CHAPTER 7

Next-Generation Systemwide Liquidity Stress Testing

CHRISTIAN SCHMIEDER • HEIKO HESSE • BENJAMIN NEUDORFER • CLAUS PUHR • STEFAN W. SCHMITZ

This article presents a framework for stress testing and monitoring banks’ liquidity positions from various perspectives. The associated Excel-based tool can be used to run systemwide, balance sheet data–based liquidity stress tests and is part of the new-generation stress testing framework introduced in Schmieder, Puhr, and Hasan (2011). The liquidity framework includes three elements: (1) a module to simulate the impact of bank-run-type scenarios; (2) a module to assess risks arising from maturity transformation and rollover risks (it enables simplified tests for rollover risk or a full-fledged cash flow–based approach to simulating liquidity shortfalls in different maturity buckets; and (3) a framework for linking liquidity and solvency risks. Our framework can also be used to simulate how banks would cope with upcoming regulatory changes (Basel III) and takes into account the fact that data availability differs widely.

METHOD SUMMARY

Overview
• The method provides a framework for stress testing and monitoring banks’ liquidity positions from various perspectives.
• It also simulates how banks would cope with upcoming regulatory changes (e.g., Basel III).

Application
The tool enables the running of systemwide liquidity stress tests for banks (and, in principle, other financial institutions) from complementary perspectives:
1. to simulate bank-run-type tests;
2. to assess maturity mismatch, accounting for both contractual and behavioral cash flows; and
3. to establish links between liquidity and solvency.

The tool also enables computation (of proxies) for the Basel III ratios.

Nature of approach
Balance sheet data–based.

Data requirements
• Accounting information on assets and liabilities, including maturity mismatch and, if available, detailed contractual and behavioral cash flow data as well as banks’ off-balance-sheet positions.
• To establish a (dynamic) link between liquidity and solvency risk, capitalization ratios as reported and under stress are needed, as well as the relationship between capitalization and funding costs.

Strengths
The method allows more granular and comprehensive liquidity stress tests and accounts for the fact that data availability differs widely across financial systems.

Weaknesses
• The quality of the results depends on the data available for running the tests.
• Strong assumptions are required on liquidity requirements associated with contingent liabilities, such as derivatives (which is a common challenge).
• The framework needs to evolve, provided that more data become available, to implicitly (or more explicitly) capture the dynamic nature of liquidity risks.

Tool
The Excel spreadsheet macro is available in the toolkit, which is on the companion CD at www.elibrary.imf.org/stress-test-toolkit.
Contact author: C. Schmieder.

This chapter is an abridged version of IMF Working Paper 11/203 (Schmieder and others, 2011). The working paper benefited from comments by Martin Čihák, Daniel Hardy, Maher Hasan, Torsten Wezel, Nico Valckx, Martha Ruiz-Arranz, Fabian Valencia, and Minsuk Kim as well as from seminar participants at the IMF and the European Central Bank, participants at an IMF-Oesterreichische Nationalbank stress testing workshop in Vienna, and numerous central bankers and bank supervisors during IMF Financial Sector Assessment Program and technical assistance missions.
Traditionally speaking, liquidity risk has been at least as important for banks as solvency risk. It was only with the introduction of Basel I in 1988, when liquidity risk was omitted from the framework, that solvency risk gained greater prominence and the erosion of capitalization came to a halt (Goodhart, 2008). However, the global financial crisis has shown very clearly that neglecting liquidity risk comes at a substantial price. Liquidity risk at banks is triggered by maturity transformation (long-term maturity profile on the assets side versus short-term maturities on the liabilities side). Over the last decade, the large banks have become increasingly reliant on short-term wholesale funding (especially in interbank markets) to finance their rapid asset growth. At the same time, the supply of funding from nondeposit sources such as money market mutual funds has soared. As the global financial crisis unfolded, interbank markets froze as counterparty risk rose, resulting in funding liquidity challenges for many banks.

The liquidity stress testing framework presented in this chapter was developed for application in the IMF’s Financial Sector Assessment Programs (FSAPs). It extends the seminal work of Čihák (2007) and that of the Austrian National Bank/Oesterreichische Nationalbank (OeNB). Four key aspects were taken into account in the development of the framework, namely that

1. the availability of data varies widely across countries;
2. liquidity risk has several dimensions, and assessing banks’ resilience vis-à-vis funding risks requires multidimensional analysis;
3. designing liquidity scenarios is more challenging than for solvency risks, mainly because liquidity crises are relatively rare and can originate from many different sources; and
4. there is a close link between solvency and liquidity risks.

The resulting framework is an Excel-based, easy-to-use balance sheet–type liquidity stress testing tool that allows the user to run bottom-up tests for hundreds (and even thousands) of banks. It has the following features:

- First, the tool can be used in circumstances where data are very limited to run some basic liquidity tests. Likewise, a cash flow based module allows the user to run detailed liquidity analysis like those carried out by (large) banks for their internal purposes.
- Second, the framework includes three broad dimensions (based on four modules) that allow for complementary views on liquidity risks, including the link to solvency risks.
- Third, we provide benchmark scenarios based on historical evidence on the one hand and common scenarios used by FSAP missions on the other, and these also are informed by Basel III.
- Fourth, the framework allows an assessment of the link between liquidity and solvency, although additional effort is needed in this context, including work that captures the dynamic aspects of this relationship and spillover effects.

Overall, the framework is aimed at giving users the ability to run a meaningful systemwide liquidity stress test.

The framework consists of three types of stress testing concepts:

1. Stress testing funding liquidity based on implied cash flow–type methods, which comprises (a) simulating bank-run-type scenarios while accounting for fire sales of liquid assets; (b) liquidity gap analysis (assessing different maturity buckets); and (c) calculating Basel III liquidity ratios.
2. Cash flow–based liquidity tests, which produces an intuitive view of each bank’s liquidity risk-bearing capacity in the form of the cumulated counterbalancing capacity at the end of each maturity bucket.
3. Tests linking solvency and liquidity risk through (a) an increase in funding costs; (b) the closure of funding markets; and (c) potential vulnerabilities stemming from funding concentration.

The chapter is organized as follows: Section 1 first provides some generic considerations on concepts and methods to assess liquidity risks. Section 2 presents the newly developed methodological framework. Section 3 is devoted to designing “extreme yet plausible” scenarios, complemented by an illustrative study in Schmieder, Hesse, and others (2011). Section IV concludes the chapter.

1. REVIEW OF GENERAL CONCEPTS TO ASSESS LIQUIDITY RISKS

A. General considerations and motivation

Liquidity stress tests are less developed compared with solvency stress tests (particularly market risk). This development can be attributed to several factors: (1) liquidity risk management was considered to be “less of an issue” until the current crisis and hence has a shorter history of making use of information technology (IT) systems, which would have facilitated its development; (2) liquidity crises are very low-frequency–high-impact events, which greatly reduces the opportunity to draw on historical experience to calibrate models; and (3) all liquidity crises are somehow different, at least if one seeks to analyze the relationship between the

1 See Appendix I of Schmieder and others (2011) for the evolution of liquidity evaporation during the crisis.
2 Examples include Germany, Turkey, Chile, and India.
3 In principle, the tool could also be used to assess nonbank financial institutions but potentially would need some adjustment.
4 See Barnhill and Schumacher (2011) and IMF (2011).
5 In some cases, central bank support via liquidity provisions has masked the extent of an explicit liquidity squeeze, with many banks hoarding liquidity and banks faced with funding liquidity challenges merely substituting their loss of market wholesale and/or retail funding with central bank funding.
sources and the resulting liquidity shortfalls, reducing the usefulness of “standard” stress assumptions.

Liquidity crises pose significant challenges in that they typically occur very suddenly and spread very quickly, giving banks very little time to react. Idiosyncratic liquidity crises can be triggered by various events, most notably solvency problems, but also political instability and fraud. Contagion can escalate idiosyncratic shocks into marketwide shocks, as seen during the recent crisis period. This dynamic warrants requiring liquidity buffers to be based on highly conservative principles—an important consideration in the design of stress scenarios (Section 3). A key principle applied by the U.S. authorities during the height of the financial crisis in late 2008 was to ensure that ailing (investment) banks made it through a business week, so that a viable solution could be found during the weekend if necessary. With the regulatory framework to be established by Basel III, the aim is to ensure banks’ resilience against a “significant stress scenario lasting 30 days” (Basel Committee on Banking Supervision [BCBS], 2010), that is, banks should be able to survive a month under (medium to severe) stress.

Liquidity crises may be sharp and short or more drawn out, each requiring different mitigating actions and considerations:

- The obvious solution to counterbalancing bank-run-type outflows is to liquidate assets through fire sales. The dilemma for banks lies in the cost of holding high-quality liquid assets, particularly cash and “prime” government bonds. More illiquid securities are less costly (i.e., they qualify as some substitute for traditional bank business) but subject to higher haircuts, at best, or cannot be sold at all (i.e., become illiquid) during periods of market stress and/or may no longer qualify as eligible collateral (to ensure secured funding).

- In the case of longer-lasting liquidity disturbances, the maturity profile of assets and liabilities plays an important role, as maturing assets can then be used to deleverage in an “orderly” manner, provided that (at least partly) maturing (longer-term) debt can be rolled over. In fact, the analysis of rollover risk has become an important aspect of liquidity risk analyses as many large banks are facing a “wall of funding” in the coming years.6

Central bank funding plays a natural counterbalancing role. In a severe crisis, central banks can act as a lender of last resort. For instance, a number of central banks entered into currency swap agreements with the Board of Governors of the Federal Reserve during the crisis so that they could supply their domestic banks with much needed U.S. dollar funding.7 Parent banks can also step in to increase or maintain credit lines to subsidiaries if a subsidiary or branch loses access to funding sources. The Committee of European Banking Supervisors (CEBS) found that the majority of instances in which parent institutions did not provide additional liquidity for subsidiaries were attributable to idiosyncratic liquidity shocks hitting the parent as a consequence of severe (perceived) solvency problems of the banking group (CEBS, 2009).

B. Methodological aspects

Overview of Recent Methods to Assess Liquidity Risks

Methods to assess liquidity risk run from use of simple indicators to very sophisticated, complex techniques. A natural starting point for assessing liquidity risk is through financial soundness indicators, which provide relevant information on the liquidity position of banks, both vis-à-vis peers (banks and/or countries) and over time. Liquidity stress tests are more forward-looking and several methods have been developed by central banks and supervisory authorities:

- The OeNB is one of the early users of cash flow–based (top-down and bottom-up) liquidity stress tests (Boss and others, 2008); more recently, the work by Schmitz (2010) has had an important influence on the European approach (see European Central Bank [ECB], 2008a).

- Another liquidity stress testing approach was developed by Wong and Hui (2009) at the Hong Kong Monetary Authority. In their framework, banks’ liquidity risk arises from the impact of marked-to-market losses on banks’ solvency, leading to deposit outflows and evaporating asset fire sales and, consequently, sharply rising contingent liquidity risk.

- The Dutch Central Bank developed a stress testing model for both market and funding liquidity risk, which incorporates feedback effects as well as a Monte Carlo approach that simulates the impact on liquidity risk (van den End, 2008).

- The Bank of England attempted to link funding liquidity risk with solvency risk in the Risk Assessment Model for Systemic Institutions (RAMSI; Aikman and others, 2009). The framework simulates banks’ liquidity positions conditional on their capitalization under stress and incorporates other relevant dimensions, such as a decrease in confidence among market participants under stress.

At the IMF, liquidity stress tests have been developed to support staff’s bilateral and multilateral surveillance work. Applied stress tests in the context of the FSAP were introduced in Čihák (2007); bank balance sheet data were used to implement bank-run-type stress tests on a bank-by-bank basis. More recently, the Global Financial Stability Report

---

6 Banks’ debt maturity profiles are monitored in the IMF’s Global Financial Stability Report, for example.

7 Recently released figures by U.S. authorities on U.S. dollar liquidity support granted to large banks (including major European banks) at the onset of the crisis are also a telling example in this context.

8 In the liquidity stress tests conducted for the IMF FSAP in 2007, highly adverse scenarios were adopted to test the resilience of Austrian banks. See Section III.C for further information.
focused on analyzing systemic liquidity, using a Merton-type approach on market data and balance sheet information to estimate liquidity risk at individual banks and to calculate the joint probability of all institutions experiencing a systemic liquidity event (IMF, 2011). Barnhill and Schumacher (2011) simulated the impact of an asset price shock on banks’ solvency position, resulting in a withdrawal of bank liabilities; they subsequently tested whether banks could counterbalance these outflows with fire sales.

On the regulatory side, substantial microprudential efforts have been made to contain liquidity risk at the bank level. In 2008, the BCBS published guiding principles for sound liquidity risk management (BCBS, 2008); an overhaul of the regulatory framework followed in December 2010 (BCBS, 2010), when the Committee introduced two measures to contain short-term vulnerabilities and excessive maturity mismatches. The minimum liquidity standard incorporates (1) a 30-day liquidity coverage ratio (LCR), essentially a pre-specified substantial bank-run-type stress test lasting a month that banks have to pass in order to be considered safe in the short term; and (2) a longer-term structural liquidity ratio, the net stable funding ratio (NSFR), which aims to limit maturity mismatches, with a 12-month horizon. Both ratios are subject to a transition phase, during which they will be calibrated, and are scheduled to be fully implemented by 2015 and 2018, respectively.

In addition, several macroprudential approaches to manage systemic liquidity risk have been brought forward during the last two years. Some have been used, at least partially, in some emerging-market countries for many years. These approaches provide incentives to limit systemic liquidity risks, including through levies, capital charges, and the introduction of minimum liquidity ratios and haircuts. However, implementation seems unlikely at this stage, mainly owing to the complexity of measuring systemic risk (see IMF, 2011).

Finally, stress tests in the banking industry are centered on maturity mismatch approaches, sometimes complemented by stochastic value-at-risk (VaR) components for those funding sources for which sufficient history on high-frequency data is available. The ultimate goal of liquidity tests is to determine a bank’s risk tolerance for liquidity risk, that is, the maximum level of risk that the bank is willing to accept under stress conditions. Most large European banks compute their maximum risk tolerance (ECB, 2008a). The stochastic approach aims at determining Liquidity at Risk (maximum liquidity gap within a certain time horizon and for a given confidence level) or Liquidity VaR (maximum cost of liquidity under certain assumptions). Although instructive under business-as-usual and mild stress scenarios, these models face limitations in stress testing more severe liquidity shocks. Given that liquidity risk is a low-frequency, high-impact risk, historical volatilities and correlations tend to underestimate funding risk under severe stress, which is highly nonlinear (ECB 2008a).

**Top-down or Bottom-up?**

The most intuitive way to stress test liquidity risk is to use cash flow–level data, usually available only within banks. Provided that the cash flow structure and the maturity of all cash flows are monitored through IT systems, the challenge is how to deal with

1. the volatility of funding, that is, cash flows with non-predefined cash flow structures, such as contingent liabilities (e.g., credit lines) on the asset side and demand deposits or short-term interbank market access on the liability side; as well as
2. the strategy of managing maturity mismatch.

For systemwide liquidity stress tests, the subject matter of our framework, there are two ways to stress test liquidity risk:

1. Define common scenarios that are run by banks themselves, so-called bottom-up (BU) tests, making use of granular data; or
2. Collect data by broader liability and asset types, currency, and maturity, and apply scenarios accordingly in a top-down (TD) fashion (i.e., run by authorities).

Table 7.1 summarizes the relative strengths and weaknesses of the two approaches for liquidity risk, omitting the hybrid case (TD, run by banks).

**Outcome of Liquidity Stress Tests**

The outcome of TD liquidity tests is threefold:

1. They show the counterbalancing ability of banks (and their specific limits in case of reverse stress tests) to remain liquid.
2. They allow a peer comparison, that is, the relative performance of banks under liquidity stress.
3. They can provide a link between the joint resistance to liquidity and solvency risks if the feedback between solvency and liquidity risks is modeled (in the TD stress testing framework).

**C. Framework of next-generation liquidity stress tests**

Our framework originates in the balance sheet–based liquidity stress tests of Čihák (2007). We take into account (1) lessons learned from the crisis on the one hand and (2) the evolution of conceptual and regulatory initiatives on the other. The framework is part of a larger project on next-generation balance sheet stress testing at the IMF, following

---

9 The framework can also be used to compute each institution’s contribution to systemic risk and systemic risk shortfalls, respectively, which could trigger an insurance premium.

10 Liquidity at Risk denotes computing a 99.9 percent event based on the cumulative probability distribution (as is done for market risk and credit risk).
TABLE 7.1
Comparison of Pros and Cons of Balance Sheet–Type TD and BU Liquidity Stress Tests

<table>
<thead>
<tr>
<th>Type of Test</th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
</table>
| BU tests (run by banks) | • Cash flow–level data.  
• Use of models developed by banks.  
• The effects of liquidity shocks on the profit and loss account and the cost of funding shocks can be incorporated more easily. | • Less consistent than TD.                  |
| TD tests (run by authorities) | • Consistent approach.  
• Authorities have the flexibility to run various scenarios.  
• Transparency of situation to authorities. | • Less detailed data.  
• Bank-specific situation less recognized.  
• Data are rapidly outdated, which can be prevented by a high but burdensome frequency of reporting. |

Source: Authors.

Note: BU = bottom-up; TD = top-down.

Schmieder, Puhr, and Hasan (2011). Our tool provides extensions in five dimensions (Figure 7.1):

- A more granular balance sheet structure that can be exploited.
- Maturity mismatches that are explicitly taken into account through separate tests.
- A framework that allows computation of (simplified) Basel III liquidity ratios, both the LCR and NSFR.
- A full-fledged cash flow test that shows detailed information on banks’ vulnerabilities in different maturity buckets (subject to availability of granular information).
- A framework linking liquidity and solvency risks that considers liquidity from complementary angles and allows an assessment of the impact of changes in funding costs and a (partial) closure of funding sources on solvency and liquidity, as well as funding concentration risks.

Given the lack of empirical evidence, as argued previously, the calculation of satellite models (i.e., econometric models) that link the outflow of deposits to macroeconomic conditions is not (yet) feasible. Such models can be used to determine the haircuts for assets under stress (i.e., market liquidity risk). In addition, satellite models can be used to link banks’ solvency under stress (e.g., capital ratios or banks’ default probabilities) to funding costs. Accordingly, a multiperiod solvency test could link the deterioration in liquidity conditions to the evolution of bank solvency and vice versa.

Figure 7.1  Overview on Liquidity Risk Framework
Table 7.2
Overview on the Main Elements of Three Liquidity Tests

<table>
<thead>
<tr>
<th>Type of Test</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bank-run-type tests</td>
<td>Simulates banks’ counterbalancing capacity in case of bank-run-type scenarios for a period of (1) 5 and (2) 30 consecutive periods (e.g., days). Allows for a high level of granularity with respect to fire sales (defining liquid assets, haircuts, and so forth).</td>
</tr>
<tr>
<td>Maturity mismatch/rollover risk tests</td>
<td>The liquidity gap simulation matches liability and asset maturities and identifies liquidity gaps at each maturity and under different scenarios, taking into account rollover risk. The (proxied) NSFR assesses the stability of banks’ funding sources in more structural terms, with a focus on the next 12 months. Cash flow–based liquidity tests allow for an intuitive view on each bank’s liquidity risk-bearing capacity in the form of the cumulative counterbalancing capacity at the end of each maturity bucket.</td>
</tr>
<tr>
<td>Integrated liquidity and solvency test</td>
<td>Simulates the impact of changes in solvency, rating downgrades, and concentration risk on funding costs (the first two modules require input from a solvency test and funding cost model, respectively).</td>
</tr>
</tbody>
</table>

Source: Authors.
Note: LCR = liquidity coverage ratio; NSFR = net stable funding ratio.

Our framework consists of three liquidity stress test modules (Table 7.2). They assess (1) the capacity of a bank to withstand a bank run (short-term counterbalancing capacity); (2) the extent and capacity of a bank to deal with maturity mismatches; and (3) potential threats to liquidity arising from solvency risks. A case study simulating banks’ short-term counterbalancing capacity is presented in Schmieder, Hesse, and others (2011), along with more detailed information on each of the stress tests.

2. DESIGN OF STRESS SCENARIOS

A. General considerations

In line with the overarching principles for sound stress testing, scenarios should be “extreme yet plausible.” This is even more important for liquidity risk than it is for solvency risk as only limited liquidity buffers can ultimately safeguard banks, unless there is a major systemic event when even those would no longer suffice. Given that liquidity crises are infrequent (more so than solvency crises), evidence is scarce, and, moreover, stress levels vary widely. However, conditions tend to be very unfavorable once stress occurs as it tends to be highly nonlinear.

Our aim is to present some crude benchmark scenarios by introducing a new unit: “Lehman.” This unit is meant be a benchmark for funding conditions faced by banks that were particularly badly hit in the month after the Lehman collapse. In Schmieder, Hesse, and others (2011), a case study is applied to stylized but representative banks in advanced economies, emerging markets, and low-income countries. The simulated stress levels were equal to half Lehman, Lehman, two times Lehman, and three times Lehman. In the following, evidence, regulatory parameters, and scenarios used by authorities and banks are presented.

The classic alternative to point estimate-based scenarios is to “stress it until it breaks.” Ong and Čihák (2010) also refer to reverse stress tests, where tests are used to determine a set of scenarios that would cause an increasing part of the system (or specific banks) to run short on liquidity. Reverse stress tests and tests simulating “extreme yet plausible” scenarios complement each other, and thus there is a good reason to run both, especially for liquidity risk. The advantage of running a series of stress tests is to gain a meaningful view on the sensitivities of banks (and systems) to specific stress drivers (e.g., outflow of funding, drain of liquid assets, contingent liabilities, margin calls)—key preconditions for robust stress test results (taking into account the Black Swan theory).

In general, three basic types of inputs can be useful in designing extreme-but-plausible scenarios: (1) past experience; (2) expert judgment; or (3) an individual, reverse test–type assessment of the limit for each bank. Scenarios should take into account both marketwide shocks (a worsening of market conditions and investor confidence) that affect all banks in the system as well as idiosyncratic shocks, for example, resulting from deterioration in the solvency of individual banks. Given that market confidence in individual banks is more fragile under marketwide stress, combined scenarios should complement pure marketwide shock and idiosyncratic scenarios (e.g., the LCR is modeled around such a combined scenario).

If possible, scenarios should be accompanied by a consistent “story line” that underpins the assumptions on all relevant elements. These include

1. runoff rates for funding;
2. haircuts for assets sold at fire sale prices and draw-down of contingent liabilities;

---

12 This benchmark scenario remains hypothetical and is geared toward large banks in the Organization for Economic Cooperation and Development countries. For smaller banks, the benchmark could be different, with (even) higher runoff rates for customer deposits in case of a crisis. Expert judgment is needed to design the most plausible scenario for the situation at hand.
13 The stylized banks were constructed using the universe of Bankscope data, which remains limited for low-income countries and (although less so) also for emerging-market countries.
14 The challenge is how to deal with the outcome of reverse stress tests in the context of authorities’ stress tests. Given the sensitivity of liquidity risk, an appropriate way to disseminate the results needs to be found.
3. the impact of banks’ rating downgrades, that is, a deterioration in bank solvency, resulting in margin calls (i.e., higher levels of encumbered assets), an increase in funding costs, and, ultimately, a gradual closure of funding sources.

For the analysis of maturity mismatches, additional parameters (e.g., rollover rates) need to be modeled in a consistent manner. In the case of retail deposits, the following could be guiding questions for the design of scenarios and the development of story lines:

1. Which retail deposits are the most vulnerable (e.g., foreign currency denominated deposits, deposits held by foreigners abroad, demand deposits in case of an increase in policy rates from very low levels) and would go first?
2. Would depositors hoard cash or shift deposits outside the national banking system in the event of a crisis?
3. Under what conditions would flight to quality initiate deposit inflows at a subset of banks in the system and an outflow at others?

B. Runoff rates for different funding sources

The financial crisis provided ample evidence of solvency and liquidity crises at banks. From a liquidity perspective, the most prominent victims were probably the U.S. investment banks, which suffered from a drying up of interbank markets combined with solvency concerns, which pushed them to seek much-needed capital (e.g., from sovereign wealth funds). Others became victims of their rapid and aggressive growth strategy and heavy reliance on wholesale funding, such as Northern Rock in the United Kingdom, which experienced a textbook retail bank run following a quiet wholesale run. A third group of banks were those domiciled in countries experiencing major recessions and/or banking crises, such as in the Baltic countries and Kazakhstan. More recently, banks in peripheral European countries became highly dependent on ECB funding after they were shut out of the interbank market and debt capital markets and experienced protracted outflows of funds, including retail deposits, in some cases.

The two prudential Basel III ratios provide benchmark parameters for runoff rates of funding sources: the LCR for a period of 1 month and the NSFR for 12 months (BCBS, 2010). For retail deposits, the LCR foresees minimum outflow ratios (runoff rates) of 5 percent for stable funding provided by retail customers and small- and medium-sized enterprises and 10 percent for less stable funding.\(^{15}\) For the NSFR, the level is twice as high (10 and 20 percent, respectively). Secured wholesale funding is subject to withdrawal between 0 and 25 percent, provided that it is secured with higher-quality collateral, whereas unsecured wholesale funding is associated with runoff rates of at least 50 percent (for nonfinancial corporates), most of it 100 percent (especially for financial institutions). European banks\(^{16}\) use similar parameters for their internal stress tests, with retail deposit runoff rates mostly at 10 percent (up to 30 percent) and wholesale runoff rates ranging from 0 to 100 percent (100 percent is assumed by one-fifth of the banks in the survey; ECB, 2008a).

C. Asset side of the balance sheet: Fire sales and rollover

The counterbalancing ability of banks depends on their ability to generate cash inflows from liquid assets. It includes three elements:

1. defining which asset types remain liquid;
2. defining the market liquidity for those assets, that is, the loss in value (haircut) banks have to accept to sell the asset;
3. defining the portion of liquid assets that remains unencumbered (i.e., available for fire sales or to obtain secured funding). Given recent events and the increased importance of secured funding (e.g., repos and covered bonds), it is crucial to have information on the level of unencumbered liquid assets on the one hand and to make assumptions about their availability under stress on the other, to account for potential margin calls.\(^{17}\)

Haircuts should differentiate among asset categories, accounting for the level of stress simulated as well as the “quality” of assets (e.g., in case of debt securities, the type and rating of the counterparty). In any case, double counting should be avoided—(unencumbered) liquid assets can be used only to either generate cash or maintain the level of funding (as a substitute of encumbered assets used as collateral that have lost in value). Potential haircuts to be modeled comprise

1. haircuts for (unencumbered) liquid assets;
2. haircuts for encumbered liquid assets (i.e., collateral/margin calls); and
3. add-ons (positive haircut) for contingent liabilities. Deriving model-based haircuts requires a substantial commitment of time and resources but comes with the advantage of developing expert knowledge on the value of assets under stress.\(^{18}\)

Alternatively, stress testers can use supervisory haircuts under the (comprehensive) Standardized Approach for solvency purposes (BCBS, 2006, paragraph 147f). These haircuts constitute a proxy for the 99th confidence interval for different holding periods. The Basel III framework distinguishes between two levels of high-quality liquid assets (so-called flight-to-quality assets) and refers to factors that can be used to define whether funding remains liquid (BCBS, 2010).

\(^{15}\)See BCBS (2010) for further information.

\(^{16}\)The survey is based on responses by 30 European banks in 2008.

\(^{17}\)See BCBS (2010, paragraph 27).

\(^{18}\)Calculating the volatility of market prices of assets allows assigning probabilities for the occurrence of scenarios. A useful guideline on how to do so is provided in BCBS (2006, paragraph 156ff.).
Next-Generation Systemwide Liquidity Stress Testing

D. Link between liquidity and solvency

There have been some recent attempts to link solvency and liquidity risk. In particular, the link applies to (1) funding costs and (2) the closure of funding markets once solvency conditions deteriorate further. The link between solvency and funding costs consists of two dimensions: (1) an increase in the price to be paid for funding (e.g., wholesale funding is particularly sensitive to changes in solvency conditions, but the recent competition for retail deposits is an indication that retail deposits may also be more price sensitive going forward); and (2) an increase in collateral needs for secured funding sources (margin calls).

The price of funding can be derived on the basis of empirical evidence. One way is to use econometric models to determine 2010, paragraph 22f). Table 7.3 provides an overview of supervisory haircuts based on the Basel II solvency framework and the haircuts to be used for the Basel III liquidity tests. It is important to recognize that the purpose of the parameters is different—for solvency purposes, maturity is linked to the assets, while the maturity for liquidity purposes depends on the reference ratio (and the corresponding time frame). One can see, for example, that the LCR assumes substantial stress, with equities becoming illiquid. A more granular classification of marketable assets is the one by the ECB, which distinguishes among five categories (ECB, 2008b).

Reputational considerations, which featured prominently in the crisis, need to be built into the scenario assumptions. In particular, stress testers need to take into account contingent liabilities such as committed credit/liquidity lines to customers, sponsorships of Special Purpose Vehicles, and outflows related to derivatives (i.e., margin calls). This risk is particularly high under marketwide funding market dislocations. The LCR provides a valuable benchmark for contingent liabilities, including for derivatives.

As a general rule, stress tests should focus on the ability of banks to weather severe but plausible liquidity shocks as going concerns. That implies that the bank is able to maintain its franchise value. To do so, it needs to keep generating new business (i.e., roll over maturing assets) and honor its commitments, which is the underlying assumption under Basel III and also applied by banks (see Deutsche Bank, 2010, for example).

D. Link between liquidity and solvency

| TABLE 7.3 | Supervisory Haircuts Based on Solvency Regime and Basel III Liquidity Regime |
|---|---|---|---|
| (1) Unencumbered liquid assets | | | |
| | Cash | Issue rating for debt security | Residual maturity | Sovereign | Other issuers | Securitization | 0, includes also short-term securities (less than 1 year) |
| | | AAA to AA−/A−1 | < 1 year | 0.5 | 1 | 2 |
| | | | 1 to 5 years | 2 | 4 | 8 |
| | | | > 5 years | 4 | 8 | 16 |
| | | A+ to BBB− and unrated | < 1 year | 1 | 2 | 4 |
| | | | 1 to 5 years | 3 | 6 | 12 |
| | | | > 5 years | 6 | 12 | 24 |
| | | All | 15 | Not eligible | | |
| | Equity (main index) and gold | | | | | |
| | Other equity | | | | | |
| | Mutual funds (max of allowed asset mix) | | | | | |
| | | Up to 25 (highest haircut applicable to any security in the fund) | | | | |
| (2) Encumbered liquid assets (collateral) | | | |
| | N/A | | | | |
| (3) Add-ons (contingent liabilities) | | | |
| | N/A | | | | |

Note: LCR = liquidity coverage ratio; RW = ?
TABLE 7.4

Benchmark Scenarios

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Moderate Stress Scenario</th>
<th>Lehman-Type Stress Scenario (Medium)</th>
<th>Severe Stress Scenario</th>
<th>Very Severe Stress Scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquidity outflows</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Customer deposits (Term)</td>
<td>2.5 percent</td>
<td>5 percent</td>
<td>10 percent</td>
<td>20 percent</td>
</tr>
<tr>
<td>Customer deposits (Demand)</td>
<td>5 percent</td>
<td>10 percent</td>
<td>20 percent</td>
<td>40 percent</td>
</tr>
<tr>
<td>Wholesale funding</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Short-term (secured)</td>
<td>5 percent</td>
<td>10 percent</td>
<td>20 percent</td>
<td>40 percent</td>
</tr>
<tr>
<td>Short-term (unsecured)</td>
<td>15 percent</td>
<td>30 percent</td>
<td>60 percent</td>
<td>100 percent</td>
</tr>
<tr>
<td>Contingent liabilities</td>
<td>0 percent need funding</td>
<td>5 percent need funding</td>
<td>10 percent need funding</td>
<td>20 percent need funding</td>
</tr>
<tr>
<td>Liquidity inflows</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Haircut for cash</td>
<td>0 percent</td>
<td>0 percent</td>
<td>0 percent</td>
<td>0 percent</td>
</tr>
<tr>
<td>Haircut for government securities</td>
<td>1 percent</td>
<td>2 percent</td>
<td>5 percent</td>
<td>10 percent</td>
</tr>
<tr>
<td>Haircut for trading assets</td>
<td>3 percent</td>
<td>6 percent</td>
<td>30 percent</td>
<td>100 percent</td>
</tr>
<tr>
<td>Haircut for other securities</td>
<td>10 percent</td>
<td>30 percent</td>
<td>75 percent</td>
<td>100 percent</td>
</tr>
<tr>
<td>Percent of liquid assets encumbered</td>
<td>10 percent (or actual figure)</td>
<td>20 percent (or actual figure plus 10 ppt)</td>
<td>30 percent (or actual figures plus 20 ppt)</td>
<td>40 percent (or actual figures plus 30 ppt)</td>
</tr>
</tbody>
</table>

Source: Authors.

1. The Lehman-type scenario would correspond to a scenario encountered by banks that were hit severely during the 30-day period after the Lehman collapse, i.e., a stress situation within a stress period rather than an average. The scenario has been put together based on expert judgment, using evidence as available.

2. The haircut highly depends on the specific features of the government debt held (rating, maturity, market depth) and can be higher or lower. The figures displayed herein are meant for high-quality investment-grade bonds, taking into account recent market conditions. The same applies for the remainder of the liquid assets. For the securities in the trading book, it is assumed that they are liquidated earlier, resulting in lower haircuts. Benchmark haircuts (independent of in which book securities are held) for equities are 5 percent (moderate), 10 percent (Lehman), 25 percent (severe), and 100 percent (very severe). For bonds, the corresponding haircuts are 5 percent, 10 percent, 15 percent (but high-quality bonds remain liquid—see LCR definition), and 100 percent, respectively.

3. A haircut of 100 percent means that the asset is illiquid, i.e., the market has closed.

4. The figures account for a downgrade of the bank, which triggers margin calls, and higher collateral requirements more generally. Please note that the unencumbered portion applies to a gradually narrower definition of liquid assets.

mine the increase in funding costs (i.e., interest expense) on the liability side, while also accounting for the effect on earnings on the asset side (interest income). As an illustrative example, our tool uses the estimated nonlinear relationship between solvency (measured as economic capitalization) and funding costs for Germany, as presented in Schmieder, Hesse, and others (2011). Stress testers can make assumptions with respect to the portion of the increase in funding costs that can be passed on to customers, thereby reducing the severity of the scenario. The model should be recalibrated on the basis of country-specific circumstances, taking account of the portion of wholesale funding, the level of competition, and other relevant factors. Once market conditions deteriorate further, driven by general market conditions and/or idiosyncratic strains at single banks, funding markets will close.19

Our tool provides a template to simulate different scenarios with respect to funding costs on the one hand and the (partial) closure of funding sources on the other. It is essential to ensure that the calibration is adequate for the banks and/or system at hand, which remains at the discretion of the stress tester.

E. Liquidity stress test benchmark scenarios

In Table 7.4, we define severe benchmark scenarios that stress testers could refer to in order to simulate moderate, medium, severe, and very severe stress. The level of severity of stress is benchmarked to Lehman. Although the Lehman calibration is not to be understood as being scientific, it is meant to represent the situation of banks hit hard during the first month after the Lehman collapse, and, very important, it is intuitive. Accordingly, the moderate scenario is half of Lehman crisis conditions, whereas medium, severe, and very severe are one, two, and three times that of Lehman, respectively. As a caveat, it should be highlighted that the level of stress to be considered medium, for example, depends on the specific circumstances.20 We recommend running a series of stresses to assess the sensitivity of

---

19 The RAMSI model attempts to model the deterioration in various factors and to link it to the closure of funding markets in the United Kingdom (see Aikman and others, 2009).

20 “Moderate” is already a substantial stress event in terms of overall stress, but in some countries this could be rather “mild.”
systems, including reverse stress to test the threshold that systems can withstand, and to alter the runoff rates as applicable (e.g., by using higher runoff rates for retail deposits).

3. CONCLUSION

We have argued that liquidity risk has—unjustifiably—flown under the regulatory radar with the advent of the Basel I framework and its focus on bank capitalization. However, the fact that liquidity risk turned out to be one of the key threats to financial stability during the recent financial crisis has led to a reevaluation, with an emerging focus on liquidity in industry as well as regulatory circles, not least because of the ongoing challenges in this area. This study and its associated tool aim to provide stress testers with a flexible and easy-to-use platform to assess the liquidity situation of banks from different perspectives. The predefined tests can easily be adapted to bank-specific situations and/or specificities of banking systems (or an international sample of banks). A key objective is to strike a balance between data requirements and stress test sophistication, allowing for tests with parsimonious data on the one hand and more complex/demanding tests on the other.

Although the obvious way to stress test liquidity risk is the use of cash flow data, these are often not available (yet) at regulatory or supervisory institutions. One of the main contributions of this study consists of providing input templates for cash flow–based tests that could also serve as a first step toward full-fledged cash flow analysis based on regular data collection from banks by supervisors or regulators. Once available, the cash flow module allows the simulation of detailed funding structures of single banks, which would enable the stress tester to draw some broad conclusions for the system and potential contagion effects. In the latter case, liquidity monitoring (rather than stress testing) could be another focus. Moreover, our tool enables peer comparisons that should always play an important role for liquidity stress tests as they can readily reveal vulnerabilities.

Finally, our study contributes to existing work on liquidity by explicitly modeling the link to solvency stress (tests). Although this should not be misinterpreted as the ultimate solution to this highly complex problem, the inclusion of a module in the tool to analyze this link in an easy-to-use fashion should facilitate the practitioner’s work.

REFERENCES


