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Supervisory Stress Tests

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Abstract

This article describes 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 process of the ongoing prudential supervision of banks and other large financial institutions. We then describe how the U.S. CCAR/DFAST regime is designed and what that means for the macroprudential vs. microprudential nature of the U.S. exercises. We argue 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.

Key words: stress tests, bank capital

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I. 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 process of the ongoing prudential supervision of banks and other large financial institutions. We then describe how the U.S. supervisory stress testing regime is designed and how stress tests are integrated in the broader supervisory program, and what that means for the macroprudential vs. microprudential nature of the U.S. exercises. We argue adding routine stress tests has 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 has increased dramatically since the recession and associated financial crisis of 2007—2009. However, stress tests as supervisory tools date back before this episode, and as a financial risk management tool 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 the 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 a scenario with several self-consistent variables that describe a complete macrofinancial environment. The first appearance of such exercises appears to be related to mortgage markets, perhaps because mortgage risk is tied to a few aggregate variables—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, the legislation that created the regulatory framework for the housing-related government-sponsored enterprises (GSEs) Fannie Mae and Freddie Mac. The 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 et al. 2013).

The Basel Market Risk Amendment – finalized in 1995 – contained a provision encouraging the use of stress tests to augment the Value at Risk (VaR) measures of computing risk-weighted assets, the denominators in various measures of risk-based capital.¹ VaR models consider the probability distribution of the value of a portfolio of assets. In principle VaR models can be thought of as the result of thousands of individual scenarios, weighted by their 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 a national banking system (Jones et al. 2013).

Thus, capital regulation of the 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. In addition, stress tests were widely used by credit rating agencies in the pre-crisis period. Given the substantial capital shortfalls that emerged at the GSEs, 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.

II. Stress testing as a supervisory tool

Stress tests have the potential to drive a supervisory regime that is quite different from the typical pre-crisis regime, although, as we will 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.

a. 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 an entire firm under a particular scenario. Traditional supervision is characterized by an emphasis on assessing banks' processes. For example, a primary manual of a major U.S. bank

¹ The 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.” (Basel Committee on Banking Supervision 1995).

supervisory, the OCC, known as the *Comptroller's Handbook* states "...high quality bank supervision...[e]nsures that banks have appropriate risk management systems that encompass a sound audit program and a strong internal control program." Of course, the *Handbook* also calls for a supervisory regime that "[e]nsures that examiners recognize and appropriately assess the risks posed by all significant lines of business" (Office of the Comptroller of the Currency 2013). Thus, quantitative metrics have a role to play in this view of supervision, 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 of Governors of the Federal Reserve System 2005). Maintaining the confidentiality of exam 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 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 U.S. 2009 stress test exercise (described below) and to, a certain extent, 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 direct channels, for example, counterparty valuation adjustments on derivatives, and through 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).

b. 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.

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 Bank for International Settlements 2009, Glasserman et al. 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, a statistical procedure designed to generate scenarios of a particular probability, or a so-called reverse stress test, in which 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 which 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 emphasizing any given scenario.

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 providing the market with greater information on banks' risks during more normal times (Alvarez and 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 increasing the information available to market participants. (See Bernanke 2013 for a survey of the benefits of disclosure.) Sapra and Goldstein (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, that the "Hirschleifer effect" will decrease liquidity in the interbank market. Second, that stress tests will increase the pressure on bank managers to show short-term results. Third, that negative results will result in runs by investors. Fourth, that 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 the potential 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, as we discussed earlier, is a relatively uncommon practice. Nonetheless, as discussed earlier, disclosing these actions, as well as others that may be somewhat 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 identify precisely the scenario of most concern to the markets, which may itself be changing over time. The European Banking Authority released data on banks' holdings of sovereign bonds following their 2011 stress tests. Greenwood et al. (2012) used these data to measure the degree to which any individual bank's distress would damage the financial system.

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 U.S. 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.

4. Balance sheets

Scenarios typically specify multi-year trajectories, with bank capital measured along the hypothetical path. Supervisors and market participants are often most interested in banks' capital ratios along the path. While 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. While 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 do so independently (Greenlaw et al. 2012).

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 the scenario and firm-specific risk factors into losses and income. We discuss the modeling choices made in the U.S. context below. This is a crucial and somewhat under-appreciated area.

Supervisors must first decide whether to attempt to produce wholly independent estimates, use firms' estimates, or some combination of the two – for example, taking firms' projections of revenue but modelling losses independently. Wholly independent models permit supervisors to compare results across firms on a truly apples-to-apples basis, as well as eliminating the obvious incentive for participating firms to play down potential losses in the stress scenario. That said, independent modelling 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, internal risk categorization and other systems differences, firms may struggle to provide sufficiently detailed data. If the requested data are sufficiently granular, e.g. at the loan level, the resulting datasets can be quite large – almost by definition larger than the data used by any single participating firm. Supervisors must invest in the IT 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 – everything from complex derivatives positions to private equity holdings to 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 amongst 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).

c. 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. (See Bernanke 2013 and Schuermann 2013.)

Banks that show relatively high post-stress 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 of 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.

d. Other approaches to stress testing

So far we have focused on stress tests that project firms’ capital ratios based on modeled losses and incomes along 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 would also 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 RAMSI model has precisely such “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, straightforward to implement, use only publicly available data and summarize market participants' views of a firm's risk. They can be implemented for a wide variety of publicly traded firms, not simply banks. Acharya et al. (2012) implement such an approach, and make the results available on a publicly accessible website.

III. 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 on-going supervision of large, complex U.S. banking organizations. The discussion highlights the stress test design choices made by U.S. 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.

a. 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 U.S.-owned bank holding companies, representing about two-thirds of the assets of the U.S. banking system (Board of Governors of the Federal Reserve System 2009a). The goal of the SCAP was to ensure that the largest U.S. bank holding companies 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 U.S. banking industry, following the collapse of Lehman Brothers and subsequent distress at other large banking companies and securities firms. By requiring large bank holding companies to build a buffer of capital sufficient to withstand potential stressed losses, the SCAP was intended to reduce uncertainty and promote confidence in individual banking companies and in the banking system, with the ultimate goal of averting the worst of the potential economic outcomes (Board of Governors of the Federal Reserve System 2009b). The goals

of the SCAP, therefore, had both macroprudential and microprudential aspects (Hirtle, Schuermann and Stiroh 2009).

The SCAP stress tests assessed the impact of two hypothetical macroeconomic scenarios on each bank holding company'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 bank holding companies, 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. Bank holding companies whose projected post-stress 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 post-stress ratio and the target level. These amounts were expressed in dollar terms; that is, bank holding companies 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 bank holding company were publicly disclosed, along with a description of the methods used to make the projections (Board of Governors of the Federal Reserve System 2009a, 2009b).

The SCAP identified an aggregate capital shortfall for the 19 participating bank holding companies 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 bank holding companies were identified as having a capital shortfall relative to the target levels (Board of Governors of the Federal Reserve System 2009b).

The SCAP was conducted by the Federal Reserve and the other federal banking regulatory agencies as part of the U.S. Treasury's Capital Assistance Program (CAP). Under the CAP, the Treasury provided a capital backstop to the participating bank holding companies – qualifying bank holding companies could receive contingent common equity from the U.S. government if they were unable to raise private capital (U.S. Department of the Treasury 2009). Only one of the 10 bank holding companies with a capital shortfall (Ally Financial) made use of the backstop. The remaining nine banking companies, along with

several bank holding companies 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 have been treated confidentially. As noted in the paper containing the SCAP results, 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 of Governors of the Federal Reserve System 2009b).² However, 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 banking holding companies raise additional common equity. The existence of the U.S. Treasury capital backstop was particularly important in 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, while 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 in 2009 and 2010 and the European Banking Authority 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 supervisory authorities, based on 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 post-

² Peristiani et al. (2010) find no significant stock price reaction based on whether an SCAP bank holding company was identified as having a capital shortfall, suggesting that the market had already determined which banking companies were likely to need additional 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.

stress Tier 1 capital ratio below 6 percent (Committee of European Banking Supervisors 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 post-stress 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 (Committee of European Banking Supervisors 2010; European Banking Authority 2011). National supervisory authorities were expected to work with banks whose post-stress 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 European Banking Authority committed to track developments following the release of the 2011 stress tests, and published a report in 2012 describing steps taken by each of the eight banks to increase their capital ratios (European Banking Authority 2012).

b. Stress testing in on-going supervision

Following the SCAP, U.S. supervisors began to integrate coordinated stress testing into the on-going supervision of large banks and bank holding companies. This process began in early 2011, with the introduction of the Comprehensive Capital Analysis and Review (CCAR), a supervisory program to assess large banking companies' internal capital planning processes and capital positions, and was followed by the implementation of the Dodd-Frank Act stress testing (DFAST) provisions in 2013. The DFAST and CCAR stress tests are closely linked, but are distinct in ways that reflect the objectives of each program.

1. *DFAST: Innovative Disclosure*

Similar to the SCAP, the DFAST stress tests are designed to provide information about the capital strength of the individual banking companies participating in the program as well as the capital strength of the overall U.S. 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 U.S. bank holding companies with at least \$50 in total assets³, and discloses a summary of the results. In 2014, 30 large bank holding companies were part of the exercise. The Dodd-

³ The Dodd-Frank Act also requires the Federal Reserve to generate stress test results for systemically important non-bank 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 USC 5365(i)(1) and Board of Governors of the Federal Reserve System 2012). These institutions are being transitioned into the DFAST stress test program, based on the time at which they were designated by the FSOC.

Frank Act also requires financial companies to generate and disclose stress test results based on the supervisory scenarios as well as scenarios developed by each banking company.⁴

The supervisory scenarios are developed by the Federal Reserve, following guidelines developed to ensure the rigor and consistency of the scenarios, as well as the transparency of the scenario design process (Board of Governors of the Federal Reserve System 2013b). The scenarios include assumed paths for more than two dozen macroeconomic and financial market variables – including the U.S. unemployment rate, GDP growth, interest rates, credit spreads, and stock prices, and 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 bank holding companies' regulatory capital ratios would evolve under the conditions specified in the supervisory scenarios. These calculations are based on projections of net income for each bank holding company over a nine-quarter stress test horizon. Net income is calculated according to U.S. generally accepted accounting principles (GAAP) 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 bank holding companies with large trading or derivatives exposures also incorporate losses from a one-time market shock on these positions, 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 non-interest income

⁴ All federally regulated financial companies – including bank holding companies – 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. Bank holding companies 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.

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 banking company's loan and securities portfolios, trading and counterparty 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, that are consistent across banking companies, and that are 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 the 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 banking companies 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 U.S. 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 U.S. 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 of Governors of the Federal Reserve System 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 bank holding companies participating in the exercise. The disclosures include information on nine-quarter cumulative projected pre-provision net revenue (net interest income plus non-interest income minus non-interest expense), loan loss amounts and rates by loan category, losses on securities, losses on trading and counterparty positions, and overall pre-tax 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. As noted, the capital ratios are calculated under the U.S. regulatory capital rules that will prevail in each calendar quarter of the stress test horizon. In addition, for consistency with past stress test exercises, the DFAST 2014 disclosures also included the Tier 1 common ratio, calculated based on the definition of Tier 1 capital and risk-weighted assets prevailing before the implementation of the new Basel regulatory capital rules in the United States.

No specific supervisory actions are attached to the DFAST results, beyond a requirement that the banking companies take the results into account in their capital planning (Board of Governors of the

⁵ The balance sheet projections also have a significant impact on the loss, revenue, and expense projections, since these projections are based on projections of the balance sheet over the stress test horizon. See Board of Governors of the Federal Reserve System 2014b.

⁶ In 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 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).

Federal Reserve System 2012). The key contribution of the DFAST results is to provide information about the capital strength of the individual banking companies 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, industry-level models, consistent asset and risk-weighted asset assumptions), as well as by comparison of the Federal Reserve's projections to those of the participating bank holding companies (same scenario, different models and growth assumptions). For instance, Hirtle and Kovner (2014) compare the Federal Reserve and bank holding company 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, while the bank holding company projections suggest very small increases).

2. CCAR: Innovative Supervision

In contrast to DFAST, there are direct and meaningful supervisory consequences of the stress results in CCAR. As noted above, CCAR is a supervisory program that assesses internal capital planning and capital positions of large bank holding companies. The first CCAR was in 2011, at a time when many bank holding companies 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 U.S. bank holding companies had sufficient capital to resume these distributions (Board of Governors of the Federal Reserve System 2011a). More significantly, CCAR provides a framework and tools to assess bank holding companies' internal capital planning processes and capital positions on an on-going basis, with the goal of ensuring that these processes are rigorous and robust. Following the adoption of the Capital Plan Rule in November 2011, the CCAR is now an annual process, providing the Federal Reserve with the tools and the authority to restrict capital distributions should conditions at an individual banking company deteriorate (Board of Governors of the Federal Reserve System 2011b).

In 2014, 30 bank holding companies with assets of at least \$50 billion participated in CCAR, the same population of banking companies for which the Federal Reserve makes DFAST projections. As part of the CCAR, bank holding companies 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 capital 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 and “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 bank holding companies and evaluates their processes and governance against a set of supervisory expectations and the requirements of the Capital Plan Rule (Board of Governors of the Federal Reserve System 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 especially their stress testing models, data, and assumptions. The focus of this assessment is on the processes firms use to develop and implement the “BHC stress” scenario, 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 banking companies’ 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 of Governors of the Federal Reserve System 2014a).

The quantitative aspects of the CCAR involve evaluating whether the bank holding companies’ current capital positions are adequate given their business focuses, portfolios, and risk exposures. In particular, the Capital Plan Rule requires that each bank holding company is able to demonstrate that its capital ratios would remain above minimum regulatory levels and that its tier 1 common ratio would remain above 5% under both baselines and stressed economic conditions (Board of Governors of the Federal Reserve System 2011b). 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 post-stress capital ratios. As noted above, the DFAST capital ratios use stylized assumptions about dividends based on each bank holding company's recent dividend behavior, while the CCAR capital ratios are based on the planned capital actions included in each firm's capital plan. This is consistent with the goal of the CCAR, which is to assess each bank holding company's internal capital planning and the planned capital actions that are 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 bank holding company's planned capital actions under its *baseline* scenario. This is a stringent test of capital actions included in each company's capital plan, since it assumes that the firms continue to pay dividends and do share repurchases 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 post-stress capital ratios can be higher or lower than the CCAR ratios.

If the CCAR qualitative assessment reveals significant weaknesses in a bank holding company'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 Federal Reserve may object to company's capital plan. In that event, the bank holding company 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 bank holding company'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 bank holding company's capital plan, then the firm may make the distributions included in its capital plan. All bank holding companies participating in CCAR receive extensive supervisory feedback on their capital planning processes, identifying areas that require improvement.

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

⁷ The 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.

Disclosure of the CCAR results builds on the ground established during the 2009 SCAP, as one of the few instances of public disclosure of supervisory findings. Along with the closely related DFAST disclosures, the CCAR disclosures provide potentially important information about the participating bank holding companies, 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 banking companies 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 bank holding companies through the integration of stress testing. While this aspect of the CCAR is often what attracts most attention, the supervisory elements of the program are equally as innovative and consequential. The quantitative aspects of the CCAR represent a tilt from “discretion” towards “rules” in the supervision of these large and complex institutions, since bank holding companies 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 towards “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 bank holding company. Focusing on the BHC stress scenario result can also counteract incentives for banking companies simply to 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 bank holding companies to develop a formal capital policy governing dividends, share repurchases, and other capital actions, including specifying the circumstances under which these

⁸ Bank holding companies 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 bank holding companies made such adjustments and how much the minimum values of the ratios changed after the adjustment (Board of Governors of the Federal Reserve System 2014a).

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 the banks are adhering to their own policies as circumstances change.

IV. 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.

At the depths of the U.S. 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 paper we described these fundamental design choices as well as providing some sense of the benefits and costs to be weighed in making the decisions.

We described in some detail the U.S. stress testing regime during the crisis and in the post-crisis era. Stress tests play a key role in ongoing supervision through the CCAR process, as well as in communication 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. While 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 in developing the expertise and data necessary to form an independent quantitative estimate of banks' capital adequacy.

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