


African Department
Communications Department
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Stress Testing in Sub-Saharan Africa

Practices, Communications, and
Capacity Development

*Mindaugas Leika, Hector Perez-Saiz,
Olga Stankova, and Torsten Wezel*

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SPECIAL NOTE

As the COVID-19 pandemic unfolds, the economic consequences have been dire, and financial stability risks are rapidly rising. The pandemic is expected to have an adverse impact on banking systems across Sub-Saharan Africa, including increases in nonperforming loans and corresponding drops in bank profits and capital.

This Departmental Paper offers actionable advice tailored to the needs of the SSA countries, which is relevant and urgently needed during the ongoing crisis. It reviews and shares experiences in bank stress testing in the region, including on how to communicate the results. The paper is expected to help support essential economic and financial policy action to address the crisis and support the recovery in the period ahead.

Disclaimer:

This document was prepared before COVID-19 became a global pandemic and resulted in unprecedented economic strains. It, therefore, does not reflect the implications of these developments and related policy priorities. We direct you to the [IMF Covid-19 page](#) that includes staff recommendations with regard to the COVID-19 global outbreak.

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Stress Testing in Sub-Saharan Africa: Practices, Communications, and Capacity Development

Prepared by Mindaugas Leika, Hector Perez-Saiz,
Olga Stankova, and Torsten Wezel

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Executive Summary

Many authorities in sub-Saharan Africa have embraced stress testing—after initially lagging behind advanced economies—as an instrument to assess the resilience of their banking sectors, often facilitated by technical assistance from the IMF. Using a newly compiled database, this departmental paper takes stock of the evolving stress testing and communications practices at supervisory authorities, primarily central banks, in sub-Saharan Africa, as documented in authorities’ financial stability reports and other publications. Specifically, it surveys the types of risk assessment and stress tests that are conducted to assess the adequacy of banks’ buffers to confront credit, liquidity, market, and other banking risks. Specifically, the paper focuses on analyzing the authorities’ disclosure and communications approach to informing the public about stress test outcomes and illustrating how technical assistance has helped shaped stress testing and communications.

The paper finds that supervisory stress tests are conducted in more than half of sub-Saharan African countries, particularly in western and southern Africa, and that the number of individual stress tests has grown exponentially since the early 2010s. By contrast, few central banks publish assessments of macro-financial linkages; the focus leans more toward discussing trends and weaknesses within the financial sector than on outside risks that may negatively affect its performance. Most countries assess credit and liquidity risks, typically using straightforward sensitivity analyses based on shock sizes generally in line with historical events, except for a few countries applying lower stress to credit quality (that is, increases in the stock of nonperforming loans) than past crisis episodes would suggest. In doing so, few countries change the shock size over time. Analysis of market risk (that is, interest rate and exchange rate risk) and operational risk are found to be less common in sub-Saharan African countries. The paper recommends that all countries run some form of stress test regardless of the state of financial development and

provides examples of good practices in analyzing macro-financial and banking sector risks as well as examples of quality disclosure of stress test outcomes.

Following a brief discussion as to why a strategy for communicating stress tests is critical, the paper proceeds to assess the quality of stress test disclosure. It finds that, analogously to coverage across countries, the detail of communications of stress tests for credit and liquidity risk is greater than for market risk and macro-financial risk assessment, albeit with wide variations across countries in each assessment category. Among potential drivers of stress-test disclosure, a regression analysis finds that financial deepening (as measured by the credit to GDP ratio) has a significantly positive effect on developing stress test frameworks and publishing them, whereas no such effect was found for other variables (size of the economy (using GDP), economic development (GDP per capita), financial account openness or exchange rate regime). Based on this finding, the paper concludes that the authorities' disclosure and communications approach should consider the state of financial market development and literacy as well as authorities' communications capacity, which may suggest limited or more aggregated disclosure of stress test outcomes where constraints still exist. In the event, the decision as to whether and what level of detail to publish should also take the severity of financial stability risks revealed by the stress tests into account.

Taking stock of IMF technical assistance for stress testing since 2003, the paper finds that most recipient authorities asked for help with adopting or further extending the stress testing tool for their own reporting, as well as help with designing stress test scenarios and creating satellite models given their lack of specific expertise. In the process of delivery, many technical assistance missions found a lack of detailed data inhibiting more sophisticated stress testing as well as issues with the quality of existing data quality, particularly consistency of reported data. In addition, missions found methodological and institutional shortcomings, such as insufficient differentiation of stress test scenarios or their formulation without management involvement, infrequent updating of models, and lack of use of stress test results as an early warning instrument to address credit and liquidity risks in a risk-based supervisory process. The paper also gives a recent example of IMF technical assistance for strengthening communications capacity, notably in financial stability communications. High demand for IMF technical will likely continue for the remaining sub-Saharan African countries striving to adopt stress testing and for those already conducting stress testing and aiming to upgrade their approaches.

Introduction

Spurred by the global financial crisis, stress testing has become an integral part of financial stability frameworks. Stress tests permit simulating the likely impact of assumed adverse economic and financial conditions on the viability of financial sector entities, particularly commercial banks. International organizations such as the IMF, World Bank, and Bank for International Settlements have put out guidance on principles and best practices in stress testing. For example, the Basel Committee for Banking Supervision (BCBS 2018) published updated stress testing principles that give guidance to banks and supervisory authorities alike on essential aspects such as stress test objectives, use of stress tests as risk management tool in the supervisory process, comprehensive assessment of banking sector risks in stress tests, periodic review of the appropriateness of stress test models, and proper communication of stress tests and outcomes.

Stress testing in sub-Saharan Africa (SSA) initially lagged behind more advanced economies. Possible reasons for this include authorities' data and capacity constraints, the prevalence of hard-to-model idiosyncratic shocks (for example, governance slippages), and a lower degree of banking system sophistication that may have given the impression of limited vulnerabilities. Even so, with the global financial crisis affecting SSA economies and banking systems, SSA authorities have increasingly embraced stress testing as an essential tool to assess banking sector resilience and frequently report stress test outcomes to the public, for example, in financial stability reports (FSRs).

This paper takes stock of the evolving stress testing and communications practices at supervisory authorities in SSA. To our knowledge, this is the first paper compiling and analyzing information on authorities' stress testing efforts in SSA. Specifically, the paper surveys what types of risk assessment and stress tests are conducted by SSA supervisory authorities and investigates whether the severity of the tests is appropriate given historical shocks

to credit quality and funding in each country and whether authorities have changed the shock sizes over time. The paper analyzes the disclosure and communications approach of authorities in informing the public about stress test outcomes, and gives broad recommendations as to what type of country should disclose such information, depending on the sophistication of financial markets, official communications, and the media. The authors employ econometric analysis to ascertain whether the economic and financial development of countries help explain whether they run and publish stress tests. Finally, the paper sheds light on technical assistance (TA) for stress testing by the IMF and the data, methodological, and institutional challenges encountered in the process. The paper does not cover stress testing for risks at nonbank financial institutions nor does it survey SSA banks' own approaches to risk assessment and stress testing that have emerged, particularly at some global and pan-African banks.

A primary finding of the paper is that more-developed financial sectors tend to have more complex and comprehensive stress testing frameworks and communications strategies. Specifically, we show that the propensity to engage in and report on stress tests in SSA countries hinges on financial development. From this we conclude that the disclosure and communications approach should consider the state of financial market development and literacy as well as authorities' communications capacity, which may imply limited or more aggregated disclosure of stress test outcomes where constraints still exist. Another finding is that the size of assumed shocks to nonperforming loans (NPLs) and liquidity differs greatly across countries. The shocks are largely in line with historical experience, although they rarely change over time.

The adoption of stress testing in SSA countries has been facilitated by TA and guidance by international organizations. Surveying IMF TA for stress testing, we find that it has helped overcome technical and institutional constraints, enabling authorities to develop or refine stress tests of differing complexity—at all levels of financial development. We conclude from this review, however, that more sophisticated stress testing approaches should be employed only by authorities that have managed to address, including with IMF assistance, a range of data and methodological issues that we find are common in the region.

The remainder of the paper is structured as follows. Chapter 2 investigates the analytical coverage of macro-financial risks, bank vulnerabilities, and stress testing for a variety of banking risks. Chapter 3 analyses SSA authorities' approaches to disclosing and communicating stress test results in official publications. Chapter 4 examines the role of technical assistance in establishing stress testing frameworks and discusses salient data, methodological, and institutional issues to be addressed when implementing stress testing. Chapter 5 provides conclusions and an outlook on further development of stress testing in SSA.

2 Coverage, Methodology, and Outcomes of Stress Tests

Overview of Stress Testing Practices and Macro-Financial Risk Assessment

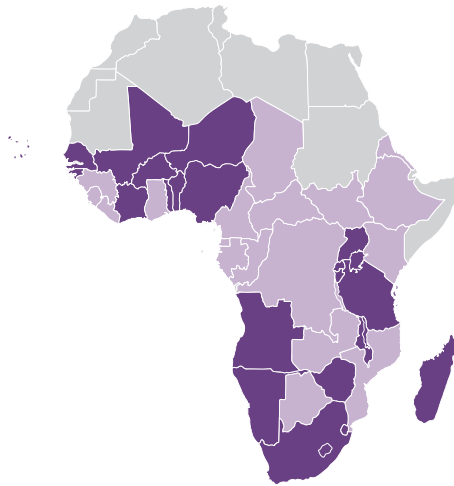
Stress tests should ideally be grounded in proper identification and assessment of macro-financial risks, although many SSA countries opt for ad hoc single-factor shocks. Such assessment can be instrumental in identifying risk drivers, determining the coverage of stress tests, and designing scenarios. Perhaps owing to the predominant use of ad hoc shocks, only a limited number of supervisory agencies discuss and appraise domestic and external risks facing the banking sector as well as the transmission channels through which such risks may impact the banks. Similarly, few go beyond presenting developments in financial soundness indicators and actually assess structural banking sector vulnerabilities that may amplify outside shocks and impair the provision of bank credit, thereby possibly creating a negative feedback loop onto the real economy.

We have conducted a survey of authorities' publications aiming to shed light on current and emerging best practices in macro-financial risk assessment and stress testing. To this end, we have compiled information in these thematic areas from central banks' publicly available documents, i.e., primarily financial stability reports¹ and, in a few cases, annual reports and banking supervision reports. The latest-available documents were in most cases published during 2017–18 (a few in 2016).² At the time, 24 out of the 45

¹About one-third of SSA countries routinely publish financial stability reports, most of which feature a section on stress testing. A few other countries publish banking supervision reports instead.

²The data collection cut-off date was March 31, 2019. The information on the stress tests of the West African Economic and Monetary Union (WAEMU) countries was obtained from a recent IMF publication (IMF 2018b). Despite being conducted centrally by the regional central bank (Central Bank of West African States—BCEAO), our analysis treats the stress tests as though they were conducted by the individual country authorities that effectively delegated this task to the BCEAO.

**Figure 1. SSA Countries Publishing Stress Test Results
(2017–2018)**



Source: Authors.

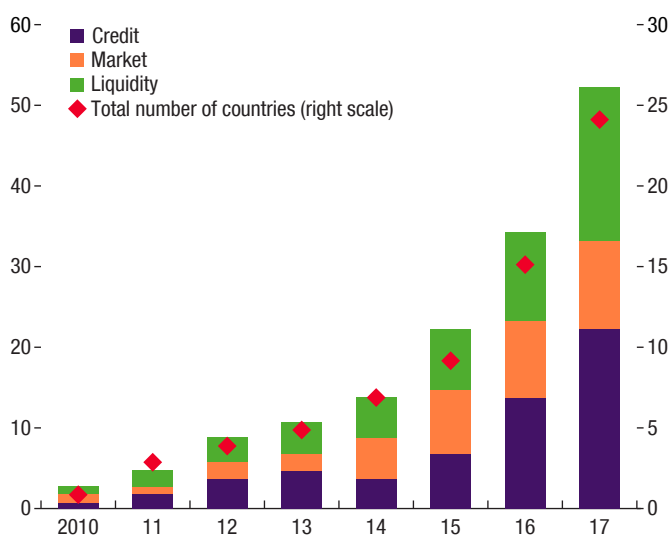
SSA countries published stress test results. Figure 1 shows the geographic distribution of these countries, indicating relatively strong disclosure in western and southern Africa.³

The survey also indicates that SSA authorities started adopting stress testing and reporting on it in the early 2010s. As Figure 2 shows, the number of countries running *and* publishing stress tests has more than quadrupled since the early part of the decade, and the total number of stress tests for credit, market, and liquidity risks has grown exponentially to about 50 in 2017.⁴ This number exceeds the total number of countries publishing stress tests as many countries run multiple tests (for credit, market, and liquidity risk). All tests are “top-down,” i.e., run by the supervisory agency, with one country (South Africa) also requiring “bottom-up” tests to be run by the banks. It is important to emphasize that we rely only on published information in assessing where and how risk analysis and stress testing are performed. This implies that we may inadvertently omit some authorities’ activities in cases where they are not disclosed in official publications. In a few cases, anecdotal information about purely internal use of stress tests (with no publication) that IMF country teams happened to obtain was taken into account as well.

³Not visible on the map are three island economies that publish stress tests: Cabo Verde, Mauritius, and São Tomé and Príncipe.

⁴We assume that the countries whose latest publication was in 2016 continued to do stress testing in 2017 and beyond.

**Figure 2. Publication of Stress Test Results:
Number of Countries, Stress Tests by Type of Test**



Source: Authors' calculations.

As part of this survey effort, we also compiled information on stress test communications practices (Chapter 3) and IMF technical assistance delivered (Chapter 4). This part of the database includes information gathered from publications and websites of central banks regarding disclosure and public communications practices in stress testing. To round off the picture, we added to the database IMF-internal information on technical assistance for stress testing. We have been able to find detailed information for all 45 countries in SSA.

Although identifying the stress test communications approaches through external sources is quite easy, finding evidence on undisclosed frameworks is more challenging. Some central banks may develop internal stress tests and choose not to disclose any results, even informally or through a press release. Therefore, in about one-third of the countries, we could not confirm that any stress testing was being conducted (see Table 1).⁵ In terms of stress test communications, in slightly more than half of the countries stress tests are disclosed in publicly accessible documents. Also, more than half of the countries have received technical assistance on stress testing and three-fourths of those do conduct stress tests. However, more than one-third of TA recipients do not communicate stress test endeavors, and this includes some country cases of stress tests being conducted without disclosure of results.

⁵However, there is anecdotal evidence that some countries are preparing for stress testing.

Table 1. Categorization of Publication Practices and Technical Assistance Received

| Stress Test | Stress Test Published | Technical Assistance Received | Number of countries |
|-------------|-----------------------|-------------------------------|---------------------|
| Yes | Yes | Yes | 16 |
| Yes | Yes | No | 8 |
| Yes | No | Yes | 4 |
| Yes | No | No | 0 |
| Unknown | No | Yes | 6 |
| Unknown | No | No | 11 |
| | | | 45 |

Sources: Central banks' publications; and authors' calculations.

Stress tests in SSA nearly always take a purely national perspective, whereas a regional approach would arguably be more appropriate in some instances. Stress tests assess the viability of banks as though none of them had any cross-border linkages. Particularly in the case of regional or pan-African banks this approach may not allow for a correct assessment of the health of a banking group when its subsidiaries in different countries show a varied performance, and it remains unclear whether there could be spillovers from poorly performing subsidiaries to the holding company (e.g., the need to recapitalize subsidiaries) and indirectly to other parts of the group in case of lack of resources. Stress test conducted at the individual country level are unlikely to capture such spillovers adequately. For this reason, the IMF (2015) has called for establishing a Pan-African Bank Supervisory Oversight Committee comprised of regional and larger national central banks to conduct a periodic assessment of such spillovers, including by stress testing, that the emergence of pan-African banks has brought about.

Macro-Financial Linkages

The analysis of macro-financial linkages has been mainstreamed in IMF surveillance and would also benefit authorities' stress testing exercises. During a two-year pilot phase, IMF staff sought to "articulate the role of the financial sector in the macroeconomic baseline, and to integrate the financial sector into the risk assessment, taking into account both the impact of macro shocks on the financial sector as well as the effect of financial shocks on macroeconomic stability" (IMF 2017). Now the analysis of such macro-financial linkages is common practice in IMF surveillance, but it would also benefit authorities embarking on stress testing exercises. As mentioned previously, identification of risks is critical for the calibration of risk factors, shock sizes, and scenario design. While sensitivity analyses may be formulated ad hoc and without prior risk assessment, macro-financial risk assessment sharpens the view for risk drivers to be accounted for when designing stress tests for various banking sector risks. Even authorities not yet performing stress tests may consider macro-financial assessment a useful analytical tool to evaluate risks facing the banking sector.

Few supervisory authorities in SSA publish macro-financial risk assessments. The focus in central bank publications is clearly on discussing trends and weaknesses within the financial sector and not on outside risks which may negatively affect its performance. Yet a number of countries provide information about such risks in sufficient detail (even using a risk assessment matrix [South Africa] or a spider web [Eswatini]):⁶

- *Real sector risks* include excessive credit risk among borrowers (including over-indebtedness of corporates and households), exposure to volatile oil/gas producers and service providers of natural resources, and generally slower domestic growth (Kenya, Mauritius, Nigeria, South Africa).
- *External risks* are cited by authorities in Malawi, Mauritius, Namibia, Rwanda, South Africa, and Uganda (for example, risk of capital outflows, higher international interest rates, lower exports, rising oil prices) as affecting domestic liquidity conditions, credit growth, and asset quality.
- *Fiscal risks* include widening sovereign spreads, crowding out effects from delayed fiscal adjustment, and government arrears that impact on banking funding and credit are mentioned by a few countries (Kenya, Rwanda).
- *Monetary policy risks* include changes in the monetary policy stance that ultimately lead to narrowing bank interest margins or higher loan interest rates (Rwanda, Seychelles, Uganda).

Banking Sector Vulnerabilities

The impact of adverse macro-financial linkages can be compounded by weaknesses in the banking sector, which requires analysis of the underlying banking risks. If banks already in distress are hit by a shock originating in the real, monetary, or fiscal sector, their reaction may be more pronounced than when enjoying ample buffers. For example, illiquid and/or ill-capitalized banks may restrict credit origination in an effort to de-risk and rebuild their balance sheets, while sound banks can draw on existing buffers to maintain a healthy flow of credit to the economy. To correctly gauge the impact of macro-financial risks, it is therefore necessary to identify and assess existing weaknesses in the banking sector.

Analysis of banking sector performance and weaknesses figures quite prominently in authorities' publications. The majority of SSA supervisory authorities discuss banking sector performance. However, fewer go beyond a mere discussion of the evolution of common financial soundness indicators and

⁶There may be other risks worth assessing. For example, banks in some countries have had to cope with what could be called regulatory risk (for example, Kenya—interest rate controls that meanwhile have been lifted; Nigeria—requirement of a minimum loan-to-funding ratio introduced in mid-2019) considering that certain forms of financial repression can have a significant impact on both the banking sector and the real sector (see, for example, Alper and others 2019 or Jafarov, Maino, and Pani 2019).

indeed flag certain features as representing elevated risks in the banking sector and causing vulnerabilities. Authorities' publications mention a wide range of banking sector weaknesses that subsequently can be assessed further in stress tests:

- *Asset quality* issues are mentioned and assessed almost everywhere, notably elevated NPLs and write-offs as well as high credit concentration.
- *Low solvency/profitability* is flagged as a concern in countries where banks' capital buffers are thin and operational efficiency is weak.
- *Liquidity and funding* issues are often cited, particularly lack of longer-term funding obstructing credit origination or leading to maturity mismatches as well as high deposit concentration.
- *Market risk* mostly reflects unbalanced foreign currency exposures (large net open FX position) causing valuation losses in case of exchange rate swings.
- *Other risks* mentioned include cyclical risks (measured by macroprudential indicators such as the credit-to-GDP gap, loan-to-deposit ratio, household debt indicators—Lesotho, South Africa, Tanzania), strong market concentration with a few banks dominating the system (Nigeria), contagion risks from interconnected banks (Madagascar), and the emergence of cybersecurity risks (Kenya, South Africa).

Credit Risk

Within the stress test sphere, credit risk analysis is the most common type of assessment in SSA, including for credit concentration, which is a major risk for SSA banks. Of the 24 SSA jurisdictions that published stress test results through March 31, 2019 (cut-off date), all but one run tests for credit risk in some form, although a few do not specify the size of the NPL shock. Of the countries reporting stress test results, a majority (17) also assess the impact of so-called name concentration, that is, the impact of a deterioration in exposures to the very largest clients. Such credit concentration risk is not unique to SSA countries but is particularly pronounced in the region. It arises from the lack of economic diversification and large informal sectors, inevitably causing banks to focus lending on only a few sectors and corporations (for example, in the WAEMU region the 50 largest companies account for one-third of total bank credit; see Imam and Kolerus 2013). In the same vein, a few countries gauge banks' sectoral concentration, for example, by assuming differentiated loan default rates.

General Credit Risk

Many SSA countries employ a simple, Excel-based stress testing tool to calculate shocks to NPLs and subsequent impact on capital adequacy of banks,

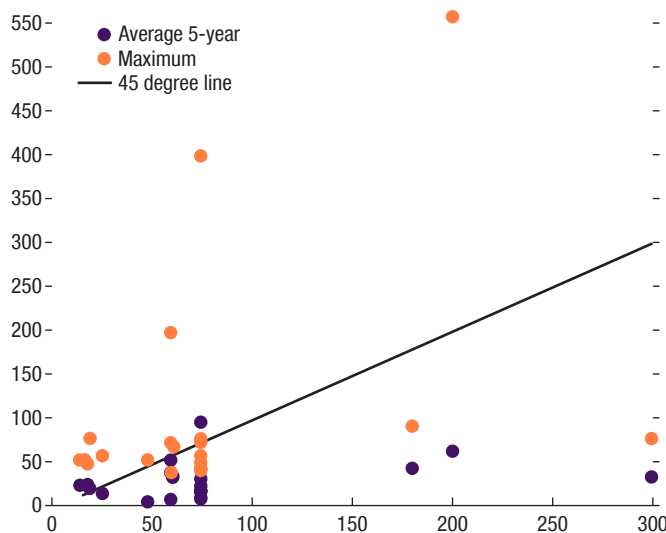
typically in a one-period setup. Countries typically rely on either the original or modified version of the IMF Stress Tester (see Čihák 2007). The Excel file accompanying that working paper has a simple one-period structure that is based on an accounting approach, that is, it does not distinguish between exposure classes (regulatory definition) and asset categories (accounting definition). As a result, it does not allow to model changes in risk-weighted assets (RWAs). Thus, it is most appropriate for financial systems that apply the Basel I or Basel II Standardized Approach to calculation of capital requirements. The tool incorporates solvency, liquidity, and interbank contagion risk analysis.⁷ SSA countries typically asked for help with RWAs calculations, making the tool multi-period, adding a more granular calculation of market risk (especially exposures to sovereign bonds) and a more granular decomposition of various profit-and-loss items.

Most authorities apply ad hoc shocks to the stock of existing NPLs or assume the migration of a share of performing loans to NPLs. The most common form of assumption is an outright percentage increase in the amount of NPLs (occasionally, differentiated by economic sector—for example, Cabo Verde, Malawi) and often with multiple scenarios of increasing severity. Less common is an assumed transition of a certain percentage of performing loans to NPL status (for example, Madagascar, Tanzania). Some authorities apply both approaches under separate scenarios (for example, WAEMU countries) or both a transition of performing to nonperforming status and higher provisioning on existing NPLs in the same scenario (Madagascar). Many of the countries employing outright increases in NPLs have less-developed financial systems.

A few countries feature special approaches such as macro modelling, reverse stress testing, and multi-factor tests. South Africa and Mauritius have developed macro/satellite models whereby shocks to macro-financial variables impact on loan quality in baseline and stress scenarios, underscoring the presumption that countries with more-advanced financial systems also tend to employ more-advanced stress testing techniques. Eswatini and Uganda apply a “reverse stress test” (see Ong, Maino, and Duma 2010) that computes the NPL stock, notably the transition rate of performing to nonperforming status, that would make the first bank fail the minimum capital requirement. A few countries (for example, Madagascar and Malawi) run multi-factor tests that combine several risks (credit, interest, foreign exchange, and income shocks) to estimate the aggregate impact of worsening economic and financial conditions on bank capitalization.

⁷The tool allows ranking banks by key factors (for example, capital, profitability, loan quality) and performs simple sensitivity tests or more-advanced analysis (for example, NPL prediction by satellite models to be developed outside the tool). The latest version allows users to compare supervisors’ top-down stress tests to banks’ own bottom-up tests.

Figure 3. Assumed and Historic Shocks to NPLs
(Percent of total NPLs)

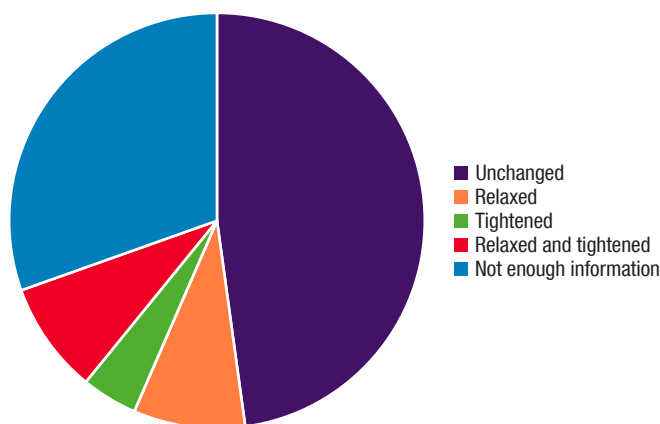


Source: Authors' calculations.
Note: NPLs = nonperforming loans.

The selected size of the shocks to NPLs tends to exceed historical averages but occasionally falls short of the most severe shocks in the past. Stress test scenarios should feature shocks that are “extreme but plausible.” As Figure 3 illustrates, the most-severe shocks assumed may appear plausible from the recent past but fall arguably short of being extreme. Specifically, the assumed percentage hikes in NPLs (of stocks, not of ratios) exceeds the average five-year change in most cases. The reverse tends to be true in relation to the maximum shock that depicts the largest one-period increase in NPLs as far back as 2006. In a few cases, the most-extreme shock was a multiple of the shock assumed in the stress test.⁸ To be sure, in cases where NPL stocks are already high, a relatively small additional shock may be warranted. Only a few countries (for example, Rwanda) explicitly link the size of the assumed shock to shocks experienced in the past.

Only a few countries have varied the size of shocks over time (Figure 4). Nearly half of the countries kept the shock sizes identical in terms of the shock applied to the NPL stock or ratio at each time, which may imply a somewhat stronger (weaker) shock in absolute terms if the stock increased

⁸However, for all but one WAEMU country the assumed extreme shock of an increase in NPLs of 75 percent exceeds the highest-recorded increase since the mid-2000s.

Figure 4. Change in Size of Shocks to NPLs

Source: Authors' calculations.
 Note: NPLs = nonperforming loans.

(decreased) in the meantime.⁹ Only five of the 24 countries both running and publishing stress tests changed the size of any of the shocks over time (mostly in credit risk stress testing, but also in market and liquidity risk testing, where applicable).¹⁰ Interestingly, only one country tightened the stance, while the other four either relaxed the assumptions or both tightened and relaxed over time. For the remaining countries, the available evidence was inconclusive (for example, only one observation, shocks not comparable, reverse stress tests).

Although shock sizes are usually published, the assumptions on the provisioning of additional NPLs are often not disclosed or motivated. Many authorities stop short of disclosing the provisioning rate applied or simply assume a rate without discussing its appropriateness in relation to current provisioning (coverage ratio) or prospective needs considering information on the loss given default (LGD).¹¹ Some authorities simply choose full provisioning, which is prudent but likely to overestimate the actual provisioning need.

⁹To be sure, this includes the eight WAEMU countries where the latest stress test exercise used the same shocks as the one in 2017. If excluding the WAEMU region from the calculation, the share of countries that adjusted the shock size rises to one-third.

¹⁰An easing of shock sizes that, as argued before, may be warranted occurred, for example, in Namibia that entered into recession in 2017. The central bank then relaxed the assumptions for the risk parameters for credit and market risk in 2018–19, while tightening those for liquidity risk slightly.

¹¹In countries with a loan classification system distinguishing different NPL categories, an assumption would have to be made about the categorization of the additional NPLs (for example, substandard loans often require a provision of about 25 percent, whereas defaulted/loss loans call for full provisioning). A shorthand method to circumvent this question is to apply the average ratio of specific provisions to NPLs (coverage ratio) or link the provisioning rate to the LGD in case such information is available.

Only two countries (Malawi, Madagascar) assume different provisioning rates under a moderate and a more severe stress scenario.

Disaggregation of results of credit risk tests differs across countries. In addition to overall outcome at the system level, about three-fourths of countries also provide disaggregated results in different ways. Some authorities disclose the number of banks failing the test (that is, becoming undercapitalized), occasionally grouped by size. In some cases, the combined market share of those banks or total capital shortfall is also published. The remaining countries either do not quantify results at all or report aggregated results only at the system level.

Credit Concentration Risk

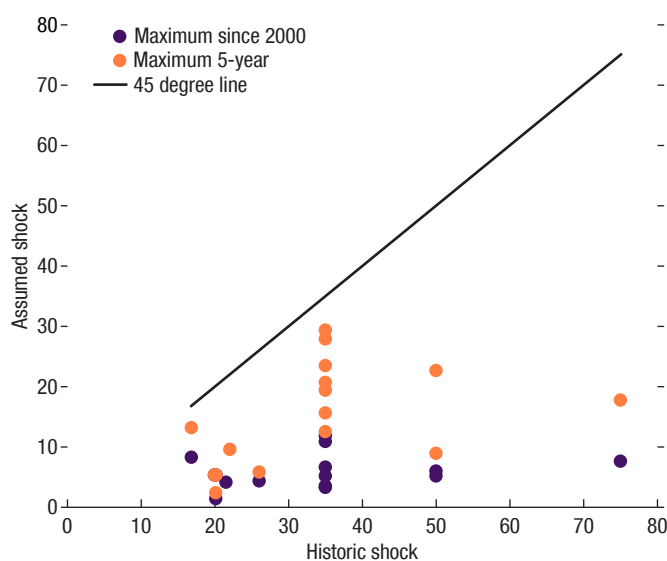
Stress tests for credit concentration are common and the design quite similar across countries. Two-thirds of the countries running a credit risk stress test also assess credit concentration risk. The typical concentration test contemplates the deterioration or default of the largest one to five exposures that, coupled with an implicit or explicit assumption about provisioning, has an ad hoc impact on bank capital. As with general credit risk, Eswatini administers a reverse stress test also for default of the largest borrowers. A special case is a test for sectoral concentration risk, with a few countries (Nigeria, South Africa) shocking exposures to specific sectors or type of firms (oil and gas sector, state-owned enterprises).

All countries running credit concentration stress tests also disclose disaggregated results. As with general credit risk, disclosure typically includes either the number of banks failing the test or the finding that only small banks (or in one case, a systemic bank) would become non-compliant.

Liquidity Risk

Liquidity stress testing is as commonplace as testing for credit risk and ordinarily involves a direct shock to deposits. The same number of countries running credit risk stress tests also check banks' resilience to sudden withdrawal of funding (demand, time, and savings deposits) and sometimes coupled with other liquidity risks (for example, haircuts due to asset encumbrance). Most countries apply single-factor shocks to deposits such as a cumulative outflow within a typical time horizon of five days, often with different shock sizes. Banks need to be able to meet such assumed outflows by drawing on their liquid assets, a certain minimum level of which is typically required by regulation.

Figure 5. Assumed and Historic Shock to Deposits
(Percent of total deposits)



mum month-on-month percentage drop since 2000 and the highest outflow rate during the previous five years (typically, 2012–16)—in several cases by a wide margin. A few countries, intentionally or inadvertently, do not report the size of the shock despite disclosing the methodology and outcome in much detail.

Most countries provide detailed bank-by-bank results of the liquidity test as well. The number of banks failing the minimum liquidity requirement during the duration of the deposit run is reported, including the increment for each day in some cases. As opposed to the solvency tests, hardly any countries report results only at the system level or not at all.

Market Risk

About one-fourth of SSA countries run stress tests for market risk, comprising interest rate risk and foreign currency risk. The seemingly lower importance of these risks may be owed to exchange rate pegs, passive monetary policy, or lack of integration with international financial markets, making the transmission of such risks less relevant. Results are sometimes withheld or not disaggregated.

Interest Rate Risk

There are different approaches to stress testing for interest rate risk across SSA countries. Some authorities impose an outright shock on net interest income (and non-interest income in single cases), others assume a rise in funding costs or perform a more detailed stress test using gap analysis with several maturity buckets (typically ranging from one or three months to three years—Namibia, Nigeria, Tanzania). Still others evaluate the impact of changes in interest rates on bond holdings (and of equity prices on stocks) in the trading book.

Exchange Rate Risk

The risk of exchange rate swings is assessed quite uniformly, but essential information is not reported. Most authorities performing such tests assume a depreciation of the national currency against the US dollar and other world currencies; in single cases (for example, Burundi), the impact of an assumed depreciation on credit quality is assessed (“indirect credit risk”). It is noteworthy that about three-fourths of countries running FX stress tests have a non-floating exchange rate (that is, managed/stabilized arrangements or currency pegs), which is sensible as a possible sudden exchange rate adjustment

is likely to have sizable balance sheet effects for banks and their clients. However, it is generally not clear what asset and liability positions are subjected to the FX shock or whether banks' net open position as such is shocked. Similarly, the transmission mechanism through which the shocks is translated into changes in capital is not disclosed in most cases.

Other Risks

A few SSA countries also test for other banking risks, including operational risk. More traditional tests include interbank market contagion risk (Nigeria) or tests for cross-border risks involving defaults of exposures abroad (Angola, Madagascar), but authorities also assess operational risks nowadays. For example, Madagascar gauges the impact of the destruction of a share of financial assets on bank capital, while South Africa evaluates the implications of cyber risks on the banking sector. Interestingly, sovereign risk embedded in banks' holdings of government bonds is not analyzed at all, even though the strong reliance on such investments does pose considerable risk in many cases.

Recommendations and Examples of Good Practices

Stress testing should be conducted by all countries, even if only for internal purposes, regardless of the state of financial sector development. It is important to simulate the effect of potential adverse shocks, as identified by a macro-financial risk assessment, on the banking sector regardless of the level of financial development, since balance sheet effects and banks' effort to de-risk may disrupt the flow of credit to the economy in any case. Obviously, authorities in more-developed financial systems may want to run more refined tests to account for the scope and intensity of the risks that these systems harbor, whereas less-complex systems may warrant a simpler sensitivity analysis as presented above.

Although analytical approaches differ in scope and rigor, some countries are headed toward defining best practices. There are notable country examples of comprehensive analysis of macro-financial and systemic risks, and of exemplary stress test disclosure that deserve mentioning:

- *Macro-financial risk analysis.* In *Eswatini*, a spider web chart visualizes key risks in seven categories that are identified as posing a threat to financial stability (external, domestic, household debt, corporate sector, banking sector, payment systems, and nonbanks). *Namibia* is a prime example of a detailed macro-financial assessment, notably the impact of external developments on the banking sector (for example, the tightening of monetary policy in neighboring South Africa leading to higher domestic interest

rates and ultimately higher NPLs). *Rwanda's* 2016–17 FSR¹³ featured specifically a detailed macro-financial analysis in a separate box discussing possible external shocks (export price decline and capital flow reversal) and domestic shocks (government arrears and continued low interest rates) and their likely impact on the banking sector. *South Africa* uses a proper risk assessment matrix for flagging conceivable shocks (for example, lower global and domestic growth, and tighter financial conditions) as a starting point for an extensive macro-financial assessment.

- *Analysis of bank vulnerabilities/systemic risks.* The *Cabo Verde* FSR flags specific systemic risks such as maturity mismatches as well as large deposit and credit concentration and also performs a peer comparison to similar island economies in the region. *Lesotho* and *Tanzania* assess systemic risks via indicators (credit-to-GDP gap, loan-to-deposit ratio, Herfindahl-Hirshman Index for cyclical/credit (concentration) risk; net open position in foreign currency for exchange rate risk; and several liquidity indicators for funding risk). *Uganda* provides a detailed analysis of bank-specific systemic risks, covering credit risk (credit growth, loan write-offs), liquidity risk, market risk (currency depreciation, low interest-rate environment), asset concentration risk, and exposure to nonresident banks.
- *Quality of stress test disclosure.* *Malawi* is an example of a smaller country with a detailed disclosure of stress test results. The analysis includes several credit risk scenarios with the number of banks that fail the test, sensitivity analysis of different market risks (interest income and foreign currency shocks), and detailed funding shocks (deposit withdrawals and haircut on liquid assets). In *Nigeria*, the impact of moderate and severe stress test scenarios each for credit, credit concentration, sectoral (oil and gas), interest rate, and liquidity risk on banks' capital adequacy ratios are presented both at the system level and broken down by size of bank. *Lesotho*, *Madagascar*, *Malawi*, and *Namibia* are among the countries that explicitly mention the provisioning rate assumed for additional NPLs under stress.

¹³National Bank of Rwanda (2017).

Disclosure, Transparency, and Communication of Stress Test Results

Overview and Definitions

Disclosing and communicating stress test results—if handled skillfully—can reduce risks to financial stability. Public disclosure can help maintain, or restore, confidence in the banking system, especially if accompanied by corrective action to address the problems uncovered. However, disclosure can be destabilizing, if the stress tests results show unexpected serious vulnerabilities in systemically important banks or the banking system as a whole, especially if disclosure is not accompanied by sufficient corrective action or backstops. Finding the right degree of transparency and proactively communicating policy messages requires careful consideration and skill.

The terms disclosure, transparency, and communications are often used interchangeably, but in fact their meanings differ somewhat:

- *Disclosure* means simply making information available to the public, for example by publishing reports or data on the website.
- *Transparency* refers to the amount and detail of information disclosed, relative to the overall information available to the policy institution.
- *Communications* encompasses disclosure but goes beyond it to more proactively and strategically send specific messages, for example to shape the public's view or expectations in a way that helps to accomplish the policy objectives. The means of proactive communications include press releases, press conferences, social media outreach, and others.¹

¹The IMF, for example, has a transparency policy and a communications strategy. The transparency policy determines which documents will be disclosed to the public and when, and their degree of transparency. The IMF's communications strategy sets out broad objectives and principles for the IMF's external and internal communications. It seeks to ensure, among other things, that communications are appropriately planned, coordinated, and consistent, and that IMF policies and advice are understood by the public. The transparency policy and the communications strategy are periodically reviewed by the IMF Executive Board and published.

Table 2. Simple Typology of Stress Test Publications

| | Disclosure | Transparency | Communications |
|---|--|--|--|
| Dedicated Stress Testing Publication | Factual information is provided about stress test methodology and outcomes. Past policy actions are reported. | The choice of degree of transparency balances different objectives. For example, while informing the markets and public about the vulnerabilities uncovered, avoid triggering turbulence or otherwise disrupting the banking system. | Proactive communications, including press releases, press conferences, and interviews, provide explanations of the outcome of the stress tests to a wider audience and build public support for policy decisions. |
| Publication as Part of FSR | Factual information on stress tests is presented in a broader context of recent developments in financial stability. The emphasis may be on stress tests or on other risks to financial stability. Past policy actions are reported. | | Proactive communications explain the stress tests to a wider audience in a broader context of recent developments in financial stability. Communications explain how policy decisions help maintain or restore financial stability aiming to build public support for policy action. |

Source: IMF staff.

Note: FSR = financial stability report.

Depending on the context and objectives, various combinations of disclosure, transparency, and communications are available for use by the authorities (Table 2).

Trade-Offs in Communicating Stress Tests

Some research has somewhat challenged the generally held view that more transparency in financial systems allows improving market discipline and efficiency. Although better-informed investors can better monitor banks, which may become more prudent in their risk-taking behavior, there may be important associated costs (Landier and Thesmar 2011). For instance, public information could crowd out private incentives to acquire information or may reinforce coordination failures and generate self-fulfilling equilibria. These trade-offs have led to proposals for optimum levels of transparency (see Bouvard, Chaigneau, and De Motta 2015).

Regarding the communications of stress test results, the possible negative effects of too much transparency may require well-designed supervisory strategies. For instance, it is theoretically possible that too much transparency by banks alleviates uncertainty in the market, thereby reducing the incentives to use financial instruments for risk sharing and containing risks. Also, banks could act strategically and choose to hold portfolios that are suboptimal but apt to pass the stress test. Furthermore, disclosure of stress test results could reduce the traders' incentives to gather information on banks which might make market prices less informative (see argument by Goldstein and Sapra 2014). If the possibility of such negative effects is perceived, bank supervisors can attenuate them by choosing to disclose in times of financial stress only, providing information on an aggregate basis, or providing it only on issues about which market participants are not well informed.

In practice, however, such theoretical concerns have not discouraged most supervisory authorities from communicating stress test results, albeit often only at the system level. Among supervisory agencies around the globe, a broad range of practices have been developed for public disclosure of stress testing results. A recent survey of the BCBS (2017) shows that while 62 percent of authorities publish stress test results, only 50 percent disclose aggregated results, and a mere 19 percent report bank-specific results. It is not clear whether these divergent strategies are the result of well-designed communications strategies aimed at resolving the apparent trade-offs as best as possible. In a 2012 survey with central banks and supervisory authorities in 32 advanced economies and major emerging market economies, 68 percent of respondents were communicating results from solvency stress tests and 26 percent from liquidity stress tests. Regarding communications, 68 percent did not have any requirements for public communications (see IMF 2012). In addition, there are usually important distinctions between communicating stress tests that are conducted as part of a crisis response, and those that are held on a routine basis in normal times (see Box 1).

The relationship between stress test disclosure and financial stability has not been investigated much, but there is empirical work on the impact of FSRs. Čihák and others (2012) find little evidence of a direct relationship between FSR publication per se, and financial stability in the country. They do find, however, that FSRs of higher quality (that is, more detailed content) are associated with greater financial stability (as measured by using indicators of banking crises, and the volatility of the stock market).

Current Practices in Sub-Saharan Africa

The results of stress tests are disclosed in sub-Saharan African countries as part of regular central bank publications. Such publications are typically financial stability reports or annual reports. There has been no practice so far of publishing the results of the stress tests in a dedicated report as was done, for example, by the European Central Bank/European Banking Authority (see classification in Table 1 and mention in Box 2). The degree of disclosure and transparency in publications varies among countries. Proactive communications, on stress testing and financial stability more generally have not been practiced much.

The press and public in sub-Saharan Africa appear to be interested in the financial condition of banks. This is especially true in periods of bank distress or incidents of bank closures. Discussions with representatives from SSA central banks have revealed that the press raises questions about banks' condition on various occasions, including in the context of monetary policy press confer-

Table 3. Quality of Disclosure of Stress Tests and Macro-Financial Risk Assessment

| | Obs | Mean | Std. | Min | Max |
|-----------------------|-----|------|------|-----|-----|
| Credit | 45 | 0.93 | 0.96 | 0 | 2 |
| Liquidity | 45 | 0.87 | 0.94 | 0 | 2 |
| Market | 45 | 0.33 | 0.67 | 0 | 2 |
| Total | 45 | 2.13 | 2.14 | 0 | 6 |
| Macrofinancial | 45 | 0.47 | 0.73 | 0 | 2 |

Source: Authors' calculations.

Note: In each case we use provide a score of zero if the analysis of credit/liquidity/market risks or macro-financial is non-existent, a score of 1 if it is conducted for the entire financial system, and a score of 2 if there is bank-level analysis.

ences, sometimes diverting monetary policy press conferences to a discussion on financial stability issues.² This may be explained also by the absence of dedicated communications on financial stability policies, such as press conferences or seminars, for example, in conjunction with the releases of FSRs. It appears that there is room for strengthening communications on financial stability policies in SSA countries, let alone on risk assessment and stress testing.

Based on our survey of stress test publication practices (Table 1), we have also developed a set of indicators to evaluate the quality of disclosure. We evaluate the analysis of credit risk, liquidity risk, and market risk in each financial system, and in each case provide a score of zero if the analysis is non-existent, a score of 1 if it is conducted at the system level, and a score of 2 if there is bank-level analysis.

The quality of the disclosure differs across SSA countries (Table 3). On average, credit and liquidity risk have a relatively similar coverage score of about 0.9, while the quality is lower for market risk (0.3). Also, for countries where there is an analysis of macro-financial risks we attach a score of 2 when we deemed the analysis comprehensive and 1 when deemed partial (and zero in cases of no such analysis). Table 3 shows that the coverage of macro-financial risks in our sample is in general quite low.

In addition, we analyze factors that may help explain the large variation in stress test disclosure across SSA countries. To test the hypothesis that countries with greater economic and/or financial development have better analysis and disclosure of risk analysis and stress tests, we specify different econometric models (using probit and ordinary least squares approaches), regressing stress test attributes (for example, stress test run, results published, TA received) on a set of macroeconomic variables (see Annex IV for details).

²Discussions were held during a seminar on monetary policy communications organized by the IMF in Tanzania in March 2019. The seminar was attended by representatives from central banks from Ethiopia, Kenya, Malawi, Rwanda, South Sudan, Tanzania, and Uganda.

Table 4. Drivers of Stress Test/Disclosure, TA, and Macro-Financial Risk Assessment

| VARIABLES | (1) Probit Stress test | (2) Probit ST public | (3) Probit TA received | (4) OLS Information disclosed | (5) OLS Macro financial |
|--------------------------|------------------------------|----------------------------|------------------------------|--|----------------------------------|
| GDP (log) | 0.184 (0.145) | 0.0707 (0.140) | 0.00913 (0.135) | 0.132 (0.205) | 0.0870* (0.0510) |
| Priv credit to GDP (log) | 1.362*** (0.479) | 1.108*** (0.361) | 0.0989 (0.290) | 1.219*** (0.299) | 0.433*** (0.120) |
| Constant | 27.583* (4.002) | 24.618 (3.626) | 20.170 (3.153) | 24.212 (4.903) | 22.748** (1.240) |
| Observations | 40 | 40 | 40 | 40 | 40 |
| R-squared | | | | 0.186 | 0.239 |

Source: Authors' calculations.

Note: The number of countries is smaller than the sample size due to unavailability of certain macro data for some countries. Robust standard errors in parentheses. *** p , 0.01, ** p , 0.05, * p , 0.1. OLS = ordinary least squares; TA = technical assistance.

Although our sample is rather small, we manage to find some interesting patterns. Table 4 shows some results from the regression analysis. Using a probit regression model, we find that financial deepening (as measured by the credit to GDP ratio) has a positive and significant relationship with developing stress test frameworks and publishing them. By contrast, we do not find an effect for the size of the economy (using GDP), nor for economic development (as measured by GDP per capita), financial account openness, and exchange rate regime (not shown in the table). In columns (4) and (5) using an OLS model, we show that financial deepening is also significantly related to specific elements of the disclosure (for example, whether macro-financial risk analysis is undertaken). However, none of these factors appear to have an effect on the likelihood of having received technical assistance on stress testing (column 3), which is arguably owed to the fact that stress testing TA has been delivered to countries in various stages of economic and financial development.

Recommendations on Disclosure and Communications

A key recommendation for SSA countries is to establish a dedicated channel for communicating financial stability issues, including on stress testing. This should be done to separate communications on financial stability from those on monetary policy. Current best practice emphasizes the importance of separating communications on the two areas of policy, reflecting the separation of objectives, decision-making structures, and accountability mechanisms (IMF 2013, 2014). This practice would also help ensure adequate focus on stress tests. Many advanced economies hold separate press conferences on the release of FSRs, and implementing this approach would also be beneficial in most SSA countries.

The objective of communications on stress tests, which can take different forms, is to maintain or reinstate financial stability. The following key factors should be taken into consideration when making decisions on the disclosure of stress tests, the degree of transparency, and the modalities of communications to the markets, press, and public:

- the authorities' capacity to communicate effectively on financial stability issues,
- the level of sophistication of the banking system and financial markets,
- the capacity of the national media to report on financial issues, and
- the financial literacy of the population.

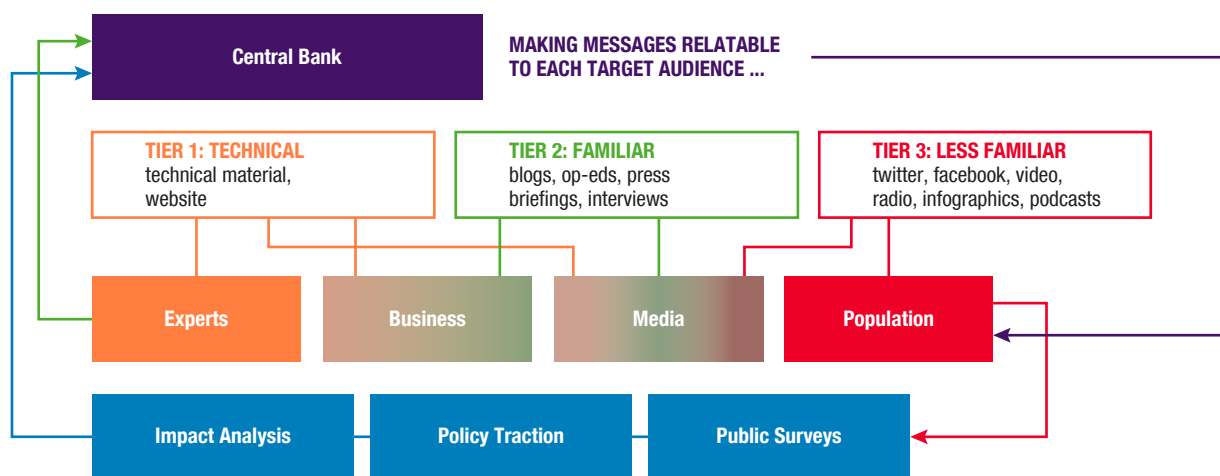
Two broad categories of countries may be distinguished using these factors:

- *In countries with more-advanced financial markets and economic media, higher financial literacy, and stronger communications capacity among the authorities*, more extensive disclosure is recommended. For certain such countries in SSA, a high degree of transparency and more proactive communications can thus be envisaged. As in advanced-economy jurisdictions (the European Union, for example), the publication of data and results for individual financial institutions could be considered.
- *In countries where financial markets and media are less developed, financial literacy is lower, and the authorities' communications capacity is still developing*, it is advisable to be more cautious about the amount and detail of disclosure. Greater restraint in disclosure can reduce the risk of misunderstandings, misreporting, and adverse reactions. Thus, for some frontier economies in SSA, more limited disclosure may be considered. Experience with the publication of IMF/World Bank FSAP reports has shown that, in most cases, it should not be problematic to disclose the aggregate impact of the stress scenarios on banking system capital adequacy, profitability, and liquidity. More detail might be provided if the problems are limited to one or two banks, and this fact is already publicly known. In this case, provision of information by official agencies may in fact help to quell rumors and their destabilizing effects.

The communications strategy and modalities will also depend on the outcomes of the stress tests. There are two main possibilities (Stankova 2019):

- *No significant financial stability risks are revealed by stress tests*. In such cases, more routine communications modalities such as publication of a (financial stability) report, press releases, social media postings, and interviews with leading officials would be recommended. Communications would also describe the corrective actions (which would likely be of a more routine nature) that

Figure 6. Tiering Communications by Content and Channels



Source: IMF staff.

need to be taken. Thought should be also given to, and preparations made for, potential misunderstanding and unforeseen market or public reactions.

- *Substantial risks to financial stability are revealed by stress tests.* In such cases, communications need to combine a recognition of the problems with a convincing and decisive plan to address them. Attention to communications should be elevated and the principles and practices related to crisis communications may come into play. Communications, including on the required corrective actions, may involve a number of different agencies (central bank, ministry of finance, other supervisory agency) and require high-level political coordination beyond the agency that conducted the stress tests.

In all cases, communications will need to reach audiences of different degrees of sophistication. To accomplish this, messages should be tiered by content and channels. Tiering by content means that the same core message is provided at two or three levels of technicality (Figure 6). Recipients would then choose the format that is most meaningful to them. Tiering by channels means that the same message is adapted to and sent via print, television, radio, video, online, and social media, to reach all tiers of recipients. To achieve this comprehensive approach, advance planning and preparations are required, which can also help to handle possible leaks, and speculations about the outcome of the stress tests (especially those that may trigger turbulence on the markets), and misreporting.

Box 1. Communications on Stress Testing: Crisis Response versus Normal Times

Communications efforts for stress tests as part of a crisis response can differ from those that are held routinely in normal times.

- During a *crisis (or postcrisis)* period, the stress tests are usually expected to inform decisions on bank restructuring and resolution, and communications need to be closely coordinated with other elements of the crisis response, including monetary and fiscal policies. Communications need to find the right degree of transparency about systemic risks; exercise caution in the release of information on individual institutions to avoid self-fulfilling expectations and destabilizing bank runs; and explain the policy changes needed to correct the problems uncovered, including the communications of any bank closures. When it comes to restoring confidence, communicating the coherence of the policy package can be crucial. In these circumstances, a dedicated publication on stress tests would often be appropriate, along with a well-planned campaign on how to present the outcome given the likely strong media interest (for example, the European Central Bank/European Banking Authority Comprehensive Assessment; ECB 2014).
- During *normal times* stress tests can be more routine. In some cases, when no serious vulnerabilities are uncovered, little communication beyond simple disclosure may be needed. If, however, serious vulnerabilities are indeed found and micro- or macroprudential corrective action is needed, proactive communications to financial markets, press, and the public can help to explain how such action will address the vulnerabilities. Being transparent about vulnerabilities uncovered, and at the same time showing the way forward, helps the authorities to maintain credibility and instill confidence. In all cases, the granularity of the information disclosed needs to balance different objectives (for example, to avoid triggering turbulence or otherwise disrupting the banking market while at the same time providing enough information about vulnerabilities to inform investors and depositors).
- In *normal times*, the results of the bank stress tests are often disclosed, and communicated, as part of the financial stability reports (FSRs). This approach enables the authorities to present the stress tests results as part of the broader picture of developments on financial stability in the country. However, generating media interest in financial stability reports in normal times has proven to be challenging. This will especially be the case for countries in which the economic and financial media are not well developed.
- Example of *disclosure in normal times*: The publication of the results of the stress tests in the November 2018 FSR of the South African Reserve Bank (SARB) illustrates one approach to disclosure and transparency. The FSR is published twice a year, usually in May and November, and as part of the rollout process, SARB senior management—the governor or deputy governor—typically presents the report

**Box 1. Communications on Stress Testing:
Crisis Response versus Normal Times (*continued*)**

to various stakeholders, including the press. Ahead of the presentation, technical experts are available to respond to questions from the press under embargo. For the November 2018 edition, a media advisory from the Treasury flagged the upcoming publication and associated media opportunities, as per established practice. The results of the stress tests were presented in the FSR concisely, in both the executive summary and in the main body, likely reflecting the resilience of the banking system despite a sizable impact of the assumed shocks. The stress tests methodology was explained in detail in an annex. Media articles covered the key risks to financial stability as identified in the FSR, even though the stress tests were not discussed.

- At *all times*, it is important for communications to explain that scenarios used for stress testing are hypotheticals, not forecasts.

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Technical Assistance for Stress Testing and Communications Capacity

IMF Technical Assistance for Stress Testing

Development of stress testing capacity is often helped by technical assistance (TA). Stress testing can be a complex endeavor requiring expertise and data, and technical assistance helps develop operational frameworks and capacity. Although in a few cases authorities in SSA have developed stress testing frameworks on their own, it is much more common for technical assistance to be requested, particularly from the IMF.

From 2003 to the first quarter of 2019, the IMF delivered more than 100 TA missions solely focusing on stress testing, many of which to SSA countries. African countries received more than half of such missions, and SSA countries more than 40. Most of the countries in the region requesting such TA received more than one mission. Moreover, the IMF also provided technical support for developing systemic risk analysis and stress testing capacity via regional initiatives, such as within the East African Community (EAC).¹

Overall, SSA authorities consider stress testing an important tool to enhance the risk analysis framework, including when moving to risk-based supervision. Focus on supervisory stress testing differs from IMF TA being provided in other regions such as Europe or Asia where stress tests often use advanced methodologies (for example, network/contagion analysis) and macroprudential stress testing² and its use for macroprudential policy.

Countries requesting stress testing TA have asked for adoption or further extension of the tool for their own reporting as well as help with scenario

¹The IMF also has delivered multi-topic TA missions that focused on improvements in supervisory capacity, crisis management, and financial stability, with stress testing an integral component.

²By macroprudential stress testing we mean top-down stress testing to simulate the impact of macro-financial shocks on credit provision to the economy and subsequent second round effects.

design and satellite models. SSA authorities have asked for TA to build a model allowing for stress tests that are more suitable for supervisory purposes, given the transition to Basel II/III or other changes in supervisory requirements. Their ideal model enables comprehensive stress testing of various risks, notably credit quality and concentration risk, market risk, liquidity risk, contagion risk, and other risks affecting bank income and profitability.³ Tests can be run using a single-factor (sensitivity analysis) or combination of factors (scenario analysis). TA missions also focused on creating satellite models given authorities' lack of expertise (for example, econometric skills), but occasionally their own efforts were prompted by IMF activity (for example, FSAP in Mauritius).

To implement or upgrade stress testing frameworks, TA missions have typically focused on a sequence of steps (see Annex I for details). This procedure includes (1) risk identification; (2) assessing data availability and needs for stress testing; (3) calibration of risk factors; (4) identification of shock transmission channels; (5) quantification of shocks; (6) estimation of satellite models; (7) designing balance sheet models for calculation of impact; (8) recommendation for policy use of stress testing models; and (9) an assessment of staff availability and resource constraints.

Data Issues

Before opting for more-advanced stress testing methodologies or upgrading existing tools, supervisors need to ensure data availability, consistency, and quality. Many SSA central banks and supervisors have adequate data for simple sensitivity and scenario-based stress tests but face challenges in putting together data for genuine macroprudential stress testing. Data availability has been a challenge because of the limited data that supervisors collect on banks' balance sheet exposures as well as on liquidity, market, and operational risk. Limited availability of data from private sources or central credit registers also hinders risk analysis and model-building efforts. Acute data limitations were encountered in macro data; banks' balance sheets; and information about credit, market, and liquidity risk (see Annex II).

Even with available data, ensuring quality and consistency remains a challenge. Many SSA countries still rely on old data reporting systems as well as manual data submissions and validation. Not surprisingly, TA missions have often found inconsistent data, such as the sum of large exposures being larger than total exposures, or provisioning ratios exceeding 100 percent. TA missions have recommended employing automated data reporting sys-

³More specifically, it would need to incorporate assumptions about the migration of loans within a portfolio and among different risk categories, and model banks' net income before provisions.

tems that include data point validation rules flagging inconsistent reporting more readily.

Many TA missions have provided recommendations for collecting needed data and improving its quality to enable authorities to do more-advanced stress testing. In particular, recommendations have typically focused on (1) starting the collection of data on real estate prices, loan write-offs and recoveries of written-off loans, banks' cross-border exposures, and the financial situation of bank debtors; (2) checking collected data for consistency; and (3) exploring the use of credit registry data.⁴ To collect such data, supervisory authorities need to cooperate with other entities such as financial institutions, statistical agencies, and private sector firms (for example, private credit bureaus, real estate agencies).

Methodological and Institutional Issues

Technical assistance missions also flagged a number of methodological and institutional issues in countries' stress-testing approaches (see Annex III). Stress parameters are often formulated on an ad hoc basis, and no separation may exist between the baseline and hypothetical shock scenarios. TA missions also emphasized the need to develop a simple macro stress testing model that requires minimum data and is credible enough for policy use, particularly concerning credit risk, whereas for liquidity risk models are already straightforward. Missions also noted that little modeling is used to assess income risk.

There is also a trade-off between more-advanced stress tests models and their potential use and cost. Upgrading to a more-advanced version of a balance sheet stress-test tool, such as a multi-period, dynamic model, needs to be assessed against its potential use and reliability as well as the authorities' ability to maintain and update such models. Although more-advanced models may better represent reality, they are subject to multiple model-related uncertainties, and the need to apply a range of assumptions. Also, SSA central banks may not have enough staff with relevant modeling skills to periodically update these models. Therefore, most of the TA missions recommended to make sure that a more basic stress test framework is put in place, with which staff can perform analysis, and results are used to inform decision makers about idiosyncratic/systemic risks in the banking system.

⁴Collecting such data would allow central banks and supervisory authorities to do more advanced credit risk analysis (such as the calculation of probability of default and loss given defaults, and loan transition matrices), estimate imbalances in housing and commercial real estate markets to may give rise to credit risk, and check the adequacy of loan-loss provisioning.

TA missions also found several institutional issues. Stress test scenarios are formulated by technical staff and usually not discussed with management before the exercise. Missions also noted deficiencies in the use of stress test results that may be used for monetary policy purposes⁵ but typically do not influence the supervisory process. Importantly, stress tests are not used as an early warning instrument to address the identified credit and liquidity risks and to engage in risk-based supervision by focusing on more risky banks.

There are a few success stories of authorities gradually upgrading their stress test methodology (Box 2). Among others, Namibia transitioned from using a simplistic approach with limited publication of results to using coherent single-factor sensitivity tests with more detailed reporting and further to applying a state-of-the-art macro stress testing model (use of a scenario-conditional dynamic balance sheet structure). All of these stages were enabled by dedicated IMF technical assistance, which also provided for a gradual capacity-building process.

IMF Approach to Building Capacity for Communicating Financial Stability Issues

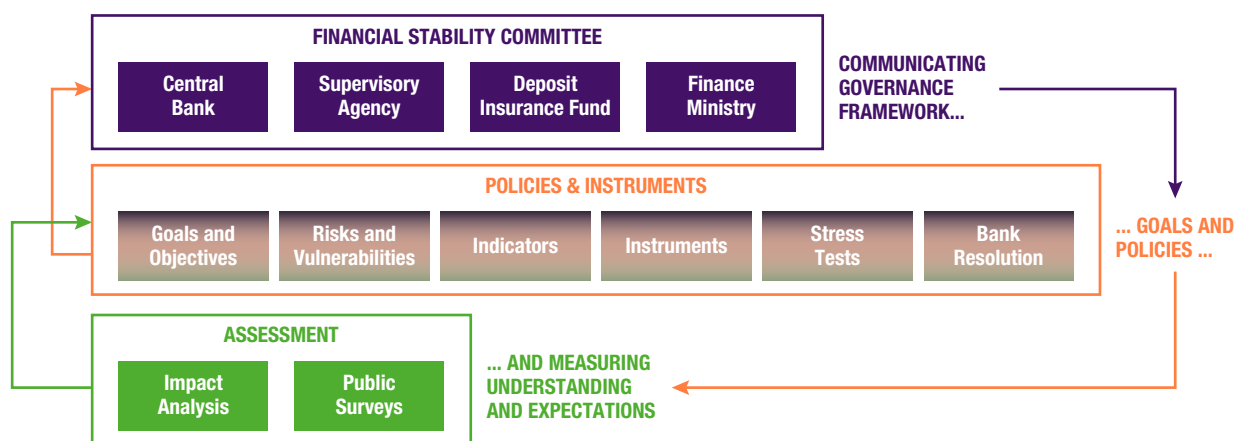
The IMF takes a holistic approach to strengthening communications capacity. This approach draws on the IMF's Logical Framework for strengthening financial stability communications at the institutional, national, and supranational levels. The framework covers communications (and coordination where needed) by the authorities in charge of financial stability issues, including central banks, supervisory authorities, deposit insurance funds, and ministries of finance (Figure 7). The framework's recommendations on communications may arguably be considered best practices.

There is value in building capacity to communicate about financial stability in parallel with building policy and analytical capacity. It is important to avoid communications capacity falling behind; indeed, a case can be made that it should always be somewhat ahead of the policymaking, and ready to respond to unexpected developments.

Mozambique is a good example of technical assistance that aids in building communications capacity. As part of a comprehensive central bank modernization project that began in 2017, the IMF Communications Department developed a Logical Framework for building capacity to communicate on

⁵Stress testing is conducted for Monetary Policy Committee (MPC) meetings and can be produced monthly, in line with the MPC meeting schedule, where the report is presented.

Figure 7. Holistic Approach to Financial Stability Communications



Source: IMF staff.

financial stability policies at a national level.⁶ A key workstream involved building the capacity to communicate on financial stability policies in parallel with the development of a macroprudential department at the central bank, a financial stability report, and stress testing capacity. This approach was further supported in a workshop on financial stability communications held at the Bank of Mozambique (BoM) in 2017.⁷ The IMF also provided operational advice to the BoM on strengthening financial stability communications in bank distress to help preserve the central banks' credibility in a challenging environment.

Although many SSA countries request TA on developing stress testing models, few TA missions have focused on communications of supervisory components. This capacity development work would include the communication of stress test results to the public and their use for policy purposes, notably microprudential and macroprudential policy purposes. The TA advice needs to explain the use of stress tests in the day-to-day supervision, for example, when setting capital and liquidity requirements.

⁶The framework mapped out strengthening capacity, in a coordinated manner, by the Bank of Mozambique, Ministry of Finance, and the Deposit Insurance Fund, for a period of three years, including developing communications strategies; establishing communications units and joint working groups; signing a memorandum of understanding on information exchange among the central bank, Ministry of Finance, and Deposit Insurance Fund; establishing a high-level collegial body with a mandate and composition defined by law; and adopting a coordinated national crisis communications strategy.

⁷The workshop was attended by staff from departments involved in financial stability work; discussions focused on a first draft of the FSR, in parallel with broader discussions on financial stability communications and building communications capacity in this area.

Box 2. Namibia—An Example of Upgrading Stress Test Methodology and Reporting

A number of sub-Saharan African (SSA) countries have moved from straightforward sensitivity analyses to more-advanced stress testing techniques. Namibia is a prime example of first anchoring stress testing at the central bank, while also addressing data and capacity constraints, and then gradually upgrading the methodology. IMF technical assistance (TA) was delivered in three phases during 2013–18.

During 2013–14, TA missions provided options for solvency and liquidity stress testing and dealt with data issues. Previous non-IMF TA had recommended using a probability of default/loss given defaults (PD/LGD) approach, which the IMF team found inappropriate given that Namibian banks were applying the Basel II Standardized Approach without these risk metrics. Instead, the IMF TA suggested focusing on migration of performing loans to nonperforming loan (NPL) status, while also adjusting risk weights. The Bank of Namibia (BoN) subsequently conducted stress tests and published abridged results in its financial stability report (FSR). At the time, the mission team also noted that BoN had difficulty retaining staff qualified in stress testing, and for the sake of business continuity the mission suggested involving staff from other units and producing internal documentation to safeguard knowledge transfer. Another mission, in early 2015, performed solvency and liquidity stress tests, and provided more training in using the IMF Stress Tester tool.

Although the 2015 FSR subsequently included a description of the methodology as well as the impact of assumed interest rate hikes on capital adequacy, the framework and the reporting remained incomplete. In mid-2015, a TA mission provided advice on model-based stress testing, notably linking risk factors to macro-financial variables, but results were rather tentative given the limited data available (for example, relatively short time series for NPLs at the time). The BoN subsequently applied a range of single-factor sensitivity tests and published more-detailed results in the FSR—in 2016, only of stress tests for credit risk, but in 2017/18 also for market and liquidity risk, which, incidentally, an IMF Financial Sector Assessment Program mission had evaluated in late 2017 (IMF 2018a). The FSR now includes a detailed assessment of macro-financial risks.

Lastly, in 2018 a TA mission implemented a customized solvency stress model framework for the BoN with a simple dynamic balance sheet structure allowing gross credit stocks to grow in the projection and a multiyear scenario-conditionality of up to five years. At its core, it contains a scenario-conditional credit risk module (involving satellite models for NPL ratios at the bank level) as well as a scenario-conditional market risk module for both the trading and banking book of Namibian banks (including interest rate risk in the banking book).

Conclusions

Stress testing in SSA has come a long way, notwithstanding simple methods, uneven macro-financial assessment, limited use of stress test results, and sparse communications. This paper finds that thanks to healthy adoption rates in the last years, the majority of SSA authorities now conduct stress tests for a range of banking risks, most prominently credit and liquidity risk, to ascertain bank resilience in the face of adverse conditions and to inform the public to this end. Fewer countries, however, conduct a proper assessment of macro-financial linkages and banking sector vulnerabilities, which may explain why straightforward sensitivity checks dominate. The severity of the assumed shocks to risk factors is found to be broadly appropriate, and therefore even single-factor stress tests may convey a realistic picture of bank performance under stress. However, few countries change the size of the shocks over time, although this may lead to procyclicality in the scenario design, for example, when keeping shock sizes unchanged in a recession. The fact that so many SSA central banks now run stress tests routinely suggests their elevated importance, although the results do not necessarily serve as inputs to the supervisory process or other policy objectives and communication of the stress tests is rather concise in some cases.

Our findings also suggest a gap in stress testing practices between authorities in more-advanced financial systems and those less-developed. We show that more-developed financial systems tend to have more complex and comprehensive stress testing frameworks and communications strategies. In addition, our finding that nearly 40 percent of SSA countries do not appear to be using stress test methodologies at all and that 15 percent of the remaining countries do not report on the stress tests that they run in their official publications suggests room for further improvement, especially considering that these countries tend to have relatively low financial development and arguably limited technical capacity.

Technical assistance can help develop or refine stress testing methodologies across all levels of financial system development. It is logical to assume that as countries with low financial deepening develop their financial systems and, in some cases, become more financially integrated, they will seek to implement risk assessment and stress testing methodologies already in place elsewhere. Our study also suggests that IMF technical assistance has helped implement stress testing techniques and address data and capacity constraints in about half of the SSA region. The remaining countries will likely continue to seek IMF TA as they strive to adopt stress testing, as will those already conducting stress testing as they aim to upgrade their methodologies. As this paper demonstrates, TA can also be instrumental in developing a strategy for communicating stress test operations and outcomes.

Annex I. Technical Assistance Approach to Improving Stress Test Frameworks

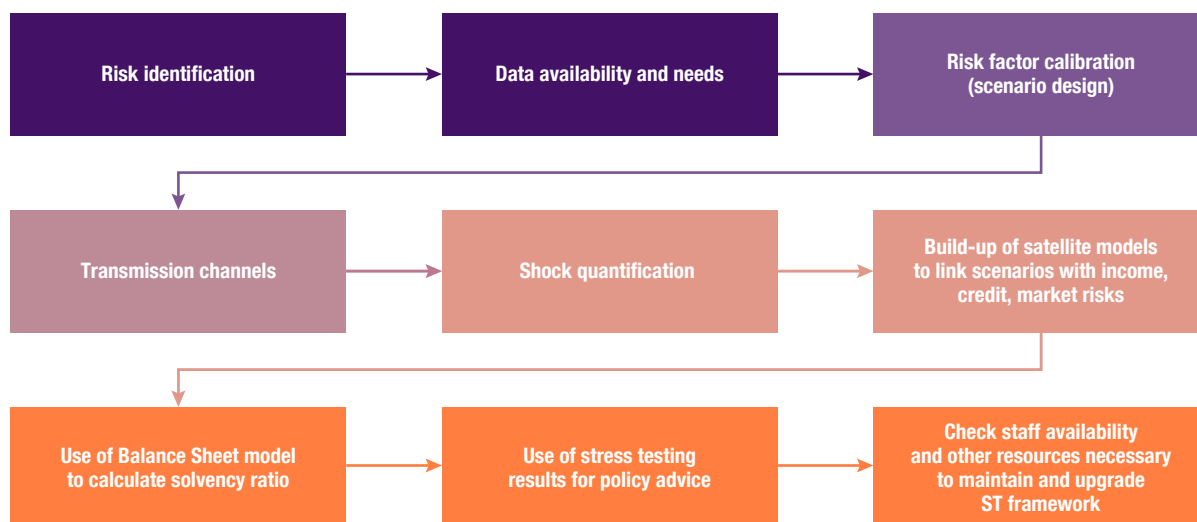
To implement or upgrade stress testing frameworks, TA missions have typically focused on the following steps (Figure 8):

1. *Risk identification.* Except for a few cases (for example, South Africa), “plain vanilla” financial systems dominate, with banks as the main providers of credit and limited intermediation by nonbank financial institutions (NBFIs). Thus, risk identification focuses on risks to banks (for example, exposure to specific economic sectors).¹ Banks are mostly funded by retail deposits but may face concentration risk from large institutional depositors (pension funds, public entities). Cross-border funding and interbank market activity are often low.
2. *Data availability and needs for stress testing.* Based on the key sources of risks, TA missions suggest collection of additional data in case of gaps in global data (for example, commodity prices), supervisory data, macroeconomic data (for example, aggregate balance sheets of corporates/households, cross exposures between sectors), and real estate data.
3. *Risk factor calibration.* As systemic financial crises have been rare in SSA as of late (Mlachila, Park, and Yabara 2013),² stress testers face challenges in using historic data to calibrate shocks to anchoring variables (such as GDP, unemployment, interest rates). Hence, scenarios are often designed not based on a past crisis episode but simply by applying a reasonable shock to NPLs (for example, largest historic annual/quarterly increase in NPLs overall/by sector). In this case, stress testers directly proceed to step

¹By contrast, countries tend to be reluctant to properly identify risks stemming from public sector entities, banks’ exposures to bonds of their own sovereign, as well as state-owned enterprises.

²In the 1980s and 1990s, however, there were a number banking crises in SSA caused by adverse macroeconomic shocks and heavy government intervention in the banking sector (see Daumont, Le Gall, and Leroux 2004).

Figure 8. Technical Assistance Approach to Improving Stress Test Frameworks



Source: IMF staff.

7), that is, bypassing transmission channels, shock quantifications, and satellite models.

4. *Transmission channels.* Identification of shock transmission channels is a crucial stress testing task as it adds to the overall narrative or storytelling behind a stress testing exercise: How would the shocks affect banks or other financial institutions, and to what extent are banks exposed to particular types of risks? Many TA missions emphasized that the purpose of the stress test is not only to quantify losses and their impact on bank capital, but to assess exactly how shocks would affect banks' borrowers and ultimately banks via their exposures to them.
5. *Shock quantification.* This step is aimed at producing other macro-financial variables that would be consistent with the initial shocked values of risk factors, such as GDP growth, unemployment, commodity price shocks, etc. Only a few SSA countries have robust enough macro forecasting models suitable for designing internally-consistent macro scenarios (for example, vector autoregression or structural models). To a large extent, this is due to a lack of reliable and sufficiently-long time series of macro and financial data, as well as econometric skills. Expert judgment may suffice for sensitivity analysis but may not produce consistent variable paths.
6. *Satellite models.* Such models link macro-financial variables with selected risk indicators (for example, NPLs or probability of default, provisioning) as well as profit-and-loss items (for example, interest income and expenses, fees and commissions, administrative costs). While authorities

wish to design or improve satellite models, TA missions have advised against them when data and capacity limitations would make maintaining the models difficult.

7. *Balance sheet models.* The last step in stress testing is designing a balance sheet model that calculates income, losses, changes in balance sheet positions, risk weights and, ultimately, capital adequacy. Countries using the Stress Tester tool asked for modifications and extensions of it, including toward performing multi-year stress tests.
8. *Policy use.* Some TA missions have provided recommendations on the actual and prospective use of stress testing. SSA countries have used stress testing more for monetary policy³ than for micro-/macroprudential purposes. Aside from doubts about data and scenario design, senior management has questioned supervisors' ability to use stress test results to force banks to increase capital and/or to de-risk. Using stress tests for macroprudential policy purposes presents even larger challenges for SSA countries.⁴
9. *Staff availability and resource constraints.* A small number of staff working on stress testing and risk assessment projects hinders full utilization of TA advice and has led to multiple requests for follow-up TA on the same subject.⁵ Staff turnover is typically high because stress testers are reassigned to other posts within the organization or leave the central bank altogether because of uncompetitive remuneration compared to the private sector.

³Specifically, this has been done to account for the impact of changes in the policy rate on bank performance (for example, change in credit quality; different credit growth; adjusted borrowing cost for companies, households, and government) as well as of shocks to exchange rates affecting banks, particularly in financially dollarized SSA countries.

⁴This is partially due to lack of adequate macroprudential policy frameworks, such as decision-making bodies, legislation, and lack of experience in systemic risk identification and prevention.

⁵Other resource constraints include software for econometric modeling and needed programming experience as well as limited allocation of time for such nontraditional projects.

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Annex II. Data Limitations Encountered by TA Missions

Technical assistance missions encountered acute data limitations in the following areas:

- *Macro data and availability of macro forecasts.* As opposed to data on economy activity, information on asset prices (for example, of construction, commercial/residential real estate, land) is not available or available with a significant lag.¹ Some countries use IMF *World Economic Outlook* (WEO) data for baseline macroeconomic forecasts, and missions to SSA have encouraged use of the *Regional Economic Outlook: Sub-Saharan Africa* (REO).
- *Credit risk.* Data gaps include information on credit risk concentration (by sector, single borrowers); macroprudential information (for example, loan-to-value, debt-service-to-income, collateral); and specific information on credit quality (NPLs by currency and written-off/restructured/cured loans, cure rates of NPLs).
- *Balance sheet information.* Banks' compliance with provisioning requirements, collateral valuation, and the sectoral composition of loans, even if available, is not checked for consistency on a regular basis.
- *Market risk.* Gaps include duration of securities held by banks; exposures to equities by company; data on banks' sensitivity to interest rate changes (for example, parallel shift in yield curve); data by maturity of asset and liability repricing (repricing gap), as well as behavioral data about loan prepayments and changes in the deposit mix (term structure).
- *Liquidity risk.* Information is often missing on cash flow/maturity ladder data (both contractual and behavioral), including cash flow data by sig-

¹Real estate prices are useful in estimating imbalances in housing and commercial real estate markets, and adequacy of provisioning. Such data are used extensively for stress-testing purposes, especially for calculation of the loss given default (LGD).

nificant currencies in financially dollarized systems; asset encumbrance (that is, banks including encumbered assets in calculation of the liquidity ratio); and largest funding sources and providers (that is, funding concentration reports).

- *Other data.* Gaps exist for the nonbank financial sector as well as data about banks' borrowers (corporates, households).

Even where banking sector data are broadly available, there are still substantial gaps and limitations with other sectors' data. This includes data for firms and household as well as nonbank financial institutions (NBFIs). For example, there may be no accurate estimate of household debt ratios due to a lack of required data on disposable income and debt, and similar concerns apply to corporate indebtedness. For the nonbank sector, data constraints are severe and limit the ability to assess performance of the large and/or interconnected NBFIs.

Annex III. Methodological and Institutional Issues Flagged by TA Missions

TA missions noted several methodological issues in SSA stress testing. Stress parameters are often formulated on an ad hoc basis, and no separation may exist between the baseline and hypothetical shock scenarios. Stress testers often use trends in NPLs to calibrate stress parameters. It is also common that scenario parameter values are not changed often (although they can be changed, if trends change), see Chapter 2. Often, only exposures change over time. In some countries, stress testers have used the same scenarios and stress parameters for multiple years (five or even more) obtained during their last IMF mission (for example, FSAP, TA).

TA missions to SSA countries emphasized the need to develop a simple macro stress testing model that requires minimum data and is credible enough for policy use. Such a simple model requires minimum macro and financial data, such as NPLs/NPL ratios (or provisions/write-offs) to be regressed on real GDP, interest and exchange rates, and, if available, unemployment. Apart from simple single-equation OLS regression, it could be based on simultaneous equation systems such as vector autoregression or vector error correction models. Dynamic panel models or Bayesian approaches are also used occasionally. Missions emphasized that more advanced modeling is subject to the availability of more complete and reliable data.

Beyond credit risk, many TA missions found that stress tests for currency risk need significant improvements, particularly in financially dollarized SSA economies. The impact of swings in the exchange rate to the US dollar as SSA banks' primary foreign currency are tested via simple sensitivity analyses, based on the net open position. Stress testers often look at the trend of the exchange rate and use the largest historical monthly shock for calibration. No assessment of indirect effects (that is, credit risk from unhedged borrowers in FX) is made.

Liquidity risk stress tests are simple and typically assume withdrawal of deposits during a certain timespan. Using balance sheet data, stress tests model cash flows by applying outflow rates to the stock of deposits (that is, implied cash flow stress tests). Resilience is assessed by comparing the available stock of liquid assets to the deposit outflow.

Little modeling or assumptions are used to assess income risk. In a typical, if rare, setup, an income risk test assumes that yield on government securities and interest income from loans will decrease by a certain magnitude determined ad hoc. In general, no specific assumptions are made about interest rate changes and the reaction of holders of such interest-bearing assets and liabilities to these (that is, loan prepayments, shifts in deposits). No other elements such as fees and commission income, and trading income are typically included.

Missions also encountered institutional issues. In most SSA countries, the stress testing work is distributed across banking supervision and research and statistics departments, and coordination issues have arisen. Enhanced cooperation among multiple units within respective central banks or supervisory agencies is necessary. Specifically, it is important to determine who the proprietor of the framework is, who produces scenarios, who collects and checks data, and who determines the use of the stress test results, including for publication.

Across SSA countries, stress test scenarios are formulated by technical staff and are usually not discussed with management before the exercise. Where scenarios are crafted, the research department provides information on possible developments in the real sector, and the financial stability/supervisory staff formulate scenarios (choose stress factors for each sector with certain shock sizes). Scenarios can be common for all the banks (that is, different stress factors are used for each sector, but they are common for all the banks) or different for each bank (that is, different stress factors for each sector and each bank). While parameter values may be discussed with the departments' senior staff, no formal approval from the top management of the central bank/supervisory agency is typically obtained. Another common issue across SSA central banks is that stress test results are not genuinely used for supervisory or macroprudential purposes, rendering the exercise more or less a research task.

Many TA missions noted deficiencies in the use of stress test results. For example, instead of supervisory use, many SSA central banks perform stress tests for monetary policy purposes. In our view, monetary policy cannot pursue several targets while using just one instrument, that is, its primary purpose is to ensure price stability and not banks' profitability. It is common that these goals may conflict (for example, in the US and the EU); when

the central bank lowers interest rates, it lowers banks profit margins and vice versa. We do not recommend mixing those two objectives in SSA countries. Moreover, evidence from SSA suggests that stress testing results are not used as a basis for a formal discussion with the respective bank, and they do not affect the inspection schedule or supervisory priorities in certain risk areas (let alone extra capital, for example, countercyclical capital/systemic risk buffer).

TA reports also emphasized the need to use stress tests as an early warning tool for potential problems. Based on the credit risk stress test results, SSA supervisors could identify banks with inadequate capital (based on expected losses), force them to prepare plans to increase capital buffers or to de-risk (that is, decrease risk-weighted assets as denominator in the capital adequacy ratio) to address the identified credit and liquidity risks better and to engage in risk-based supervision by focusing on more risky banks.¹

¹Stress tests conducted by TA missions typically found substantial differences among banks in terms of credit, market, and liquidity risks. Some banks are considerably more vulnerable than others. Given limited staff resources, emphasis should be put on the analysis of riskier banks. Also, in analyzing stress test results, the focus should be on developments over time rather than absolute values. Because of the lack of adequate underlying micro and macro data, the absolute values from the stress testing exercise should be interpreted with caution. Accordingly, more weight should be given to changes and direction of developments in banks' risk profiles (rather than absolute values).

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Annex IV. Empirical Approach

This annex briefly explains the empirical models used in Table 4. We first consider a simple probit model in which $y_c = 1$ is an indicator equal to one if country c does stress tests (case 1), if the stress test is made public (case 2), or if the country has received ST technical assistance (case 3). In this simple probit model, we assume that $Pr(y_c = 1) = Pr(y_c^* > 0)$ and a linear model

$$y_c^* = \alpha_0 + \alpha_1 \log(GDP)_c + \alpha_2 \log(PrivCred/GDP)_c + \varepsilon_c \quad (1)$$

in which $\log(GDP)_c$ is the log of the Gross Domestic Product of country c , $\log(PrivCred/GDP)_c$ is the log of the ratio of private credit to GDP, and ε_c is an error term.

In columns (4) and (5) of Table 4 we consider a simple OLS model with the same explanatory variables as in the Probit model. We use two different dependent variables. In column (4) we use as dependent variable a quality of disclosure variable that has values ranging from 0 to 6. This indicator is constructed by adding up the scores of the quality of disclosure indicators for credit, liquidity, and market risk that range from 0 to 2 (see Table 3). In column 4 we use as dependent variable depicting the quality of disclosure of macro-financial risk assessments, with values ranging from 0 to 2 (as shown in Table 3):

$$QualityDisclosure_c = \alpha_0 + \alpha_1 \log(GDP)_c + \alpha_2 \log(PrivCred/GDP)_c + \varepsilon_c \quad (2)$$

Other possible explanatory macroeconomic variables were tested, such as degree of financial account openness or type of exchange rate regime, but their inclusion in the regressions did not yield statistically significant results.

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