

Stressing Over Stress Testing: Introduction to the Components

This paper discusses the major components of a macroeconomic-based stress testing process and describes some of the challenges with which banks are contending in their efforts to comply with regulatory requirements. The paper covers the foundational components of economic scenarios and cash flow models and then introduces new business, capital consumption, other (non-credit) risks, income and expense models and finishes with a discussion of capital ratios, capital planning, quantitative information and qualitative considerations.

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Stress testing has long played an important role in bank risk management, with some form having been used in the analysis of credit, liquidity and market risk exposures for many years. Given this, you might wonder why compliance with more recent regulatory requirements for capital stress testing has proven so challenging and why so many banks continue to receive adverse findings.¹ This paper describes the major components of the stress testing process and highlights some of the challenges associated with building and managing not only a regulatory compliant process but one that is also useful to the management of risk and capital within the bank.

Before diving into the components of the stress testing process, it is helpful to understand the origins of the new requirements and how they differ from earlier business practices.

Why: The global financial crisis that began in 2007 revealed numerous shortcomings in bank risk management practices; in particular, banks and their regulators did not appreciate how the risk exposures of banks are interrelated. From 2006-12, national housing prices fell 27%², from 2007-9, the unemployment rate increased from 4.4%

The financial crisis exposed a number of critical weaknesses across the largest banks and highlighted that many BHCs had a limited ability to effectively identify, measure, and control their risks, and to assess their capital needs.

CCAR Review 2015, March 2015, Board of Governors, Federal Reserve

¹ These include public restrictions for CCAR banks and non-public requests for remediation, such as matters requiring attention (MRA) and matters requiring immediate attention (MRIA).

² Source: S&P/Case-Schiller, US National Home Price Index. Prices in some markets fell significantly more than the average, e.g. 62% in Las Vegas, 56% in Phoenix and 51% in Miami.

to 10.0%³ and key funding markets shut down⁴. As a result of these and other dislocations, between 2007 and 2014, 510 depository institutions closed or merged with other banks⁵ and government intervention was taken on an unprecedented scale.⁶

How: In 2010, Congress passed The Dodd-Frank Wall Street Reform and Consumer Protection Act (DFA), which required, among other things, that bank regulators address shortcomings with respect to capital management in order to mitigate the need for costly government support in future downturns. In particular, the legislation mandated that the Federal Reserve Bank (FRB) establish specific requirements for comprehensive balance sheet stress testing. Stress testing would be used to assist regulators with answering the seemingly simple question: Do banks have enough capital to survive an economic downturn? If, in reviewing the results from the stress testing exercise, regulators conclude that a particular institution does not have sufficient capital, that firm will be required to bolster its capital levels immediately or modify its future business plans accordingly.

While the question of capital adequacy appears simple, the process for producing a well-substantiated answer is actually quite complicated. Attempts to do so have revealed that traditionally disaggregated approaches to risk management are often inadequate for analyzing overall risk in relation to capital. Compliance with the stress testing requirements of the Comprehensive Capital Analysis and Review (CCAR)⁷ and

³ Source: Bureau of Labor Statistics, unemployment rate, LNS14000000.

⁴ Source: When Safe Proved Risky: Commercial Paper during the Financial Crisis of 2007-9, Journal of Economic Perspectives, Winter 2010 and GE Press Releases in late 2008. As investors were withdrawing deposits from money market mutual funds and fund managers were shifting their asset mixes more heavily toward US Treasuries, commercial paper issuers found that there were few buyers for their paper. In November 2008, GE Capital had difficulty rolling \$88 billion of such debt (except on an overnight basis) and turned to the Fed for assistance. The Fed had created the Commercial Paper Funding Facility (CPFF), but the Fed's assistance was only made possible by the FDIC's creation of the Temporary Liquidity Guarantee Program (TLGP) which modified the definition of institutions which were eligible to issue debt with a guarantee from the US government. By January 2009, the Fed was the single largest holder of commercial paper, owning over 22% of all outstanding paper.

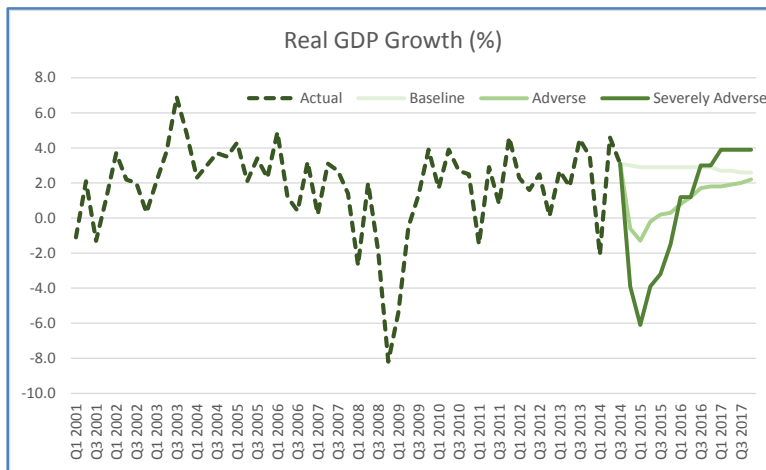
⁵ Source: FDIC. This count does not include banks or investments banks that were merged without technically failing, e.g. Bear Stearns and Wachovia, or additional assistance programs which were provided to Bank of America and Citibank in order to prevent their failure.

⁶ Source: GAO, Government Support for Bank Holding Companies and FDIC. The US Treasury was authorized to invest \$700 billion of capital directly into banks and non-banks (TARP), the FDIC temporarily extended an unlimited deposit guarantee on non-interest bearing transaction accounts, absorbed losses of \$78 billion on failed banks with combined assets of \$ 692 billion and created a funding program for non-banks (TGIF) and the Federal Reserve auctioned \$493 billion of 1 and 3-month discount window loans, took the overnight funding rate to essentially zero percent and bought roughly \$ 3.5 trillion of government and agency debt (QE I, II and III).

⁷ Applicable to bank holding companies (BHCs) with total assets over \$50 billion.

DFA stress testing⁸ have forced institutions to realize that, because risk exposures are not additive, the proper evolution of cash flows, earnings and the level of capital requires the simultaneous analysis of *all* relevant risk factors. Regulators ultimately expect banks to resolve this fundamental issue as well as a long list of other challenges in order to prove that their representations on capital adequacy can be relied upon. On top of this, with each new round of regulatory stress testing, regulatory requirements continue to evolve and the bar of expectations continues to rise.

Economic Scenarios



Source: Board of Governors of the Federal Reserve System

The starting point for CCAR and DFA stress testing simulations is a set of economic scenarios produced by the FRB; the set consists of Baseline, Adverse and Severely Adverse scenarios. Banks use the scenarios to produce estimates of capital use and capital supply in order to calculate capital ratios throughout each

scenario.⁹ The FRB provides an extensive historical time series as well as a 13-quarter forecast for 16 domestic and 12 international variables.¹⁰

While the FRB's specification of the scenarios provides a useful starting point for forecasting, accurate forecasts require several extensions of the data set:

- 1) Additional macroeconomic variables which have important explanatory power for the performance of a bank's unique lending and investing activities, e.g. oil prices and farmland prices
- 2) Expansion of the national variables down to local drivers of default and loss, e.g. state-level unemployment and zip code level home price indexes (HPI)
- 3) Extension of the forecast horizon beyond 13 quarters as necessary to meet the modeling requirements for Other Than Temporary Impairment (OTTI), e.g.

⁸ Our term for the more limited test that is applicable to BHCs with total assets between \$10 billion and \$50 billion.

⁹ Minimum capital levels are specified for several metrics: Tier 1 Common, Common Equity Tier 1, Tier 1 Risk-Based Capital, Total Risk-Based Capital and Tier 1 Leverage. Minimums have also been separately specified for Advanced Approach BHCs versus other BHCs and are being phased in through 2019. See www.federalreserve.gov/newsevents/press/bcreg/bcreg20150311a1.pdf.

¹⁰ Complete histories are provided for each variable back to 1999; additional history is provided for a subset of the variables as far back as 1976.

rates and other macroeconomic parameters through the maturity term of the securities

In addition to the FRB's specification of the scenarios and the extensions described above, there is an expectation (and for larger banks a requirement) that banks will supplement the scenarios in a way that acknowledges idiosyncratic risks, especially as they relate to liquidity risk; for example, a bank with a heavy reliance on wholesale funding should consider loss of access to certain wholesale markets, e.g. repo, CP or FHLB market shutdown. This analysis can be included with the bank's formal submission or made available for subsequent regulatory review. If the bank is solving for a post stress capital measure that aligns with the CCAR measure, the specification of the event should reside in a similar probability space as the FRB's Severely Adverse scenario.

Cash Flow Models

The assessment of realized losses and position size over the forecast horizon derives from the evolution of scenario-specific, transaction-level cash flows for each balance sheet item. The measurement of cash flows must include an estimate of contractual, voluntary and involuntary (credit loss) payments. When combined with Risk-Weighted Asset (RWA) levels, income changes and mark-to-market levels, the bank is able to forecast required capital ratios.

Challenging this process at most banks, separate and distinct functional areas manage credit and market risk.¹¹

Despite the fact that these risks are interrelated in the majority of circumstances, this segmented approach to risk management persists to this day and is evidenced by attempts to *add* the impact of market and credit risk exposures when determining product cash flows in stress testing exercises. Unfortunately, this will not produce cash flow dynamics that reflect real world behavior, particularly in scenarios where credit conditions are expected to influence customer behaviors.¹² A class of behavioral models, known as *competing risk models*, are best suited for the correct evolution of transaction cash flows, because these models consider, in each period of a simulation, the *simultaneous* impact of relevant cash flow drivers. For example,

15) How were PDs on residential mortgages estimated? What were the key risk drivers?

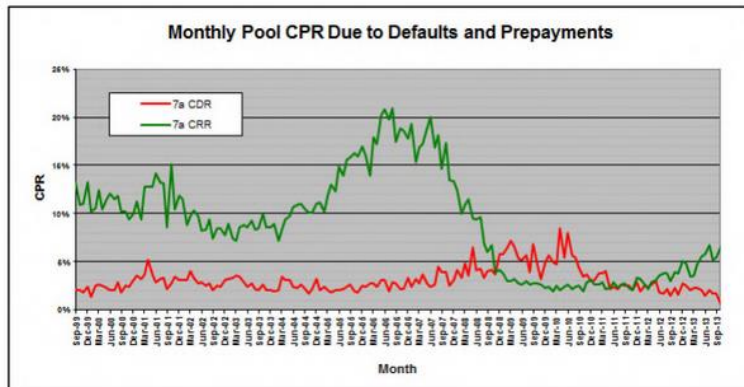
Broadly speaking, the PDs were estimated within a "competing risk" model framework where default and prepayment probabilities were simultaneously estimated.

Frequently Asked Questions, Supervisory Methodologies in CCAR 2012, Board of Governors, Federal Reserve

¹¹ Our use of the term market risk refers to the measurement of banking book position responses to changes in market and administered interest rates; this risk is typically managed by ALCO.

¹² The FRB's severely adverse scenario reflects a combination of falling interest rates *and* worsening credit conditions and presents exactly the conditions for which credit and market risk measures are not additive.

these models will incorporate market risk factors, such as current interest rates on comparable products (in order to explain voluntary prepayment behavior) as well as credit risk factors, such as loan-to-value (LTV) (in order to explain not only default and loss experience but also a potentially significant impediment to refinancing). By considering these factors jointly, competing risk models are able to acknowledge that the credit factors may serve to constrain the realization of voluntary prepayments that would otherwise be expected if one is focused solely on interest rates.



Source: Government Loan Solutions CPR Report

The requirement for competing risk models is evident when we analyze the reason for the failure of loan prepayment models that were employed before and during the recent financial crisis. In 2007-8, mortgage prepayment models predicted that voluntary prepayment rates would increase

dramatically because of the substantial decline in market interest rates. These model predictions proved incorrect because housing prices were in decline at the same as rates were falling. Homeowners found that their LTVs exceeded underwriting limits at most banks; as a result, they were unable to refinance their loans notwithstanding the cost savings associated with refinancing.

In this case, when analyzing capital adequacy in a deteriorating economic environment, prepayment models that overstate prepayment rates will understate credit exposure and capital risk. The borrowers that are unable to exercise prepayment options in an adverse credit scenario are the borrowers that consume the most capital (whether through future realized losses or additional RWA consumption), thus leading to incorrect conclusions about the sufficiency of capital. Because stress testing specifically requires the consideration of comprehensively-specified economic scenarios, cash flow models must incorporate all relevant factors that explain the evolution of cash flows.

Further complicating matters, individual behavioral models are required for each balance sheet product, because cash flows are governed not only by contractual rules, but also by voluntary and involuntary prepayment (or credit default and recovery) options, the structure of which varies from product to product and across collateral structures. The first step in building a competing risk cash flow model should involve identification of the relevant drivers of cash flow dynamics. Each model must be calibrated to the performance experience of the product. This process requires the use of numerous data fields, examples of which are in Table 1. (This list is not

complete, and for certain types of loans, certain of the fields may not be relevant.) After the model is constructed, effective model risk management¹³ requires periodic back-testing and recalibration of model factors.

The availability of sufficient internal loan data has proven problematic for most banks across their entire suite of products. Retention of loan-level performance histories is only a recent development and at some banks these histories often do not capture the most recent credit cycle; alternatively, even when sufficient data has been retained, it may fail to include an adequate breadth of performance attributes. Just as importantly, even if there is a decade of data available, this only captures the most recent business cycle; for some institutions, their most important risks may not be reflected in this data history¹⁴.

For these reasons, many banks must utilize external data sets to calibrate their behavioral models. Initially, regulators were insistent that banks use only their own data for this purpose, but they have since acknowledged the benefits of using more comprehensive data sets, provided that the bank has demonstrated that the augmented data is appropriate to the business and risk profile of the organization's existing exposures.

For securities, the following facts further complicate the cash flow modeling exercise:

- 1) While the availability of loan performance data is generally limited only by the ability of banks to capture and retain the necessary data fields, for securities, most banks are reliant on external parties to provide complete and accurate time series data necessary for modeling and analysis.
- 2) Most investment products have a waterfall structure which governs the evolution of cash flows to the investor. It is first necessary to model the performance of the underlying collateral, e.g. amortization, voluntary and involuntary cash flows on individual loans within the structure, in a manner

Loan Type
Origination Date
Maturity Date
Original Balance
Current Balance
Current Interest Rate
Fixed/Floating
Repricing Rate Index
Repricing Rate Spread
Prepayment Option Flag
Prepayment Option Type
Original Collateral Value
Current Collateral Value
Original FICO Score
Current FICO Score
Guarantor
ZIP Code
Current Delinquency Status
Vehicle Type
Vehicle Age
Borrower Age
Borrower Gender
Borrower Income

Table 1 - Sample loan fields

¹³ See OCC 2011-12 or SR 11-7 Model Risk Management for the regulatory requirements around effective model governance including model validation.

¹⁴ This issue is exacerbated by changes in the business environment, where earlier credit or rate cycles may be less relevant (or worse) to the estimation of future behaviors.

that is consistent with the specified scenario. These transaction-level cash flows must then be passed through the waterfall structure of the security in order to accurately generate the cash flows which will be realized over the forecast horizon.

- 3) Loan level cash flows on whole loans and those in structured securities are usually evolved in separate models because of the first two points. Regardless of whether they are in whole loan form or collateral in structured products, a bank should be able to demonstrate consistency in the evolution of loan level cash flows.

The first two points described above have led most banks to rely on third parties, such as broker/dealers and investment banks, to produce requisite securities cash flows. With regard to such reliance, regulators are demanding an increase in the level of transparency around the modeling process; banks can no longer use a “black box”. Despite regulatory demands, some third parties have refused to provide the necessary transparency as they utilize these proprietary models in related asset management businesses. This has left many banks searching for alternatives or attempting to develop bespoke cash flow solutions.

New Business and Reinvestment of Cash Flows

Balance sheet stress testing requires the estimation of volumes, risk, income and expenses over a multi-period horizon. The need to simulate earnings in addition to balances requires detailed assumptions around the evolution of new business and reinvestment of runoff cash flows. All of the same requirements for modeling the cash flow dynamics of the existing balance sheet apply to the new balances coming onto the balance sheet. In addition, new business assumptions should have some econometric justification which should be evolved in response to explicit business strategies.

In the same way that well-built behavioral models impose extensive data requirements on current positions, all new business will need to include the same level of specificity as these positions should be evolved using the same cash flow models used to run off the current position balances. ALM modelers will already be familiar with the need to make explicit assumptions for new business volumes coming onto the balance sheet in each period, including details of their maturity terms, repricing terms and repricing spreads. In addition to these IRR-related variables, details around the credit characteristics of the new business will also have to be specified, e.g. FICO scores, LTVs, collateral values, etc. Because credit risk has not been within the scope of ALM modeling, this information will most likely have to be sourced from the business units responsible for product origination.

While business units have long engaged in periodic budgeting and forecasting exercises, they are discovering that the level of rigor that is typically used is not sufficient to meet regulatory expectations for balance sheet stress testing. The development of a budget has traditionally been a top down exercise designed to

support high-level growth objectives, e.g. 10% earnings growth. The bank may simply plan to do 10% more of everything as a way to achieve this objective; alternatively, it might employ strategies that emphasize specific products. Regardless, the aim of the budget is to support a top down target. Econometric models, on the other hand, which correlate portfolio growth or new volume originations to economic variables, are typically not used for budgeting. This is no surprise as the primary objective of the budgeting exercise drives the assumptions, not economic rational. The stress testing question begs the question of whether the bank checks such assumptions against economically feasible outcomes.

Rarely are budgeting and forecasting exercises done within the context of fully-specified economic scenarios. Scenarios for budgeting often contain no more detail than a basic forward projection of interest rates that might not even be a forecast at all; e.g. many banks still budget under an assumption of flat rates. Even if there is a complete specification of business conditions, given their relatively short-term focus, budgeting and forecasting exercises rarely include future conditions that are materially different from current ones. As a result, business units have never developed the tools and expertise necessary to consider the relationship between economic variables and business origination in a forecast environment that is materially different from current economic conditions.

In contrast to these practices, regulatory stress testing requirements for forecasting reflect a strong preference for econometric models, because such models naturally lend themselves to the study of the impact of changes in economic conditions on business outcomes. As a result, many banks are finding that they have to increase the level of sophistication of their forecasting processes. For example, in early rounds of stress testing, banks were prone to utilize the same budget assumptions in all of the FRB scenarios, in effect saying that the budget would be achieved “come hell or high water”. While a bank may have historical evidence to support such an assumption, regulators have pushed back on this naïve approach demanding that banks understand and acknowledge the relationship between economic conditions and the business they originate.

This is not to say that a bank should ignore business strategies, but rather business unit expectations for production volumes should fit logically within the relevant economic context. For example, if a scenario calls for housing prices to fall rapidly and economic activity to shrink significantly, the forecast should anticipate a slowdown in mortgage production and related interest and fee income even if the bank had otherwise planned a significant increase in mortgage growth. Business units must contemplate that expectations for performance may fall short in adverse economic environments.

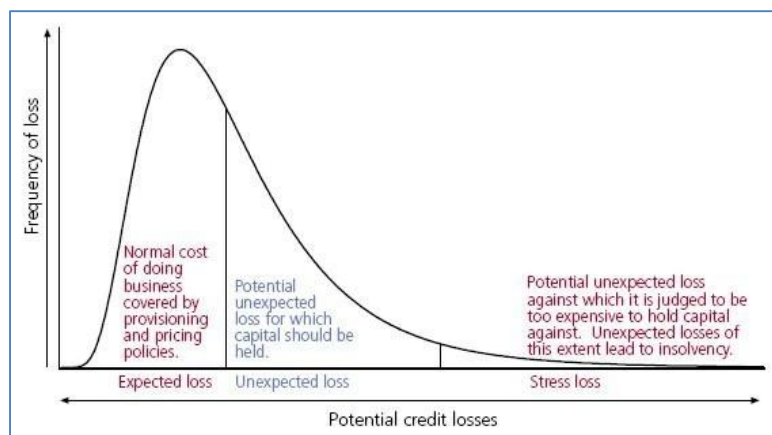
To be clear, there is not an expectation that banks should rely entirely on the output of econometric forecast models. If new strategies which emphasize certain products are currently in place, these would likely be accounted for in the predictions of historically-calibrated econometric models. In such cases, business units should

override the model output. Be cautioned! Though such overrides may be warranted, they do expose the bank to regulatory criticism if they lack proper documentation and support.

Finally, forecasts should not assume perfect foresight. Regulators are quick to reject an assumption that (risky) lending activity will be curtailed at the first sign of an economic downturn. For most market participants in the last economic crisis, there was absolutely no comprehension that it would be as severe as it ultimately was. The majority of banks remained focused on executing key strategies and were slow to pull back from the market. Regulators have rightly concluded that growth strategies are likely to drive behavior long after prudent risk-taking should prevail; there is strong evidence that banks which were lending aggressively going into the previous crisis continued to do so even as housing prices began to decline and credit quality began to deteriorate.

Risk Capital Consumption Models

Once the bank evolves the existing book and new business volumes over the forecast horizon in each scenario, the next step is to calculate the capital consumption for each asset. Capital consumption occurs through both regulatory and accounting constructs. From a regulatory perspective, the different Basel



Source: Wikipedia page: *Advanced IRB*

regimes (I, II, III) require that individual assets be placed into risk buckets, each of which has a specific RWA charge; these charges are aggregated and total RWA must be funded with a minimum level of capital. Accounting constructs relate to the management of the Allowance for Loan and Lease Loss (ALLL) account as well as the assessment of Other Than Temporary Impairment (OTTI)¹⁵ on investment securities. The ALLL account is a balance sheet account that adjusts through the provision line item in the income statement; OTTI adjustments also pass through the income statement. Changes to either of these income accounts will affect the rate of capital accumulation or shrinkage. In stress scenarios, these impacts can be material; as a

¹⁵ OTTI refers to the change in the value of a security resulting from a *forecasted* credit event, e.g. loss of cash flow to the investor due to mortgage defaults in an MBS. This impairment receives a different treatment for stress testing than a loss of value attributed to an increase in market interest rates or liquidity spreads.

result, the processes a bank uses to calculate them are likely to receive a significant amount of regulatory scrutiny.

RWA amounts are generally determined by assigning on-balance sheet assets to broad risk-weight categories according to the counterparty, or, if applicable, the guarantor or collateral. Similarly, RWA amounts for off-balance sheet items are calculated by a two-step process: (1) multiplying the amount of the off-balance sheet exposure by a credit conversion factor (CCF) to determine a credit equivalent amount, and (2) assigning the credit equivalent amount to a relevant risk-weight category. In addition to the category, the balance and risk of the position must be determined. For performing loans, the former is simply the outstanding book balance and for defaulted loans, it is the Exposure at Default (EAD). The risk of the position is a function of default likelihood, loss profile and maturity. It is important to recognize that many of the components of RWA calculations are similar to those needed for the measurement of ALLL and OTTI. There should be consistency between the bank's calculation of regulatory and accounting measures of capital consumption. To the extent that they are not consistent, the bank may be subject to regulatory criticism.

RWA classifications have also grown increasingly more granular with each subsequent Basel regime. Basle I classifications made some distinctions between asset types, but underlying credit characteristics and credit migration were largely ignored. Many of these weaknesses were addressed with the adoption of Basel II and Basel III. RWA calculations now better reflect the actual risk of the position; unfortunately, the process for determining RWA levels is now significantly more complex and requires the tracking and analysis of many more data fields. These calculations have proven challenging for a number of banks as the necessary data is not always readily available.

The calculation of OTTI has also proven problematic. Banks typically take very little credit risk in their investment portfolios, opting instead to invest primarily in sovereign or agency securities; for these instruments, OTTI is largely a moot point. In contrast, positions which do have credit risk, e.g. municipal securities, non-agency MBS (NAMBS) and preferred stock, have to be modeled in order to determine if there is credit impairment. While OTTI is often zero under baseline conditions for most bank-owned investment securities, this assumption may not hold under stress conditions. In either case, a bank cannot simply assume that there will be no OTTI. Regulators are increasingly demanding that this assumption be substantiated with properly constructed analytical models that bifurcate value changes into those due to credit events and those due to changes in market interest rates.

In addition to the forecast of RWA, ALLL and OTTI, various other capital consumption activities require the use of forecasts in order to comply with applicable accounting and regulatory standards. For example, the unrealized loss on Available for Sale (AFS) portfolio securities that flow through Other Comprehensive Income (OCI) now count against regulatory capital for large banks. Estimates of value changes must therefore be clearly documented and supported. Another modeling and reporting

challenge arises as some of the new limits and revisions to existing limits phase-in over the next several years.

Additional Risk Exposures

In addition to credit risk, there are several additional drivers of loss and capital consumption that the stress testing process must address; these include liquidity risk, operational risk, counterparty risk and trade book risk. These exposures tend to be highly idiosyncratic and the FRB scenarios do not specifically address them. Even so, banks should acknowledge and incorporate them into the stress testing exercise consistent with the specified scenario. The complexities of incorporating these measures include differences in measurement time horizon (liquidity and trade book events are typically very short-lived in relation to the nine quarter stress testing horizon) and low correlations with macroeconomic drivers (operational risk events, counterparty defaults and liquidity crises are exceptionally rare).

An example of an idiosyncratic risk which could be analyzed is the exposure to liquidity risk which occurs through a heavy reliance on wholesale sources of funding, e.g. FHLB advances, commercial paper or brokered deposits. During the most recent crisis, troubled banks lost access to some or all of these sources of funds and increased deposit rates to attract necessary funding. Such actions further reduced earnings and capital accumulation. Another example can be found in large Wall Street investment banks which have significant counterparty exposures which occur through a multiplicity of products, e.g. credit default swaps (CDS), interest rate swaps and back-up lines of credit (LOCs). Such banks should analyze the impact of similar type events in these markets. These can be constructed and analyzed in a separate scenario or incorporated directly into the FRB stress scenarios.

Income and Expense Models

Because the objective of the stress testing exercise is to calculate capital ratios over some time horizon, banks must estimate capital supply over that horizon; part of this process requires an assessment of the net income (or loss) for each period in the forecast. In a previous section, we addressed some of the challenges associated with forecasting new business volumes and cash flow dynamics on these and existing balances in credit stress tests. For this, most institutions turn to their ALM model given the longstanding practice of modeling product cash flows under stress.¹⁶

In analyzing IRR, most institutions focus on risk to the net interest margin (NIM). The NIM is simply the difference between interest income and interest expense. Some banks calculate only this measure of earnings in their analysis of IRR as it captures the majority of earnings volatility associated with changes in the level of market interest rates. For stress testing, banks must project net income (NI) and this necessarily requires that the modeling effort be extended to include non-interest

¹⁶ Although the stress events modeled in an ALM context have almost always been entirely rate-driven.

income and expense. Because the point of the IRR exercise is to understand how changes in interest rates will affect earnings and economic capital, additional risk factors are usually assumed to remain unchanged. We have already noted that traditional budgeting and forecasting exercises assume business as usual across a very short time horizon. This means that many banks are likely to find that internal models of non-interest income and expense dynamics are very simple, if they exist at all, and do not meet the needs of credit stress testing.

Examples of non-interest income and expense dynamics which need to be considered include:

- The level of mortgage origination fees in a slow housing market
- Foreclosure and asset maintenance expenses associated with an increase in unemployment
- Incentive compensation levels when capital levels are stressed
- Marketing expenses associated with raising additional retail deposits to offset the loss of other funding sources
- Legal expenses in a housing crisis
- Investment banking and legal expenses associated with efforts to raise capital

In addition to the innate challenges associated with estimating non-interest income and expense, the bank needs to ensure that these cash flows are consistent with the treatment of related balance sheet accounts; e.g. late fees on credit card accounts should track the evolution of payment delinquencies on card balances. Similarly, as loans go through the default and charge-off process, the accrual of interest income should terminate at appropriate times. These modeling requirements are difficult for banks that perform top-down accrual and credit calculations on separate systems, each of which is likely to have a different charts of accounts. This occurs most often when using separate ALM and credit systems as ALM accounts are generally organized around interest rate criteria while credit systems use factors such as geography, leverage and credit bands to group transactions. Subsequent processes that overlay behaviors from one chart of accounts (credit) onto another (ALM) will introduce inconsistencies and errors into the modeling process. These inconsistencies require considerable effort to untangle. Regardless, accuracy, speed and flexibility are significantly impaired.

Capital Ratio Calculations

A variety of regulatory and accounting measures of assets and capital make up different capital ratios for which minimum levels have been set. These ratios take the following form:

$$\text{Capital ratio} = \frac{\text{Capital Measure}}{\text{Asset Measure}}$$

The capital measure in the above equation corresponds to a capital supply measure; these include Common Equity Tier 1, Tier 1 Common, Tier 1, and Total Capital. The

Regulatory Capital Levels	1-Jan-2014	1-Jan-2015	1-Jan-2016	1-Jan-2017	1-Jan-2018	1-Jan-2019
Capital conservation buffer	.....	.....	0.625%	1.25%	1.875%	2.5%
Minimum common equity tier 1 capital ratio + capital conservation buffer	4.0%	4.5%	5.125%	5.75%	6.375%	7.0%
Minimum tier 1 capital ratio + capital conservation buffer	5.5%	6.0%	6.625%	7.25%	7.875%	8.5%
Minimum total capital ratio + capital conservation buffer	8.0%	8.0%	8.625%	9.25%	9.875%	10.5%
Maximum potential countercyclical capital buffer	.....	.....	0.625%	1.25%	1.875%	2.5%

Source: Bank for International Settlements

asset measure is either risk-weighted or volume weighted (for simple leverage measures).

In 2012, US bank regulators issued their final rule for implementation of the Basel III capital standards.¹⁸ The rule revises their risk-based and leverage capital requirements and implements a revised definition of regulatory capital, common equity tier 1, establishes a higher minimum tier 1 capital requirement and, for banking organizations subject to the advanced approaches risk-based capital rules, imposes a supplementary leverage ratio that incorporates a broader set of exposures in the denominator. The rule also incorporates these new requirements into the agencies' prompt corrective action (PCA) framework. In addition, the final rule establishes limits on a banking organization's capital distributions and certain discretionary bonus payments if the banking organization does not hold a specified amount of common equity tier 1 capital in addition to the amount necessary to meet its minimum risk-based capital requirements. Further, the final rule amends the methodologies for determining risk-weighted assets for all banking organizations and introduces disclosure requirements that would apply to top-tier banking organizations domiciled in the United States with \$50 billion or more in total assets. It also adopts changes to the agencies' regulatory capital requirements that meet the requirements of section 171¹⁹ and section 939A²⁰ of the DFA.

While all CCAR and DFAST banks are expected to demonstrate compliance with the minimum capital ratios in all of the stress testing scenarios, the FRB actually runs its own stress testing model for each of the CCAR banks in order to independently assess capital adequacy. It is these model results, not the bank's own, which determine if the bank passes or fails the quantitative criteria of the stress testing exercise. This raises a huge challenge for CCAR banks, as there is the possibility of material differences between their internal models and those of the FRB. For example, many banks with large wealth management units have found that their own loan loss projections, which are consistent with their actual loss experience, are significantly less than the

¹⁸ See OCC 2012-0008.

¹⁹ This section requires regulators to establish minimum leverage capital and risk-based capital requirements for insured depository institutions, depository institution holding companies and nonbank financial companies supervised by the FRB. In addition, it establishes that certain BHC subsidiaries of foreign banking organizations which were exempt from the minimum capital standards must now comply with the standards, albeit via a phase-in process.

²⁰ This section prohibits banks from relying on rating agency risk measures, e.g. Moody's and S&P ratings, for estimating risk exposures; alternative methods must be utilized.

FRB's. This discrepancy can lead to the need for capital buffers beyond the bank's assessment of its own risk-based need.

Because regulators anticipated that the new capital requirements would force banks to accumulate or issue significant amounts of new capital, banks are being allowed to phase-in compliance with the new minimums over the next several years. A bank may therefore find itself, within the forecast horizon of the stress test, dealing with a change in the applicable Basel regime as well as the phase-ins. This makes the task of demonstrating compliance with the minimum requirements a challenging process. Also included in the new guidance are phase-outs of certain types of capital which banks previously counted toward regulatory capital, e.g. trust preferred securities. Correct modeling of these phase-outs is necessary in order for the bank to determine if it has a need for alternative forms of capital.

Capital Planning

Core to the CCAR and DFAST exercise is the principle that capital today should be adequate to meet the challenges of a stress environment and, further, that capital actions contemplated in the future should not jeopardize bank solvency in a stress environment. The production and consumption of capital includes the accumulation of net income and accounting and RWA effects as described above in addition to traditional capital activities that include dividend payments, share repurchases, merger and acquisition activities as well as the issuance of various capital instruments. Capital plans contain the contemplation of all of these activities.

There are four mandatory elements of a capital plan:

- 1) An assessment of expected sources and uses of capital
- 2) A detailed description of the BHC's process for assessing capital adequacy
- 3) The BHC's capital policy
- 4) A discussion of any baseline changes to the BHC's business plan that are likely to have a material impact on the BHC's capital or liquidity adequacy.

Our capital plan review helps ensure that the capital distribution plans of large banks will not compromise their ability to continue lending to businesses and households even during a period of serious financial stress.

Daniel Tarullo, member of the BOG, in comments about the 2015 stress test results

Each of the elements of the capital plan must acknowledge the potential for not only base but also stress conditions across the entirety of the forecast horizon. In fact, the forecast may need to be extended beyond the 13 quarter CCAR horizon in cases where regulatory phase-ins or other business activities may materially influence the capital position of the bank. While preceding sections of the paper dealt with the capital

consumption calculations for the bank's core business activities, there are additional considerations with regard to the traditional capital activities of the bank.

Dividends

Capital plans must consider dividends to holders of both common and preferred shares of the bank. Regulators believe that a reduction or suspension of dividends in a stress environment is slow to happen because banks tend to be very hesitant to lower dividends before observing similar actions from their peers. Because of this belief, a soft cap of 30% has evolved on the dividend payout ratio.²¹ While it is possible for banks to pay out more than 30% of earnings, such intentions typically receive a higher level of scrutiny and have become increasingly difficult to justify as a regular business practice. Capital plans should also consider dividends that the bank expects to pay to their foreign parent.

Share Repurchases

Capital plans should acknowledge the variety of repurchase programs that a bank can utilize. Some remain at the discretion of the bank and are easier to curtail or halt. Others, such as non-directed accelerated share repurchase programs, are difficult for the bank to stop once they have begun. In all cases, the bank should specify criteria for what types of market and economic conditions would lead to suspension (or non-execution) of the program. Any share repurchase program should also differentiate in their plan the portion of repurchases needed to support compensation-related purchases from pure market activities as the compensation-related shares will end up back in the market. Both dividends and share repurchase programs will require a forecast of share price to allow the accurate calculation of volumes and associated impacts; this should be done in a manner that is consistent with the economic scenario being modeled.

Mergers and Acquisitions

Rarely does a bank know the specific target or timing of a contemplated acquisition well in advance of the actual acquisition, but that is not to say that an acquisitive bank can ignore future acquisitions in its capital plan. Lacking a specific target, a bank must determine what capital reserve is required to handle various sizes of potential activity without the need to modify other uses of capital such as dividends or share repurchases. The capital plan should identify the size of an acquisition at which the bank would need to re-submit or re-build its stress test and capital plan. In addition, the plan should consider what types of acquisitions, regardless of size, would represent a material change to the bank's business model. Similarly, the plan should specific the analysis of any material portfolio acquisitions or divestitures on capital adequacy.

²¹ Source: BIS Quarterly Review "How Have Banks Adjusted to Higher Capital Requirements," September 2013 and Barron's "Banks Await Fed OK on Payout Hikes," March 6, 2015.

Quantitative Information and Stress Testing Model Output

The FRY-14 and DFA schedules required for submission to the FRB are extremely detailed and capture all of the major activities of the bank. They include current position and forecast data as well as output from a bank's stress testing model. For CCAR banks, the submission of raw data must be sufficient for the FRB to run its own stress testing models. The production of the requisite schedules requires the cooperation of financial planning, accounting and risk functions. Few organizations are properly equipped with cross functional teams necessary to produce these schedules in a timely and accurate manner. Any deficiencies or errors in the data could lead to erroneous and punitive results. Additionally, the FRB load process appears to be very sensitive to format issues, so even small issues with cell formats can lead to rejection of the templates.²²

Another challenge is that many of the required data elements and schedules have not traditionally been used in internal modeling exercises or by the management of the bank; therefore, it can be difficult to get appropriate business units to review and validate the submissions. Banks should be aware that during regulatory exams of other key risk and balance sheet management functions, e.g. ALM and ALLL, regulators are likely to look for discrepancies between the regulatory schedules and other internal management reports. Stress testing data and models must be consistent with other risk and balance sheet models which have been used to manage the bank for years. Because stress testing is still largely an annual exercise, it is easy for regulators to conclude that it is not part of the business as usual process of managing the bank; hence, the representations around capital adequacy using these processes could be suspect.

Qualitative Elements

Recent results from CCAR submissions show banks are increasingly passing the quantitative aspects of the stress testing process, yet some are failing the qualitative component. While there are likely a variety of contributing factors, our survey of banks reveals a failure to utilize a validated and transparent modeling framework and an inability to demonstrate integration of stress testing results with core bank activities. These items are largely within the domain of key governance functions, including audit and model validation, yet continue to be overlooked.

Audit and model validation functions often conduct examinations of models and model output which are perfunctory. This occurs because personnel in these oversight functions are typically unfamiliar with the detailed functions of the business functions for which they are responsible. As a result, review work has focused on details that, while important, may fail to identify critical flaws in process

²² These format issues will normally result in a requirement to resubmit as opposed to outright failure. However, the presence of such errors could decrease confidence in the qualitative aspects of the bank's process.

design and execution. For example, audit and model validation are unlikely to call out the failure to use competing risk models in the computation of product cash flows. In recalling the discussion of cash flows earlier in this paper, while the math used to quantify each of these risks may be correct, market and credit risks are not additive; the proper evolution of cash flows requires a simultaneous analysis of risk factors. It is no surprise that this error escapes audit and model validation teams as it is just as likely to escape people in both market risk and credit risk functions at most banks.

Two non-US banks...failed CCAR on qualitative grounds despite having more than enough capital to pass the quantitative assessments....They show that the Fed is concerned that the firm lacks some measure of internal controls to assess and reduce risk....Banks that demonstrate a chronic inability or unwillingness to correct deficient behavior can also be subject to enhanced regulatory actions, including but not limited to cease and desist orders....

Why Big Banks Cut it Close in Fed's Stress Tests, American Banker, March 11, 2015.

Members of these and other key governance functions, e.g. capital committee, ALCO and the board of directors, will require additional education and training in order to understand the business functions for which they are responsible. This will be an ongoing challenge, especially for audit, as their work in a particular area may only occur once a year and individual responsibilities may shift every couple of years. These circumstances will hinder their ability to provide effective challenge of models and model output. While this may have been acceptable in the past, continued weaknesses may lead to a regulatory failure of stress testing which will result in severe limitations on dividend and stock buy-back activity.

As for demonstrating that stress testing is a key business management process, certain business functions should be able to evidence that they both drive and integrate feedback from the stress testing process. These include:

- 1) Risk Identification
- 2) Risk Appetite Setting
- 3) Strategic Planning
- 4) Mergers and Acquisitions
- 5) Budgeting and Forecasting
- 6) Compensation and Incentive Management
- 7) Credit Risk Measurement
- 8) Interest Rate Risk Management
- 9) Liquidity Risk Management
- 10) Operational Risk Management
- 11) Enterprise Wide Risk Management

No doubt, the effort to complete an annual or semi-annual stress testing process is all-consuming, but the submission of results to the FRB does not constitute an end to the process. In order to demonstrate an evolution in risk and balance sheet management, banks must create feedback loops that allow for lessons learned to be incorporated in the management process. This challenge is similar to what was observed in the early days of ALM; organizations would take their models off the shelf once per quarter to run IRR reports to satisfy regulators. As soon as the computations were complete, the model was put back on the shelf until the next quarter. Over time, banks learned to integrate these model results into key risk and balance sheet management activities. Stress testing is expected to follow a similar course, albeit much faster.

Another qualitative element of stress testing is the ability to demonstrate an understanding of the strengths and weaknesses of various modeling approaches. Effective risk management is about much more than just throwing quants at data and commanding them to build a solution. It is important to recognize that important components of balance sheet management, e.g. strategic development, marketing initiatives and compensation schema, can invalidate model assumptions which are predicated only on past behaviors. Without a firm understanding of the drivers of behavior, management will constantly be challenged to demonstrate that their approaches to risk and balance sheet management are complete; such weaknesses will expose the bank to regulatory criticism.

Each component of balance sheet stress testing both influences and is impacted by other aspects of the balance sheet management process. The construction of a successful stress testing process should ensure that participants are able to demonstrate proper model selection and management, evidence strong validation and effective challenge and appropriate integration with existing bank processes. Extensive education and training for bank personnel, from analysts to board members, will be required in a way that we have never seen. Stress testing must serve not only as a regulatory compliance exercise but also as a core business management activity that compels banks to make smarter and more informed decisions throughout the entirety of the business cycle.

Conclusion

The stress in stress testing arises not only from the difficulties in correctly completing each of the individual stress testing components, but also from ensuring that the scenario specification has been applied consistently across each of them. It is imperative to recognize that the forecasting requirements and supporting elements are remarkable in their breadth and their detail; as such, all of the related work effort, including model validation, must remain cognizant of critical submission deadlines. There need to be severe consequences associated with delayed completion of a component or a deficiency, especially in relation to best practices. While we may never fully take the stress out of stress testing, an understanding of the requirements and role of each of the end-to-end process components can help each of the business units appreciate the challenge of the overarching problem and align them around a set of productive and fruitful efforts; after all,

Suffering becomes beautiful when anyone bears great calamities with cheerfulness, not through insensibility but through greatness of mind.

– Aristotle

About the Authors

David and Jim are partners in the Financial Services practice of The Exequor Group.

The Exequor Group is a consultancy with industry verticals in Life Sciences and Financial Services. The Financial Services practice specializes in designing analytical and governance solutions to the challenges associated with risk and performance measurement. Our areas of expertise include stress testing, asset/liability management, funds transfer pricing and capital and liquidity management.

We provide both strategic advisory services related to Treasury and Risk Management as well as data modeling and quantitative solutions that define best practice risk analytics. In addition to developing and implementing strategic risk and balance sheet management solutions to address business problems and improve financial returns, The Exequor Group strives to derive incremental value from regulatory compliance spends.

Our partners have in-depth experience in Treasury and Risk Management in leading GSIB and DFA US and global financial service providers. Leadership roles have included Head of Capital Planning, Treasurer, Chief Investment Officer, Head of Asset/Liability Management, ICAAP Director, and Head of Credit Portfolio Management.

Given the stringent and evolving regulatory environment our clients face, we apply our expertise in several ways:

Training Exequor develops and delivers courses on a variety of risk and balance sheet management subjects, including stress testing, ALM, FTP, and non-maturity deposit modeling. We also provide special training tracks for validation and audit teams, helping them to understand the business functions and regulatory issues in the areas they review.

Validation We conduct both quantitative and qualitative reviews of models and processes for validation across multiple disciplines: capital, credit, ALM, FTP, forecasting, stress testing, and liquidity.

Policy and Governance Design CCAR and DFA stress testing use test requirements demand new approaches to the implementation, operation and management of models of capital and liquidity risk. The Exequor team has the expertise and experience to develop viable solutions and best practices in addressing these highly complex challenges.

Behavioral Model Design We have developed a suite of cash flow models, which combine vital industry knowledge with PhD-level quantitative modeling skills; these models are capable of leveraging both client data and our own exhaustive industry data, which spans a broad range of asset classes.

Please visit www.exequorgroup.com or call David Green at 404.966.0054 for more information.