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Supervisory Stress Tests

Beverly Hirtle¹ and Andreas Lehnert²

¹Federal Reserve Bank of New York, New York, NY 10045; email: beverly.hirtle@ny.frb.org

²Board of Governors of the Federal Reserve System, Washington, DC 20551; email: andreas.lehnert@frb.gov

Annu. Rev. Financ. Econ. 2015. 7:339–55

The *Annual Review of Financial Economics* is online at financial.annualreviews.org

This article's doi:

10.1146/annurev-financial-111914-042040

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JEL codes: G21, G28

Keywords

bank stress testing, bank capital, bank supervision

Abstract

We describe the background, design choices, and particular details of stress tests used as part of an overall supervisory regime, that is, their formal integration into the ongoing prudential supervision of banks and other large financial institutions. We then describe how the US Comprehensive Capital Analysis and Review (CCAR) and Dodd-Frank Act stress testing (DFAST) regime is designed and what that means for the macroprudential versus microprudential nature of US supervisory exercises. We argue that routine stress tests have the potential to substantially change the nature of the supervisory process. We also argue that a great deal depends on the philosophy underpinning modeling decisions, which has not received as much attention as scenario design, disclosure, or other stress test design choices.

1. STRESS TESTING AS A RISK MANAGEMENT TOOL

In this article we describe the background, design choices, and particular details of stress tests used as part of an overall supervisory regime, that is, their formal integration into the ongoing prudential supervision of banks and other large financial institutions. We then describe how the US supervisory stress testing regime is designed, how stress tests are integrated into the broader supervisory program, and what that means for the macroprudential versus microprudential nature of US supervisory exercises. We argue that routine stress tests have the potential to substantially change the nature of the supervisory process. In addition, we argue that a great deal depends on the philosophy underpinning modeling decisions, which has not received as much attention as scenario design, disclosure, or other stress test design choices.

The profile and importance of stress tests in supervision have increased dramatically since the recession and associated financial crisis of 2007–2009. However, stress tests as supervisory tools predate this episode, and as financial risk management tools they date back further still.

In financial risk management, stress tests typically attempt to measure the value of an asset in a particular hypothetical scenario. The scenario describes all relevant variables required to model the asset. Stress tests are distinguished from routine scenario-based analysis by the pessimistic nature of the underlying scenario. Thus, in some sense, stress testing began at the same time as financial risk modeling, when analysts contemplated pessimistic or worst-case outcomes before investing.

That said, modern stress tests feature scenarios with several self-consistent variables that describe complete macrofinancial environments. The first appearance of such exercises appears to be related to mortgage markets, perhaps because mortgage risk is tied to only a few aggregate variables—mainly house prices and interest rates (Del Negro & Otrok 2007). In the late 1980s, credit rating agencies developed scenarios to assess the viability of thrifts and monoline mortgage insurers. The scenarios featured adverse housing market developments such as large and persistent declines in house prices (Lederman 1990).

This background likely informed the inclusion of a stress test in the Federal Housing Enterprises Financial Safety and Soundness Act of 1992 (FHEFSSA), the legislation that created the regulatory framework for the housing-related government-sponsored enterprises (GSEs) Fannie Mae and Freddie Mac. These GSEs were subject to a leverage requirement and a risk-based capital requirement. The risk-based capital calculation was based on their losses under a stress scenario specified by Congress (Frame, Gerardi & Willen 2013).

The Basel Market Risk Amendment, finalized in 1995, contained a provision encouraging the use of stress tests to supplement value at risk (VaR) measures of computing risk-weighted assets, which are also used in various measures of risk-based capital.¹ VaR models consider the probability distribution of the value of a portfolio of assets. In principle, a VaR model can be thought of as the result of thousands of individual scenarios, weighted by probability. In practice, however, the distributions are not tied to real-world variables other than the observed empirical distributions of the values of various assets. Stress tests thus provide a useful check on VaR analysis by carefully working out the consequence of a particular, intuitively appealing scenario for the value of an asset portfolio.

In its periodic financial stability assessment programs, the International Monetary Fund also uses top-down stress tests to assess the resiliency of national banking systems (Jones, Hilbers & Slack 2004).

¹The internal models–based calculation for market risk exposures required that all banks using the approach “have in place a rigorous and comprehensive stress testing approach” (BCBS 1995, p. 17).

Thus, capital regulation of GSEs and of large banks via the Basel Accord were two of the most prominent early examples of the use of stress tests in regulatory regimes. Also, stress tests were widely used by credit rating agencies in the precrisis period. Given the substantial capital shortfalls that emerged at Fannie Mae and Freddie Mac, several large banks, and the top-rated tranches of asset-backed securities, this is not an encouraging track record. Nonetheless, as we discuss in the next section, stress testing can play a useful role in the prudential supervision of large banks.

2. STRESS TESTING AS A SUPERVISORY TOOL

Stress tests have the potential to drive a supervisory regime that is quite different from the typical precrisis regime, although, as we discuss, they can also be integrated with more standard supervisory practices. In part, stress testing regimes may be seen as a way of removing supervisory discretion and potentially enhancing the overall credibility of the supervisory regime.

2.1. Differences Between Stress Testing Regimes and Standard Supervisory Practices

It is useful to begin with a discussion of how a supervisory regime based on stress tests is potentially quite different from older or more traditional supervisory regimes.

First, stress tests are inherently quantitative: The result of an exercise is a quantitative view of the value of a portfolio, or even of an entire firm, under a particular scenario. Traditional supervision is characterized by an emphasis on assessing banks' processes. For example, the *Comptroller's Handbook* (OCC 2013, p. 2), a primary manual of the Office of the Comptroller of the Currency, a supervisor of national banks in the United States, states that "high-quality bank supervision . . . ensures that banks have appropriate risk management systems that encompass a sound audit program and a strong internal control program." Of course, it (OCC 2013, p. 2) also calls for a supervisory regime that "ensures that examiners recognize and appropriately assess the risks posed by all significant lines of business." Thus, in this view of supervision, quantitative metrics play a role, but examiners are not directed to come to an independent view of a firm's creditworthiness in a stress scenario.

Second, stress test results have, in recent years, been made public by supervisory authorities in a variety of countries (although they need not be). However, supervisory findings have traditionally been confidential and, indeed, in the United States have been protected by law from disclosure (Board Gov. Fed. Reserve Syst. 2005). Maintaining the confidentiality of examination findings, ratings, and other supervisory work has been defended, among other reasons, as permitting banks to share information fully with their supervisors.

Third, supervisory actions carry some amount of discretion; that is, confronted with similar fact patterns, different supervisors may react in different ways, or the same supervisor may react differently over time (Agarwal et al. 2014). This is because supervisory actions take place in a context of complex incentives, institutional history, and operational constraints, all of which differ across agencies and over time. If the results of the stress tests are publicly disclosed, they may offer a commitment mechanism for supervisory action. In an analogy to the debate in the field of monetary policy, publicly disclosed stress tests open the possibility of supervision by rule rather than discretion (among many others, see Fischer 1990). A commitment by regulators to publish the results of supervisory stress tests and to tie certain actions to firms' quantitative results on those stress tests offers a potential mechanism to increase the credibility of the regulatory regime and improve communication with market participants.

Fourth, stress tests have been relied upon by supervisors in times of widespread financial distress, although not always coupled with public disclosure. Certainly stress tests envision periods of financial distress, so they are a natural tool when authorities in the midst of a crisis wish to understand the potential capital needs of their financial systems—in other words, to understand “how bad it can get.” This was certainly the context for the US stress test exercise in 2009 (described below) and, to a certain extent, for the exercises undertaken by European authorities in the European sovereign debt crisis period. Under such circumstances, standard supervisory procedures for assessing capital adequacy may need to be augmented.

Fifth, stress tests can be used to assess the resiliency of the entire financial system, rather than focusing on each institution’s safety and soundness independently. Thus, a given macrofinancial shock might leave most financial institutions relatively unscathed in the first instance, while severely damaging a few others. Yet the distress of those institutions could precipitate wider distress among the broader set of institutions through both direct channels (for example, counterparty valuation adjustments on derivatives) and indirect channels (for example, the affected institutions’ distress might severely constrain certain types of lending), leading to a deeper recession. At the extreme, supervisors may want certain institutions to deleverage not because of any inherent risk in their balance sheet but because of the presence of other, more vulnerable, institutions in critical parts of the financial system (Greenlaw et al. 2012).

2.2. Design Choices in Using Stress Tests as a Supervisory Tool

When designing a supervisory regime in which stress tests play a significant role, authorities have a number of design choices to make. This section describes the most important of these choices, with some discussion of the merits of various options.

2.2.1. Supervisory scenarios. First, and most obviously, authorities must decide on the nature of the scenarios to be used in the stress tests. Much has been written about scenario selection (see, for example, BCBS 2009; Glasserman, Kang & Kang 2013). Individual market participants, e.g., risk managers at a large bank, often design scenarios to stress a particular conjectured vulnerability of the bank. Scenarios are typically chosen based on a particular historical episode, a hypothetical episode of particular concern to risk managers, or a statistical procedure designed to generate scenarios of a particular probability. In a so-called reverse stress test, the scenario is chosen to be the least severe scenario that nonetheless causes a particular outcome (usually the failure of the firm).

However, a supervisory stress testing regime would use different scenario selection criteria. Supervisors typically use the same scenario across all institutions in an effort to understand the response of the system to a particular shock. Given this, the appropriate scenario is one that represents a stress on the system rather than on a given institution or class of institution, although in practice these may be similar scenarios: Banks and the banking system may both be vulnerable to aggregate, undiversifiable shocks to asset prices and economic activity.

In addition, supervisors often attempt to communicate the procedure by which they develop scenarios so that supervised institutions can, to a certain extent, predict the severity and nature of the scenario they would face. Thus, supervisory stress testing may emphasize a transparent and repeatable process for selecting scenarios rather than any given scenario.

2.2.2. Disclosure. Second, authorities must decide what, if anything, to disclose about the stress tests. Most obviously, the results of the tests themselves may be disclosed. However, authorities

may also disclose (or permit the disclosure of) firms' own separate estimates, qualitative supervisory judgments about the firm, and underlying data on firms' risk drivers.

The results of a supervisory stress test usually take the form of predicted levels of losses, revenue from ongoing business, and the resulting net income and capital levels. Disclosing these results can bolster market confidence in the banking system in times of stress, as well as provide the market with greater information on banks' risks during more normal times (Alvarez & Barlevy 2014). Disclosing the underlying components of capital rather than simply the top-line result can also increase the credibility of the exercise by showing how supervisors came to their final results, as well as increase the information available to market participants (for a survey of the benefits of disclosure, see Bernanke 2013). Goldstein & Sapra (2013) acknowledge the benefits of disclosure but point to four potential problems. First, because banks cannot realistically write contracts contingent on the results of stress tests, the Hirshleifer effect will decrease liquidity in the interbank market. Second, stress tests will increase the pressure on bank managers to show short-term results. Third, negative results will result in runs by investors. Fourth, market participants will decrease the amount of effort devoted to understanding risks in the banking industry and come to rely on the supervisory results.

If the supervisory stress testing regime has banks and supervisors simultaneously estimating losses under the same scenario using different models, authorities face the question of whether to disclose the banks' own results (or rather to permit banks to release their own results). The obvious potential cost of doing so is confusion among market participants should the two sets of results differ markedly. However, having banks disclose results comparable across firms and with the supervisory results can give market participants valuable insights into the quality of firms' risk management processes.

Authorities may tie supervisory actions, such as ratings downgrades, to the quantitative performance of firms in the stress test. If the triggers for supervisory actions are publicly announced, release of the results is tantamount to disclosure of the supervisory actions, which is a relatively uncommon practice. Nonetheless, as discussed earlier, disclosing these actions, as well as others that may be loosely tied to a firm's performance, can enhance the credibility of the supervisory regime.

Finally, supervisors may decide to release sufficient firm-level information to permit market participants to effectively run stress tests of their own, potentially under more severe scenarios than those used by the supervisors. This could reap some of the benefits of stress testing, such as enhanced market discipline and transparency, without necessarily requiring the authorities to precisely identify the scenario of most concern to the markets, which may itself be changing over time. The European Banking Authority (EBA) released data on banks' holdings of sovereign bonds following their 2011 stress tests. Greenwood, Landier & Thesmar (2012) use these data to measure the degree to which any individual bank's distress would damage the financial system.

2.2.3. Capital policy. Third, authorities must decide how to handle any capital shortfalls that are identified by the stress tests. In the case of the 2009 US exercise, the authorities used the stress test to estimate the amount of capital required by the participating banks to permit them to survive an even more severe downturn. Without a clear source of capital, negative revelations about firms' potential losses could cause a coordination failure among market participants, with a resulting run on the affected firms. That said, stress tests conducted during normal business conditions may hypothesize scenarios that are highly unlikely and would take time to develop, thus allowing affected firms to raise additional capital. Authorities may restrict capital payouts (i.e., dividend payments and share repurchases) by firms with poor stress test results, in effect forcing them to build capital buffers from retained earnings.

2.2.4. Balance sheets. Scenarios typically specify multiyear trajectories, with bank capital measured along the hypothetical path. Supervisors and market participants are often most interested in banks' capital ratios along the path. Although supervisors can model the losses on existing loans and securities, they must make assumptions about new business undertaken by the firms. In other words, they must make assumptions about the firms' balance sheets. An easy assumption to communicate and to implement is that total risk-weighted assets remain constant over the scenario horizon. Implicitly, assets that are charged off are replaced with assets that take no further losses.

If they are allowed to project their balance sheets independently, firms face an obvious incentive to project decreases in risk-weighted assets. Although such shrinkage could come at the cost of forgone business, thus translating into lower net revenue, it would also boost capital ratios. However, supervisors may wish to require firms to be sufficiently well capitalized to remain as functioning intermediaries. In such cases, they would likely have to specify rules for the projection of balance sheets or project them independently (Greenlaw et al. 2012).

2.2.5. Models. Some of the most important decisions in designing a supervisory stress testing regime involve the underlying models used to translate macroeconomic developments from scenario- and firm-specific risk factors into losses and income. We discuss the modeling choices made in the US context below. This is a crucial and somewhat underappreciated area.

Supervisors must first decide whether to attempt to produce wholly independent estimates, to use firms' estimates, or some combination of the two, for example, taking firms' projections of revenue but modeling losses independently. Wholly independent models permit supervisors to compare results across firms on a truly apples-to-apples basis, as well as eliminate the obvious incentive for participating firms to play down potential losses in the stress scenario. That said, independent modeling is a resource-intensive process for both supervisors and participating firms. Data on risk factors have to be collected from firms on a completely comparable basis; given potential differences in definitions, in internal risk categorization, and in other systems, firms may struggle to provide sufficiently detailed data. If the requested data are sufficiently granular, e.g., at the loan level, the resulting data sets can be quite large—almost by definition larger than the data used by any single participating firm. Supervisors must invest in the information technology systems to acquire, process, validate, and use these data. Then supervisors must estimate and validate loss and income models for a wide range of assets, including complex derivatives positions, private equity holdings, and loans to real estate developers. In addition to a certain level of technical expertise, this effort requires some data on historical loss experience on which to estimate the models. Such data are often scarce.

Moreover, supervisors choosing to take firms' estimates will likely design a process to challenge estimates that appear too rosy. Indeed, if the participating firms are sufficiently similar and do not collude among themselves, supervisors could design a mechanism where the equilibrium was for all firms to report potential losses truthfully (among many others, see Palfrey & Srivastava 1989).

2.3. Potential Risks to Using Stress Tests as a Supervisory Tool

So far we have emphasized the potential benefits to using stress tests as a supervisory tool: increased credibility of the supervisory regime, transparency, and market discipline. However, there are some potential risks as well.

If supervisors use wholly independent models as described above, participating banks may become focused on reverse engineering the models if they are not made public. Alternatively, if the models are made public, all banks may adopt them for their internal risk measurement and management purposes. This could lead to an unwelcome model monoculture in which all banks

have the same view of the risks to various asset classes and thus would fall victim to the same blind spots in the model (Bernanke 2013, Schuermann 2013).

Banks that show relatively high poststress capital ratios would presumably be perceived as good risks by investors. The sudden collapse of such a bank, perhaps caused by an idiosyncratic event, or in the face of a macro stress less severe than the stress scenario, could shake confidence in the entire stress testing regime, calling into question not just the resiliency of other participating banks, but also the competence of the supervisory authorities. Ultimately, confidence could be sufficiently diminished to precipitate a coordination failure among investors and a rush to pare exposures to the banking system.

2.4. Other Approaches to Stress Testing

So far we have focused on stress tests that project firms' capital ratios based on modeled losses and incomes under a hypothetical scenario. The focus in such exercises is on firms' net incomes, with negative net income diminishing firms' capital cushions.

However, one could also stress firms' buffers of liquid assets. Instead of—or in tandem with—a shock to credit quality, authorities could design a scenario featuring draws on committed lines of credit coupled with investor reluctance to lend to firms. (This could be seen as a longer-run version of Basel III's liquidity coverage ratio.) One could integrate capital and liquidity stresses by specifying the extent to which investors would demand greater compensation for lending to a bank as its losses mounted and its capital cushion was depleted. Indeed, the Bank of England's Risk Assessment Model of Systemic Institutions has precisely such a feedback effect (Burrows et al. 2012).

Another approach is to use historical correlations between firms' stock prices and overall stock indexes as well as basic information about firms' balance sheets to estimate the decline in market equity following a standardized shock to equity prices. Such approaches have several advantages: They are transparent, are straightforward to implement, use only publicly available data, and summarize market participants' views of a firm's risk. They also can be implemented for a wide variety of publicly traded firms, not simply banks. Acharya, Engle & Richardson (2012) implement such an approach and make the results available on the publicly accessible website <http://vlab.stern.nyu.edu/welcome/risk/>.

3. STRESS TESTING IN SUPERVISION

As discussed in the previous section, supervisors face a range of design choices in implementing a supervisory stress testing regime. This section provides a brief history of coordinated supervisory stress testing in the United States and describes how stress tests have been integrated into the ongoing supervision of large, complex US banking organizations. The discussion highlights the stress test design choices made by US supervisors in implementing these programs, with an emphasis on how the choices were influenced by the microprudential and macroprudential objectives of the programs. Given the close link between the objectives and the design choices, the section interweaves discussion of the choices with discussion of the broader objectives of the programs, rather than discussing each design choice separately in turn.

3.1. Supervisory Stress Testing During the Financial Crisis

Coordinated supervisory stress tests of large bank holding companies were first conducted in the United States during the depths of the financial crisis. The Supervisory Capital Assessment Program (SCAP) involved stress tests of the 19 largest US-owned BHCs, representing about two-thirds of the assets of the US banking system (Board Gov. Fed. Reserve Syst. 2009a). The

goal of the SCAP was to ensure that the largest US BHCs had sufficient capital to withstand a worse-than-anticipated macroeconomic outcome and continue to lend. The SCAP was launched in February 2009, a period of extreme stress in the US banking industry, following the collapse of Lehman Brothers and subsequent distress at other large BHCs and securities firms. By requiring large BHCs to build a buffer of capital sufficient to withstand potential stressed losses, the SCAP was intended to reduce uncertainty and promote confidence in individual BHCs and in the banking system, with the ultimate goal of averting the worst of the potential economic outcomes (Board Gov. Fed. Reserve Syst. 2009b). The goals of the SCAP, therefore, had both macroprudential and microprudential aspects (Hirtle, Schuermann & Stiroh 2009).

The SCAP stress tests assessed the impact of two hypothetical macroeconomic scenarios on each BHC's net income and capital over a two-year forward horizon. The scenarios were a baseline scenario that reflected consensus expectations for the path of the economy and a more adverse scenario that was a deeper and longer recession than was expected at the time. Projections of net income and capital were combinations of projections made by the BHCs, projections from models developed by supervisors, comparisons to historical data and benchmarks, and supervisory judgment. Capital ratios were calculated for each firm under each scenario and compared to minimum target levels. BHCs whose projected poststress capital ratios fell below one or more of these targets were required to raise new capital in amounts sufficient to eliminate the shortfall between the poststress ratio and the target level. These amounts were expressed in dollar terms; that is, BHCs with a capital shortfall in the SCAP were required to raise a given dollar amount of capital rather than to increase their capital ratios to the target levels. This was a critical element of the SCAP, as banks could not meet the targets by reducing lending or shrinking their balance sheets. The results of the SCAP for each BHC were publicly disclosed, along with a description of the methods used to make the projections (Board Gov. Fed. Reserve Syst. 2009a,b).

The SCAP identified an aggregate capital shortfall for the 19 participating BHCs of \$185 billion, nearly all of which represented a deficit in common equity relative to the target levels established for the exercise. After taking into account asset sales and restructuring of capital instruments (for instance, conversions of preferred shares into common) that had taken place after the as-of date of the stress tests, the net capital shortfall was \$75 billion. Ten of the 19 BHCs were identified as having a capital shortfall relative to the target levels (Board Gov. Fed. Reserve Syst. 2009b).

The SCAP was conducted by the Federal Reserve and the other federal banking regulatory agencies as part of the US Treasury's Capital Assistance Program (CAP). Under the CAP, the Treasury provided a capital backstop to the participating BHCs; qualifying BHCs could receive contingent common equity from the US government if they were unable to raise private capital (US Dep. Treas. 2009). Only one of the ten BHCs with a capital shortfall, Ally Financial, made use of the backstop. The remaining nine BHCs, along with several BHCs without an SCAP capital shortfall, raised \$100 billion in private common equity in the months following the release of the SCAP results.

The SCAP was an innovation in supervisory practice in several dimensions. The most frequently noted aspect of the SCAP is the public disclosure of firm-specific results, which represented a significant departure from previous supervisory practice. Traditionally, supervisory assessments of individual firms had been treated confidentially. Public disclosure of these findings was viewed as critical to achieving the SCAP's goal of reducing uncertainty and enhancing confidence, as well as to supporting the credibility of the work (Board Gov. Fed. Reserve Syst. 2009b).² However,

²Morgan, Peristiani & Savino (2014) find no significant stock price reaction based on whether an SCAP BHC was identified as having a capital shortfall, suggesting that the market had already determined which BHCs were likely to need additional

perhaps as fundamental as increased public transparency, using forward-looking stress test results instead of current static capital ratios was a major innovation. The approach provided supervisors with an analytical tool to address the shortcomings of book-value regulatory capital measures, which were particularly acute in the crisis period given the sharp drop in bank equity market values. In particular, evaluating current capital positions against possible future stress helped distinguish which firms were less likely to be able to continue to lend should economic conditions worsen and provided credible evidence to support supervisory insistence that the BHCs raise additional common equity. The existence of the Treasury capital backstop was particularly important in that regard, given the uncertainty and volatility of the financial crisis setting.

European banking authorities also conducted a series of stress testing exercises during the financial crisis. The first of these, in October 2009, involved about two dozen large, cross-border banking organizations, whereas subsequent exercises in 2010 and 2011 involved 90 banks in 20 countries. The exercises were overseen and coordinated by centralized European banking authorities—the Committee of European Banking Supervisors (CEBS) in 2009 and 2010 and the EBA in 2011—with the participation of the various national banking authorities. The stress test results in these exercises were generated by the banks and reviewed and adjusted by national banking authorities on the basis of common scenarios provided by the European authorities.

In contrast to the SCAP, the 2009 European stress tests exercise did not publish firm-specific results. Instead, summary results were released, indicating that none of the 22 participating banks had a poststress Tier 1 capital ratio below 6% (CEBS 2009). In 2010 and 2011, however, stress test results for individual firms were published, along with, in 2011, extensive country-level information about each bank's private and corporate lending exposures. The results suggested that seven and eight banks would have poststress capital ratios falling below supervisory target levels in 2010 and 2011, respectively, taking into account capital raised by the banks after the as-of date of the stress test (CEBS 2010; EBA 2011). National banking authorities were expected to work with banks whose poststress capital ratios fell below target levels to develop plans to increase those ratios and to work with banks with significant sovereign exposures to strengthen their capital positions. The EBA committed to tracking developments following the release of the 2011 stress tests, and it published a report in 2012 describing steps taken by each of the eight banks to increase their capital ratios (EBA 2012).

3.2. Stress Testing in Ongoing Supervision

Following the SCAP, US supervisors began to integrate coordinated stress testing into the ongoing supervision of large banks and BHCs. This process began in early 2011 with the introduction of the Comprehensive Capital Analysis and Review (CCAR), a supervisory program to assess large BHCs' internal capital planning processes and capital positions, and continued with the implementation of the Dodd-Frank Act stress testing (DFAST) provisions in 2013. The DFAST and CCAR stress tests are closely linked, but they are distinct in ways that reflect the objectives of each program.

3.2.1. Dodd-Frank Act stress testing: innovative disclosure. Similar to the SCAP, the DFAST stress tests are designed to provide information about the capital strength of the individual BHCs participating in the program as well as the capital strength of the overall US banking system. As required by the Dodd-Frank Act, on an annual basis the Federal Reserve generates stress test results under three supervisory scenarios—baseline, adverse, and severely adverse—for all US

capital, but that stock price reactions were associated with the size of the capital shortfall. Their conclusion is that the disclosure of SCAP results provided valuable information to the market.

BHCs with at least \$50 billion in total assets³ and discloses a summary of the results. In 2014, 30 large BHCs were part of the exercise. In addition to the supervisory scenario results generated by the Federal Reserve, the Dodd-Frank Act also requires financial companies to generate and disclose stress test results based on scenarios that they develop as well as on the three Federal Reserve scenarios.⁴

The supervisory scenarios are developed by the Federal Reserve, which follows guidelines developed to ensure the rigor and consistency of the scenarios and the transparency of the scenario design process (Board Gov. Fed. Reserve Syst. 2013b). The scenarios include assumed paths for more than two dozen macroeconomic and financial market variables—including US unemployment rate, GDP growth, interest rates, credit spreads, and stock prices as well as variables for several foreign countries and country blocks—over the stress test horizon. As in the SCAP, the baseline scenario is intended to capture consensus expectations for the development of the economy over the stress test horizon. The severely adverse scenario is designed to incorporate a significant recession, including a meaningful increase in the unemployment rate; the size of the increase and the peak level of unemployment will vary based on prevailing economic conditions to reduce procyclicality in the severity of the scenario. The severely adverse scenario can also include elements designed to capture salient risks under current economic and financial market conditions, such as severe deterioration in a particular sector of the economy or extreme stress in a given geographic region, that might not be captured by more generic recession-based factors. In general, the adverse scenario will be less harsh than the severely adverse scenario, though it can be designed to explore perceived vulnerabilities or risks of particular interest given prevailing economic conditions.

The DFAST supervisory stress tests are intended to assess how the BHCs' regulatory capital ratios would evolve under the conditions specified in the supervisory scenarios. These calculations are based on projections of net income for each BHC over a nine-quarter stress test horizon. Net income is calculated according to US generally accepted accounting principles for all significant components of revenues, expenses, and losses, including losses on the accrual loan portfolio and losses on investment securities. Net income projections for BHCs with large trading or derivatives exposures also incorporate losses from a one-time market shock on these positions, which is assumed to occur in the first quarter of the stress test horizon. Revenues include net interest income (the difference between interest earned and interest paid) and noninterest income such as fees and commissions. Expenses include compensation and operating costs as well as projected losses from operational risk events, legal settlements, and mortgage repurchases.

Projections of the various components of net income are generated using a series of independent supervisory models developed by the Federal Reserve. These include models that project loss rates for various types of loans (e.g., first lien residential mortgages, credit cards, loans to corporate borrowers, and commercial real estate loans), losses on investment portfolio securities, operational risk losses, and various revenue and expense categories. The models are designed to capture the impact of the characteristics of each BHC's loan and securities portfolios, trading and counterparty

³The Dodd-Frank Act also requires the Federal Reserve to generate stress test results for systemically important nonbank financial institutions designated by the Financial Stability Oversight Council (FSOC) to be supervised by the Federal Reserve, as well as for certain savings and loan holding companies (see 12 U.S.C. § 5365(i)(1); Board Gov. Fed. Reserve Syst. 2012). These institutions are being transitioned into the DFAST stress test program on the basis of the time at which they were designated by the FSOC.

⁴All federally regulated financial companies, including BHCs, with assets greater than \$10 billion are required to generate stress test results under the three supervisory scenarios and to disclose the results once a year. BHCs with assets greater than \$50 billion are also required to generate and disclose a second set of stress test results based on baseline, adverse, and severely adverse scenarios that they develop.

positions, and revenue and expense sources, as well as the impact of changes in the macroeconomic and financial market variables in the supervisory scenarios.

The goal in developing these models is to generate projections that reflect important firm-specific characteristics and that are consistent across BHCs and independent of the banks' own projections. The models are calibrated using industry-wide data from many banks, meaning that the model parameters reflect average behavior across firms rather than being firm specific. Variation across firms is captured via extensive firm-specific input data collected by the Federal Reserve on monthly, quarterly, and annual regulatory reports (the Federal Reserve Y-14 reports). Much of this input data is collected at the loan level, including information about the characteristics of the borrower, loan, and collateral. The models make very limited use of fixed effects or other techniques intended to capture persistent cross-firm differences that cannot be explained by other variables.

Projected net income, along with assumptions about capital actions such as dividends and stock issuance and repurchases, drives projected changes in regulatory capital over the stress test horizon. In DFAST calculations, dividends are assumed to equal each firm's average dividends (in dollars) over the last four historical quarters and new stock issuance and repurchases are assumed to be zero, except for issuance associated with employee compensation. This assumption is intended to be neutral across BHCs participating in DFAST, in the sense that each firm's own recent historical behavior is reflected in the projections, rather than imposing supervisory assumptions about how each firm might behave under the different scenarios. Regulatory capital is calculated in each quarter of the stress test horizon under the US regulatory capital rules that will apply in that actual calendar quarter, consistent with the transition to the new Basel capital rules in the United States.

Regulatory capital ratios are calculated using projections of total assets and risk-weighted assets for each scenario.⁵ The risk-weighted asset projections are based on the US regulatory capital rules that will apply to each firm in the actual calendar quarter during the stress test horizon. Beginning with DFAST 2014, the Federal Reserve's stress test results are based on its own independent balance sheet and risk-weighted asset projections; prior to 2014, balance sheet and risk-weighted asset projections from the firms were used in the Federal Reserve's DFAST calculations. The Federal Reserve's projections of total assets and other balance sheet components are made under the assumption that credit supply does not contract during the adverse and severely adverse scenarios. This assumption tends to result in higher levels of assets and risk-weighted assets than projections that do not enforce this assumption (Board Gov. Fed. Reserve Syst. 2014b). This assumption is also consistent with a macroprudential view of the DFAST stress tests, in that the results measure capital strength relative to the benchmark that banks should continue to be able to lend to creditworthy borrowers even in stressful economic conditions.

The results of the DFAST stress tests are publicly disclosed, both in the aggregate and for each of the individual BHCs participating in the exercise. The disclosures include information on nine-quarter cumulative projected preprovision net revenue (net interest income plus noninterest income minus noninterest expense), loan loss amounts and rates by loan category, losses on securities, losses on trading and counterparty positions, and overall pretax net income, as well as the starting, ending, and minimum values of each of the regulatory capital ratios projected in the exercise⁶ under the adverse and severely adverse scenarios.

⁵The balance sheet projections also have a significant impact on the loss, revenue, and expense projections, as these projections are based on projections of the balance sheet over the stress test horizon (Board Gov. Fed. Reserve Syst. 2014b).

⁶In DFAST 2014, these capital ratios were the ratio of common equity Tier 1 capital to risk-weighted assets (the common equity Tier 1 ratio), the ratio of Tier 1 capital to risk-weighted assets (the Tier 1 risk-based capital ratio), the ratio of total

No specific supervisory actions are attached to DFAST results beyond a requirement that the BHCs take the results into account in their capital planning (Board Gov. Fed. Reserve Syst. 2012). The key contribution of DFAST results is to provide information about the capital strength of individual BHCs and of the banking system as a whole. These kinds of assessments are facilitated by the consistency of the Federal Reserve's DFAST projections across firms (same scenarios and industry-level models as well as consistent asset and risk-weighted asset assumptions), as well as by comparison of the Federal Reserve's projections to those of the participating BHCs (same scenario, different models and growth assumptions). For instance, Hirtle & Kovner (2014) compare the Federal Reserve and BHC projections from DFAST 2013 and find agreement about some sources of potential vulnerability in a downturn (large increases in losses on commercial and industrial loans and low potential loss increases in junior lien mortgages under the severely adverse scenario), but also significant disagreement in other areas (the Federal Reserve projections suggest large increases in first lien residential loan losses, whereas the BHC projections suggest very small increases).

3.2.2. Comprehensive Capital Analysis and Review: innovative supervision. In contrast to DFAST, there are direct and meaningful supervisory consequences of the stress test results in CCAR. As noted above, CCAR is a supervisory program that assesses the internal capital planning and capital positions of large BHCs. The first CCAR was in 2011, at a time when many BHCs wanted to resume dividend payments and share repurchase programs that had been suspended or significantly decreased during the financial crisis (Hirtle 2014). The Federal Reserve implemented CCAR to provide a framework for determining whether the largest and most complex US BHCs had sufficient capital to resume these distributions (Board Gov. Fed. Reserve Syst. 2011b). More significantly, CCAR provides a framework and tools to assess BHCs' internal capital planning processes and capital positions on an ongoing basis, with the goal of ensuring that these processes are rigorous and robust. Following the adoption of the Capital Plan Rule in November 2011, CCAR is now an annual process, providing the Federal Reserve with the tools and authority to restrict capital distributions should conditions at an individual BHC deteriorate (Board Gov. Fed. Reserve Syst. 2011a).

In 2014, 30 BHCs with assets of at least \$50 billion participated in CCAR, the same population of firms for which the Federal Reserve makes DFAST projections. As part of CCAR, BHCs must submit annual capital plans to the Federal Reserve. These capital plans must include a detailed description of the firm's internal capital planning process and governance over that process; its policy governing capital actions such as dividends, repurchases, and share issuance; its planned capital actions for the next nine quarters under both baseline and stressed economic conditions; and a set of company-run stress test projections under three scenarios provided by the Federal Reserve (baseline, adverse, and severely adverse) and under two bank-determined scenarios, including a baseline scenario and a BHC stress scenario intended to stress the firm's unique vulnerabilities based on its portfolio and business focus.

The Federal Reserve reviews the capital plans submitted by the BHCs and evaluates their processes and governance against a set of supervisory expectations and the requirements of the Capital Plan Rule (Board Gov. Fed. Reserve Syst. 2013a, Clark & Ryu 2013). This review has both qualitative and quantitative components. The qualitative component involves assessments of the firms' internal processes for determining how much capital they need to have, including

risk-based capital to risk-weighted assets (the total risk-based capital ratio), and the ratio of Tier 1 capital to average assets (the Tier 1 leverage ratio).

especially their stress testing models, data, and assumptions. The focus of this assessment is on the processes firms use to develop and implement their BHC stress scenarios, emphasizing the unique vulnerabilities arising from their particular business strategies. The qualitative review also covers the firms' internal capital policies, which are intended to provide a framework and governance structure around the BHCs' decisions about dividend payments, share repurchases, and share issuance. Finally, the qualitative review assesses the firms' progress in addressing and remediating previously identified deficiencies in their internal processes and governance (Board Gov. Fed. Reserve Syst. 2014a).

The quantitative aspects of CCAR involve evaluating whether the BHCs' current capital positions are adequate given their business focuses, portfolios, and risk exposures. In particular, the Capital Plan Rule requires that each BHC be able to demonstrate that its capital ratios would remain above minimum regulatory levels under both baselines and stressed economic conditions (Board Gov. Fed. Reserve Syst. 2011a). This assessment is based on the bank-generated stress test results and a set of supervisory stress test results generated by the Federal Reserve.

The supervisory stress test results for CCAR are very closely linked to the Federal Reserve's DFAST stress test projections. Both are based on the same three scenarios provided by the Federal Reserve—baseline, adverse, and severely adverse—and the same projections of the balance sheet, risk-weighted assets, and net income.⁷ The two sets of projections differ in the capital actions assumed in generating the poststress capital ratios. As noted above, DFAST capital ratios use stylized assumptions about dividends based on each BHC's recent dividend behavior, whereas CCAR capital ratios are based on the planned capital actions included in each firm's capital plan. This is consistent with the goal of CCAR, which is to assess each BHC's internal capital planning and the capital actions that would be the outcome of that planning. In particular, the CCAR capital ratios generated by the Federal Reserve under the adverse and severely adverse scenarios include each BHC's planned capital actions under its baseline scenario. This is a stringent test of capital actions included in each company's capital plan, because it assumes that the firms continue to pay dividends and repurchase shares even if economic conditions deteriorate significantly. Depending on the difference between each BHC's planned capital actions and the stylized capital actions assumed in DFAST, the DFAST poststress capital ratios can be higher or lower than the CCAR ratios.

If CCAR qualitative assessment reveals significant weaknesses in a BHC's internal capital planning processes or governance, or if the stress test results suggest that minimum regulatory capital levels would be breached under stressed conditions, then the Federal Reserve may object to the company's capital plan. In that event, the BHC may make only those dividend payments and share repurchases approved by the Federal Reserve and must resubmit its capital plan after addressing the concerns raised in the initial review. Depending on the nature and extent of the concerns about a BHC's capital plan and current capital position, the Federal Reserve could require the company to stop dividend payments and share repurchases entirely or could permit these actions within certain bounds. If the Federal Reserve does not object to a BHC's capital plan, then the firm may make the distributions included in its capital plan. All BHCs participating in CCAR receive extensive supervisory feedback on their capital planning processes, including identification of areas that require improvement.

The results of CCAR are publicly disclosed. These disclosures include the minimum values of each company's regulatory capital ratios under the adverse and severely adverse scenarios as

⁷The company-generated CCAR and DFAST stress test results are also closely linked, as they are also based on the three supervisory scenarios provided by the Federal Reserve and the same balance sheet, risk-weighted assets, and net income projections.

projected by the Federal Reserve and, starting with CCAR 2013, whether the Federal Reserve objected to each company's capital plan. For those firms whose capital plans received an objection, a brief description of the reasons for the objection is also disclosed.

Disclosure of CCAR results builds on the ground established during the 2009 SCAP, one of the few instances of public disclosure of supervisory findings. Along with the closely related DFAST disclosures, CCAR disclosures provide potentially important information about the participating BHCs, though, as we discussed earlier, there are some who argue that regular disclosure of supervisory information is not necessarily optimal. Beyond information about the individual firms, disclosure of CCAR and DFAST results also plays a role in fostering the continued rigor of the program and of the supervisory stress testing that supports it. Market participants and analysts can track the severity of the scenarios and the stringency of the projections over time to gauge whether the BHCs are still being credibly stressed in the analysis.

CCAR represents a number of important innovations in supervisory practice. Most obviously, it builds on the 2009 SCAP by incorporating forward-looking, dynamic assessment of capital adequacy at large, complex BHCs through the integration of stress testing. Although this aspect of CCAR is often what attracts most attention, the supervisory elements of the program are equally as innovative and consequential. The quantitative aspects of CCAR represent a tilt from discretion toward rules in the supervision of these large and complex institutions, as BHCs with stressed capital ratios falling below regulatory minimum levels face objection to their capital plans and thus limits on their ability to distribute capital to shareholders.⁸ As noted, the public disclosure of these outcomes reinforces this tilt toward rules.

The qualitative elements of CCAR emphasize self-identification of risks to capital rather than reliance on static supervisory measures of capital adequacy. Much of the CCAR review focuses on the stress tests performed under each firm's idiosyncratic BHC stress scenario, which is intended to reflect the particular risks facing each BHC. Focusing on the BHC stress scenario result can also counteract incentives for BHCs to simply mimic Federal Reserve stress test results and the resultant risk of model monoculture, in which all banks evaluate risk using the same kind of models under the same sort of scenarios (Schuermann 2013). Further, the Capital Plan Rule requires each of these BHCs to develop a formal capital policy governing dividends, share repurchases, and other capital actions, including specifying the circumstances under which these distributions can be increased or might be curtailed. This requirement has fostered the development of more robust governance structures around these actions, as well as the ability for supervisors to track whether banks are adhering to their own policies as circumstances change.

4. CONCLUSION

Prior to the financial crisis, stress testing was seen as one of many risk management tools and was not a major component of bank supervisory programs. Perhaps because housing-related assets are subject to a few major and undiversifiable risk factors (mainly house prices and interest rates), there is a longer tradition of scenario analysis in assessing the risk embedded in mortgage portfolios. For example, the capital regulation of Fannie Mae and Freddie Mac was based on a stress test, many of whose parameters were set by law.

⁸BHCs have an opportunity to make a one-time downward adjustment in their planned capital actions after receiving the initial results of the Federal Reserve's CCAR stress tests. The final CCAR quantitative assessment is based on stressed capital ratios using the adjusted capital actions. The CCAR disclosures include capital ratios based on both the initial and the adjusted capital actions, so it is clear which BHCs made such adjustments and how much the minimum values of the ratios changed after the adjustment (Board Gov. Fed. Reserve Syst. 2014a).

At the depths of the US financial crisis (in 2009) and the peak of the European sovereign debt crisis (in 2010 and 2011), national authorities turned to bank stress tests as a credible means of assessing and communicating to the public the health of banking systems. Since then, supervisory authorities have moved to make stress testing a central part of their supervisory regimes; the Dodd-Frank Act and the associated Capital Plan Rule in the United States and the European Central Bank's Single Supervisory Mechanism both put stress testing at the center of new supervisory regimes.

However, in designing a supervisory regime around stress tests, authorities have a number of choices and decisions to make. In this article we described these fundamental design choices and provided some sense of the benefits and costs to be weighed in making the decisions.

We described in some detail the US stress testing regime during the crisis and in the postcrisis era. Stress tests play a key role in ongoing supervision through the CCAR process, as well as in communicating information to market participants through the DFAST process.

Among the myriad concerns facing policymakers as they design a supervisory regime, we highlighted the role of independent supervisory modeling and associated disclosures. Although such a regime generates clear incentives for banks to mimic or reverse engineer supervisory models, leading to an unwelcome model monoculture, there are clear benefits to developing the expertise and data necessary to form an independent quantitative estimate of banks' capital adequacy.

DISCLOSURE STATEMENT

The authors are not aware of any affiliations, memberships, funding, or financial holdings that might be perceived as affecting the objectivity of this review. The views expressed in this article are those of the authors and do not necessarily represent the views of the Federal Reserve Bank of New York, the Board of Governors of the Federal Reserve System, or their staffs.

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