.g. for background monitoring), they do not provide a complete picture because mechanical approaches can neither fully take account of changing business conditions nor incorporate qualitative judgments from across the different areas of a bank. Furthermore, in many banks, stress tests were carried out by separate units focusing on particular business lines or risk types. This led to organisational barriers when aiming to integrate quantitative and qualitative stress testing results across a bank.

Lepus research highlighted that many banks previously did not have an overarching stress testing programme in place but ran separate stress tests for particular risks or portfolios with limited firm-level integration. Risk-specific stress testing was usually conducted within business lines. While stress testing for market and interest rate risk had been practiced for several years, stress testing for credit risk in the banking book has only emerged more recently. Other types of stress tests are still in their infancy. As a result, there was insufficient ability to identify correlated tail exposures and risk concentrations across the bank.

Interviews conducted with North American and European banks indicated that stress testing frameworks were usually not flexible enough to respond quickly as the crisis evolved (for example, inability to aggregate exposures quickly, apply new scenarios or modify models). Bearing in mind, the FSA's new regime and requirements, further



investments in IT infrastructure may be necessary to enhance the availability and granularity of risk information that will enable timely analysis and assessment of the impact of new stress scenarios designed to address a rapidly changing environment. For instance, investing in liquidity risk management information systems would enhance a bank's ability to automate end-of-day information, obtain more granularity as to unencumbered assets and forecast balance sheet needs of business units.

Stress testing methodologies

Stress tests cover a range of methodologies. Complexity can vary, ranging from simple sensitivity tests to complex stress tests, which aim to assess the impact of a severe macroeconomic stress event on measures like earnings and economic capital. Stress tests may be performed at varying degrees of aggregation, from the level of an individual instrument up to the institutional level. Stress tests are performed for different risk types including market, credit, operational and liquidity risk. Notwithstanding this wide range of methodologies, Lepus research highlighted several methodological weaknesses.

According to various top-tier North American and European banks, at the most fundamental level, weaknesses in infrastructure limited the ability of banks to identify and aggregate exposures across the bank. This weakness limits the effectiveness of risk management tools – including stress testing.

Most risk management models, including stress tests, use historical statistical relationships to assess risk. They assume that risk is driven by a known and constant statistical process, i.e. they assume that historical relationships constitute a good basis for forecasting the development of future risks. Two leading banks from both sides of the Atlantic described serious flaws with relying solely on such an approach.

First, given a long period of stability, backward-looking historical information indicated benign conditions so that these models did not pick up the possibility of severe shocks nor the build up of vulnerabilities within the system. Historical statistical relationships, such as correlations, proved to be unreliable once actual events started to unfold.

Second, in stressed conditions, risk characteristics can change rapidly as reactions by market participants within the system can induce feedback effects and lead to system-wide interactions. These effects can dramatically amplify initial shocks as recent events have illustrated.

Extreme reactions (by definition) occur rarely and may carry little weight in models that rely on historical data. It also means that they are hard to model quantitatively. The management of most banks did not sufficiently question these limitations of more traditional risk management models used to derive stress testing outcomes nor did they sufficiently take account of qualitative expert judgment to develop innovative ad-hoc stress scenarios. Therefore, banks generally underestimated the strong interlinkages between, for example, the lack of market liquidity and funding liquidity pressures. The reliance on historical relationships and ignoring reactions within the system implied that firms underestimated the interaction between risks and the firm-wide impact of severe stress scenarios.

Prior to the crisis, most banks did not perform stress tests that took a comprehensive firm-wide perspective across risks and different books. Even if they did, the stress tests were insufficient in identifying and aggregating risks. As a result, banks did not have a comprehensive view across credit, market and liquidity risks of their various businesses. An appropriately conducted firm-wide stress test would have beneficially drawn together



experts from across the organisation. For instance, the expertise of retail lenders, who in some cases were reducing exposure to US subprime mortgages, should have counteracted the overly optimistic outlook of traders in securities backed by the same subprime loans.

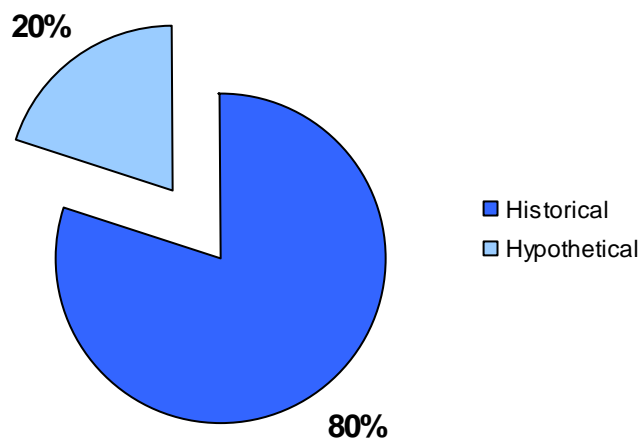
Scenario selection

All of the interviewed banks agreed that their stress tests were not designed to capture the extreme market events that were experienced. During interviews, Lepus understood that these firms discovered that one or several aspects of their stress tests did not even broadly match actual developments. In particular, scenarios tended to reflect mild shocks, assume shorter durations and underestimate the correlations between different positions, risk types and markets due to system-wide interactions and feedback effects. Prior to the crisis, “severe” stress scenarios typically resulted in estimates of losses that were no more than a quarter’s worth of earnings.

Across the industry, a range of techniques has been used to develop scenarios. Sensitivity tests, which are at the most basic level, generally shock individual parameters or inputs without relating those shocks to an underlying event or real-world outcomes. Given that these scenarios ignore multiple risk factors or feedback effects, their main benefit is that they can provide a fast initial assessment of portfolio sensitivity to a given risk factor and identify certain risk concentrations.

More sophisticated approaches apply shocks to many parameters simultaneously. Approaches are typically either historically based or hypothetical. As expected, all of the interviewed banks use a mix of both approaches and the chart below highlights that historical scenarios have traditionally been the preferred option.

Figure 4: Historical versus hypothetical approaches



Source: Lepus

Historical scenarios were frequently implemented based on a significant market event experienced in the past. Such stress tests were not able to capture risks in new products that have been at the centre of the crisis. Furthermore, the severity levels and duration of stress indicated by previous episodes proved to be inadequate. The length of the stress period was viewed as unprecedented and so historically based scenario analysis underestimated the level of risk and interaction between risks.



Banks also implemented hypothetical stress tests, aiming to capture events that had not yet been experienced. Prior to the crisis, however, banks generally applied only moderate scenarios, either in terms of severity or the degree of interaction across portfolios or risk types. At many banks including two European banks that Lepus interviewed, in the past it was difficult for risk managers to obtain senior management buy-in for more severe scenarios. Scenarios that were considered extreme or innovative were often regarded as implausible by the board and senior management.

Reverse stress testing

Stress tests should be geared towards the events capable of generating most damage whether through size of loss or through loss of reputation. A stress testing programme should determine what scenarios could challenge the viability of the bank (reverse stress tests) and thereby uncover hidden risks and interactions among risks.

Commensurate with the principle of proportionality, stress tests should be geared towards the most material business areas and towards events that might be particularly damaging for the firm. This could include not only events that inflict large losses but which subsequently cause damage to the bank's reputation.

Reverse stress tests start from a known stress test outcome (such as breaching regulatory capital ratios, illiquidity or insolvency) and then asking what events could lead to such an outcome for the bank. As part of the overall stress testing programme, it is important to include some extreme scenarios which would cause the firm to be insolvent (i.e. stress events which threaten the viability of the whole firm).

For a large complex firm, this is a challenging exercise requiring involvement of senior management and all material risk areas across the firm.

A reverse stress test induces banks to consider scenarios beyond normal business settings and leads to events with contagion and systemic implications. For instance, a leading European bank provided Lepus with the following example. A bank with a large exposure to complex structured credit products could have asked what kind of scenario would have led to widespread losses such as those observed in the recent financial crisis.

Given this scenario, the bank would have then analysed its hedging strategy and assessed whether this strategy would be robust in the stressed market environment characterised by a lack of market liquidity and increased counterparty credit risk.

Given the appropriate judgements, this type of stress test can reveal hidden vulnerabilities and inconsistencies in hedging strategies or other behavioural reactions.

Before the financial market turmoil, such an analysis was considered of little value by most senior management since the event had only a remote chance of happening. However, Lepus uncovered that many banks now express the need for examining tail events and assessing the actions to deal with them, however, only some banks are actively pursuing reverse stress testing approaches.

Only three of the five interviewed banks currently use this methodology and they all have expressed success in using this kind of stress test to identify risk concentrations and vulnerabilities. One of these banks added that a good reverse stress test also includes enough diagnostic support to investigate the reasons for potential failure.



Areas which benefit in particular from the use of reverse stress testing are business lines where traditional risk management models indicate an exceptionally good risk / return tradeoff; new products and new markets which have not experienced severe strains; and exposures where there are no liquid two-way markets.



Reporting and Transparency

Lepus uncovered that particular risks not covered in sufficient detail in most stress tests included:

- The behaviour of complex structured products under stressed liquidity conditions
- Pipeline or securitisation risk
- Basis risk in relation to hedging strategies
- Counterparty credit risk
- Contingent risks
- Funding liquidity risk

Each bank that Lepus spoke with said that scenarios were not sufficiently severe when stress testing structured products and leveraged lending prior to the crisis. This to some degree can be attributed to reliance on historical assumptions. In general, stress tests of structured products suffered from the same problems as other risk management models in this area in that they failed to recognise that risk dynamics for structured instruments are different from those of similarly-rated cash instruments such as bonds. These differences were particularly pronounced during the crisis, further degrading the performance of the stress tests. In particular, stress tests should specifically consider the credit quality of the underlying exposures, as well as the unique characteristics of structured products. Furthermore, three top-tier banks mentioned that stress tests also assumed that markets in structured products would remain liquid or, if market liquidity would be impaired, that this would not be the case for a prolonged period. This also meant that banks underestimated the pipeline risk related to issuing new structured products.

In many cases stress tests dealt only with directional risk and did not capture basis risk, thereby reducing the effectiveness of hedges. A leading US bank also added that another feature of the crisis was wrong-way risk, for example related to the credit protection purchased from monoline insurers.

In addition, stress tests for counterparty credit risk typically only stressed a single risk factor for a counterparty, were insufficiently severe and usually omitted the interaction between credit risk and market risk (specific wrong way risk). Stress testing for counterparty credit risk should be improved by utilising stresses applied across counterparties and to multiple risk factors, as well as those that incorporate current valuation adjustments.

The majority of the interviewed banks also cited that another weakness of the models was that they did not adequately capture contingent risks that arose either from legally binding credit and liquidity lines or from reputational concerns related, for instance, to off-balance sheet vehicles. Had stress tests adequately captured contractual and reputational risk associated with off-balance sheet exposures, concentrations in such exposures may have been avoided.

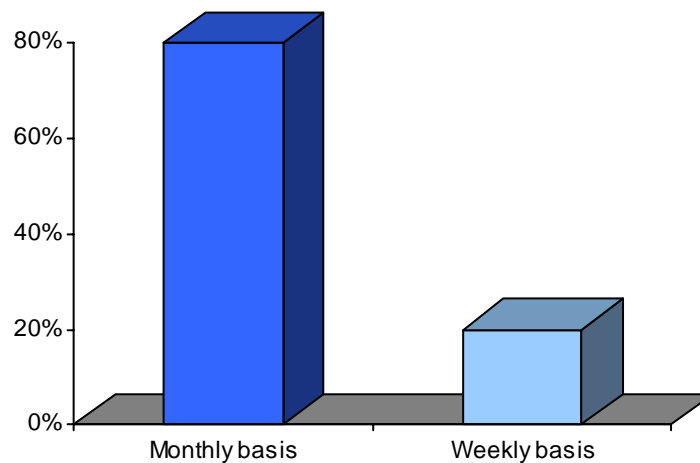


Changes in stress testing practices since the outbreak of the crisis

Given the unexpected severity of events, stress testing has gained greater prominence and credibility within banks as a complementary risk management and capital planning tool to provide a different risk perspective. It is important that this process continues so that stress testing programmes become embedded in banks' governance structures. Moreover, this process needs to be led by the board and senior management.

When Lepus questioned banks about how frequently internal management met to discuss issues such as their risk exposures, frameworks and methodologies, this yielded some interesting results as illustrated in figure 4.

Figure 5: Frequency of internal risk management meetings



Source: Lepus

Although only one tier-1 European bank has weekly meetings with its senior risk managers and the rest conduct monthly meetings, all of these firms cited that they provide full access to the regulators when they require it.

All of the banks that Lepus spoke with recognise that current stress testing frameworks must be enhanced both in terms of granularity of risk representation and the range of risks considered. All of these banks have started to address these issues and other weaknesses of stress tests for the specific risks identified above. More general areas in which the majority of banks that were interviewed are considering future improvement include:

- Constantly reviewing scenarios and looking for new ones
- Examining new products to identify potential risks
- Improving the identification and aggregation of correlated risks across books as well as the interactions between market, credit and liquidity risk
- Evaluating appropriate time horizons and feedback effects



Generally, firm-wide stress testing is an area that many banks recognise they will need to improve to ensure appropriate risk capture and to aggregate risk more effectively across business lines.

After the onset of the crisis, ad hoc 'hot-spot' stress testing has been used by the majority of the interviewed banks as an important tool to inform senior management's crisis management decisions. The ability to conduct stress tests at very short notice has proven to be valuable during a period of rapidly changing market conditions.

Reporting under the new FSA regime

Having highlighted some of the changes facing banks after the crisis, the FSA has also set out its guidelines with regards to reporting under its new regime which is summarised in the table below.

Figure 6: What to report under the new FSA liquidity risk regime

Data item	Description	Frequency	Submission deadlines
FSA047: Daily Flows	Collects daily flows out to three months to analyse survival periods and spot potential liquidity squeezes early	Business as usual (BAU) Weekly Firm-specific and / or market-wide liquidity stress Daily (Respectively Monthly and Weekly for Simplified and Low Frequency firms)	BAU: End-of-day (22:00 London time) Monday for the week ending the previous Friday Stress: End of the following business day for the previous business day (Respectively 15 days and end of Monday for Simplified and Low Frequency firms)
FSA048: Enhanced Mismatch Report (EMR)	Captures the ILAS risk drivers and contractual flows across the full maturity spectrum	As above	As above
FSA050: Liquidity Buffer Qualifying Securities	Provides more granular analysis of firms' marketable asset holdings	Monthly	15 business days after month end
FSA051:	Captures firms' borrowings from	Monthly	15 business days



Funding Concentration	unsecured wholesale funders (excluding primary issuance), by counterparty class		after month end
FSA052: Wholesale liabilities	Collects daily transaction prices and transacted volumes for wholesale unsecured liabilities	Weekly (Becomes Monthly for Simplified and Low Frequency firms)	End-of-day Tuesday for the week ending the previous Friday (15 business days after Month end for Simplified and Low Frequency firms)
FSA053: Retail, SME and Large Enterprises Type B and Corporate Funding	Captures firms' retail and corporate funding profiles and the stickiness of various retail deposits	Quarterly	15 business days after quarter end
FSA054: Currency Analysis	Provides an analysis of foreign exchange (FX) exposures on firms' balance sheets	Quarterly	15 business days after quarter end

Source: Lepus

The new regulatory reporting requirements will align with the transitional period as highlighted above and banks will continue to submit their current liquidity reporting until the transitional period is complete. In addition, the table below highlights the key 'go live' dates for each data item.

Figure 7: When to report under the new rules

Class of Firm	FSA047, 048, 052	FSA050, 051, 053, 054
Sterling stock bank	1 June 2010	1 November 2010
Building Society (Standard ILAS)	1 June 2010	1 November 2010
Building Society (Simplified ILAS)	1 October 2010	1 November 2010
Mismatch banks	1 October 2010	1 November 2010
Branches with or without Global Liquidity	1 November 2010	1 November 2010



Concessions (GLCs) and investment firms		
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Source: Lepus



Business benefits

As one would expect, investment in stress testing initiatives would yield significant business benefits. Below are some recommendations and subsequent business benefits that would greatly improve banks' business and risk models.

Stress testing should form an integral part of the overall governance and risk management culture of the bank

Stress testing should be actionable, with the results from stress testing analyses impacting decision making at the appropriate management level, including strategic business decisions of the board and senior management. Board and senior management involvement in the stress testing programme is essential for its effective operation.

The board has ultimate responsibility for the overall stress testing programme, whereas senior management is accountable for the programme's implementation, management and oversight. Recognising that many practical aspects of a stress testing programme will be delegated, the involvement of the board in the overall stress testing programme and of senior management in the programme's design are essential. This will help ensure the board's and senior management's buy-in to the process. It will also help maximise the effective use of stress tests, especially with respect to firm-wide stress testing. The rationale for particular choices, as well as their principal implications, should be explained and documented so that the board and senior management are aware of the limitations of the stress tests performed (e.g. key underlying assumptions, the extent of judgement in evaluating the impact of the stress test or the likelihood of the event occurring). Stress testing should promote candid discussion on modelling assumptions between the board and risk managers.

Senior management should be able to identify and clearly articulate the bank's risk appetite and understand the impact of stress events on the risk profile of the bank. Senior management must participate in the review and identification of potential stress scenarios, as well as contribute to risk mitigation strategies. In addition, senior management should consider an appropriate number of well-understood, documented, utilised and sufficiently severe scenarios that are relevant to their bank. Senior management's endorsement of stress testing as a guide in decision-making is particularly valuable when the tests reveal vulnerabilities that the bank finds costly to address.

A stress testing programme as a whole should feed into the decision making process at the appropriate management level, including strategic business decisions of the board or senior management. Stress tests should be used to support a range of decisions. In particular but not exclusively, stress tests should be used as an input for setting the risk appetite of the firm or setting exposure limits. Stress tests should also be used to support the evaluation of strategic choices when undertaking and discussing longer term business planning. Importantly, stress tests should feed into the capital and liquidity planning process.

Stress testing programmes should take account of views from across the organisation and cover a range of perspectives

The identification of relevant stress events, the application of sound modelling approaches and the appropriate use of stress testing results each require the collaboration of different



senior experts within a bank, such as risk controllers, economists, business managers and traders. A stress testing programme should ensure that opinions of all relevant experts are taken into account, in particular for firm-wide stress tests. The unit with responsibility for implementing the stress testing programme should organise appropriate dialogue among these experts, challenge their opinions, check them for consistency (e.g. with other relevant stress tests) and decide on the design and the implementation of the stress tests, ensuring an adequate balance between usefulness, accuracy, comprehensiveness and tractability.

Banks should use multiple perspectives and a range of techniques in order to achieve comprehensive coverage in their stress testing programme. These include quantitative and qualitative techniques to support and complement the use of models and to extend stress testing to areas where effective risk management requires greater use of judgement. Stress tests should range from simple sensitivity analysis based on changes in a particular risk factor to more complex stress tests that revalue portfolios taking account of the interactions among risk drivers conditional on the stress event. Some stress tests should be run at regular intervals whilst the stress testing programme should also allow for the possibility of ad hoc stress testing.

Sensitivity analysis is generally intended to assess the output from quantitative approaches when certain inputs and parameters are stressed or shocked. In most cases, sensitivity analysis involves changing inputs or parameters without relating those changes to an underlying event or real-world outcomes. For instance, a sensitivity test might explore the impact of varying declines in equity prices (such as by 10%, 20%, 30%) or a range of increases in interest rates (such as by 100, 200, 300 basis points). While it is helpful to draw on extreme values from historical periods of stress, sensitivity analysis should also include hypothetical extreme values to ensure that a wide range of possibilities is included. In some cases, it can be helpful to conduct a scenario analysis of several factors at the same time, because simply testing factors individually may not reveal their potential interaction (particularly if that interaction is complex and not intuitively clear). For instance, scenarios can evaluate the combined impact on credit risk capital needs from sudden spikes in probabilities of default and concurrent changes in the dependence parameters of a credit capital model.

Sensitivity and scenario analysis has additional benefits in helping to reveal whether quantitative approaches are working as originally intended. For example, one can check the assumption that a relationship continues to be linear when extreme inputs are used. If the analysis results show that a certain model is unstable or does not work as originally intended with extreme inputs, then management should consider rethinking the model, modifying certain parameters, or at least putting less weight on the accuracy of model output. Finally, sensitivity and scenario analysis should be conducted regularly (not just during model development), since models can deteriorate and relationships among variables can change over time.

A bank should regularly maintain and update its stress testing framework. The effectiveness of the stress testing programme, as well as the robustness of major individual components, should be assessed regularly and independently.

The effectiveness and robustness of stress tests should be assessed qualitatively as well as quantitatively, given the importance of judgements and the severity of shocks considered. Areas for assessment should include:

- The effectiveness of the programme in meeting its intended purposes



- Documentation
- Development work
- System implementation
- Management oversight
- Data quality
- Assumptions used

The quantitative processes should include benchmarking with other stress tests within and outside the bank.

Since the stress test development and maintenance processes often imply judgemental and expert decisions (e.g. assumptions to be tested and calibration of the stress), the independent control functions such as risk management and internal audit should also play a key role in the process.



Conclusion

Given the recent financial crisis, the need for improvement in stress testing has been recognised by the financial industry. Even regulators such as the FSA, have taken a proactive role in improving the state of the banking industry by introducing an updated liquidity risk regime coupled with relevant deadlines. This whitepaper has highlighted some of the key areas in this space that banks cannot afford to ignore in their efforts to better manage their risks, exposures and ultimately their organisations.

The significance of adequate and appropriate stress testing practices and principles cannot be over-stated and it should be explored further by all banks. The principles include the need for stress testing to be carried out comprehensively and integrated with the overall risk management infrastructure. There is a growing need for stress testing to have a meaningful impact on business decisions, with the board and senior management having an important role in evaluating stress test results and impact on a bank's risk profile.

Ultimately there is a growing need for firms to think creatively about how the value of stress tests can be maximised, including the more recent approach of reverse stress testing to explore the events that could cause a significant impact on the firm.