

POINT OF VIEW

# OPERATIONAL RISK STRESS TESTING

EMERGING BEST PRACTICES

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## INTRODUCTION

Following the financial crisis of 2008–09, financial institutions have been devoting significant time and resources to stress testing balance sheets and P&L under different macroeconomic conditions. Banks have been increasing the comprehensiveness of Enterprise Wide Stress Testing efforts. Insurance companies have been aligning with Own Risk Solvency Assessment requirements. In the US, with the advent of Comprehensive Capital Analysis and Review (CCAR), stress testing has become a third capital measurement regime next to the traditional approaches (RWA based capital and economic capital). The focus on stress testing has been increasing in other geographies as well. For instance, the European Banking Authority has recently issued draft guidance on stress testing operational risk and conduct<sup>1</sup> and the Bank of England has published guidelines on stress testing the banking system.<sup>2</sup> One of the key components of such stress testing is the ability to estimate operational losses under various macroeconomic conditions over a given projection horizon.

In times of economic and financial turmoil, operational loss events like fraud or processing errors or lawsuits may be more likely and/or more severe. While intuitive, is such intuition actually borne out in the data? In fact, one point that has long been argued is that operational risk is idiosyncratic to the firm, and therefore not driven by macroeconomic conditions. Financial institutions are facing the challenge to investigate the existence

of a direct relationship between operational event types and macroeconomic variables. A complicating factor is that, where such relationships exist, there may often be a delay between the deterioration of macroeconomic conditions and the occurrence and realization of operational losses (e.g. legal losses). Academic studies on the topic have returned mixed results and have been largely inconclusive.<sup>3,4,5,6</sup> There are two points to emphasize: (1) These studies are based on historical data sets that were short and therefore did not contain any downturn data, and (2) Most of these studies rely on vendor data sets with known weaknesses.

There is not yet a one size fits all approach to stress testing of operational losses under different macroeconomic conditions. However, to satisfy emerging regulatory expectations and ensure appropriate stress testing results, financial institutions have been using a well-structured approach to link operational losses to macroeconomic conditions to develop credible results. Regardless of the specific operational loss estimation approach selected for stress testing, financial institutions are working to provide a clear justification of all choices made and ensure the methodology used is effective and well-supported. For event types where such relationships exist, financial institutions develop hypotheses on the relationship between operational losses and macroeconomic conditions and decide on the appropriate model structure to best capture such relationships. However, for event types

1 European Banking Authority, "EU-wide stress test 2016 - Draft methodological note", November 2015

2 Bank of England, "Stress testing the UK banking system: guidance for participating financial institutions and building societies", March 2015

3 Imad Moosa, "Operational Risk as a Function of the State of the Economy", *Economic Modelling*, September 2011, 28:5, pp. 2137-2142

4 Peggy Cagan and Yakov Lantsman, "The cyclicity of Operational Risk: The tracking phenomenon", Technical Report, Algorithmics, November 2007

5 Anna Chernobai, Philippe Jorion, and Fan Yu, "The determinants of Operational Risk in US Financial Institutions", *Journal of Financial and Quantitative Analysis*, 2011, 46:6, 1683-1725

6 Eric Cope, Mark Piche, and John Walter, "Macroenvironmental determinants of operational loss severity", Technical Report, ORX, January 2011

where such relationships are expected but not found using data-driven model, financial institutions complement such models with expert judgment and/or conduct additional analysis to ensure appropriate stress testing of operational losses. For cases where no relationships to macroeconomic conditions are expected, most financial institutions consider idiosyncratic scenarios to stress the operational loss projections. Best practitioners are supplementing a champion model with a challenger model, and also conducting a number of reasonableness tests and sensitivity analysis to provide support to operational risk stress testing results.

A typical process to follow in order to conduct operational risk stress testing consists of two complementary parts and several sub-steps described throughout this report.

1. Capturing relationships between operational losses and macroeconomic conditions
  - Conducting preliminary analysis based on event types
  - Projecting losses using appropriate model form
  - Ensuring appropriate treatment of recoveries
  - Assessing reasonableness of observed relationships
2. Addressing lack of macroeconomic relationships to ensure appropriate operational loss forecasts
  - Using alternative approaches
  - Conducting supportive analysis

## CAPTURE OF MACROECONOMIC RELATIONSHIPS

A number of hypotheses have been suggested over time to link operational losses to the economy. For example, at the bottom of the cycle, financial institutions that have cut down on controls in good macroeconomic conditions could see these controls fail to cope with, for instance, the increased prevalence of fraud.

Of course, dependency on macroeconomic conditions is likely to vary across event types, as illustrated by Exhibit 1 which summarizes typical ex ante expectations. Therefore, we expect financial institutions to struggle in finding a direct relationship between frequency and/or severity of all event types and macroeconomic variables, hence focusing the analysis on developing and understanding relationships between some event types and macroeconomic variables, while stipulating that frequency and/or severity of other event types are not dependent on the economy, and therefore will not significantly be affected by stress conditions. However, assumptions about internal controls effectiveness under stressed macroeconomic conditions could be considered for all event types.

## CONDUCT PRELIMINARY ANALYSIS BASED ON EVENT TYPE

For each event type, financial institutions should develop initial hypotheses about the relationship between macroeconomic conditions and operational losses. In developing such hypotheses, financial institutions should specify the expected cyclicity of operational losses (e.g. pro-cyclicity or higher losses in strong economy

vs. counter-cyclicality or higher losses in weak economy).

Here are some illustrative examples of such initial hypotheses:

- For Internal Fraud (IF), risk of rogue trading is higher when financial markets are booming; in addition, anticipation of threat and redundancy boost the tendency of some employees to indulge in IF and promote negligence
- For External Fraud (EF), credit card fraud is more prevalent when consumer spending is strong; in addition, when unemployment rate is on the rise, the incidence of EF increases
- For Execution Delivery and Process Management (EDPM), a steep decline or high volatility in the financial markets usually increases the trading volume, which can increase execution losses
- For Clients, Products, and Business Processes (CPBP), or legal events, correlation to the economy is anticipated and financial institutions are expected to follow a rigorous process to estimate legal losses under different macroeconomic conditions

One key consideration for the legal loss estimation process is the timing of losses during the projection horizon, especially for potential future litigations. The main issue is the incorporation of a delay between the deterioration of macroeconomic conditions and the operational loss occurrence. For litigation, multiple years elapse in certain cases before open legal cases are settled. Legal reserves, used to reserve for these losses until the case is settled, are critical components of legal losses estimation under stress testing. Financial institutions should consider reasonable lags of macroeconomic variables given that timing is critical for stress testing, unlike regulatory and economic capital using the AMA framework. When calculating capital, the full amount of a lawsuit loss is considered to be a point in time event when the first reserve is established. In stress testing, existing reserves are irrelevant, given these reserves have already impacted the P&L, but the additional potential reserves for the same losses and the associated timing are critical. Note that these reasonable lags depend on the chosen event capture date (e.g. accounting, discovery, or occurrence).

Exhibit 1: Possible Relationships between Operational Losses and Macroeconomic Conditions for Basel Event Types

INTERNAL FRAUD	EXTERNAL FRAUD	EMPLOYMENT PRACTICES AND WORKPLACE SAFETY	CLIENTS, PRODUCTS, AND BUSINESS PRACTICES	DAMAGE TO PHYSICAL ASSETS	BUSINESS DISRUPTION AND SYSTEMS FAILURE	EXECUTION, DELIVERY, AND PROCESS MANAGEMENT
Losses due to acts of a type intended to defraud, misappropriate property or circumvent regulations, the law or company policy, excluding diversity/discrimination events, which involves at least one internal party	Losses due to acts of a type intended to defraud, misappropriate property or circumvent the law, by a third party	Losses arising from acts inconsistent with employment, health or safety laws or agreements, from payment of personal injury claims, or from diversity/discrimination events	Losses arising from an unintentional or negligent failure to meet a professional obligation to specific clients (including fiduciary and suitability requirements), or from the nature or design of a product	Losses arising from loss or damage to physical assets from natural disaster or other events	Losses arising from disruption of business or system failures	Losses from failed transaction processing or process management, from relations with trade counterparties and vendors
▼	▼	▼	▼	▼	▼	▼
Possible relation to macro conditions	Possible relation to macro conditions	Limited relation to macro conditions	Possible relation to macro conditions	No relation to macro conditions	No relation to macro conditions	Possible relation to macro conditions

Source: Oliver Wyman analysis

## PROJECT LOSSES USING MODEL

Following regulatory requirements and guidance, financial institutions are expected to develop appropriate models to capture the relationship between macroeconomic conditions and operational losses. We have identified two main classes of relevant model forms: Regression models and LDA models. In practice, for CCAR, these model forms are the most prevalent within the industry. The Federal Reserve Board in the US uses the average of three model forms (the first two forms are the ones commonly used within the industry), summarized in Exhibit 2, to determine operational losses. Irrespective of the chosen model form, modeling is especially challenging for low frequency units of measure. Regardless of the exact model form selected, financial institutions should ensure legal losses are appropriately captured under different macroeconomic conditions. Here is a summary of the two prevalent model forms and of potential approaches to legal loss.

### 1. Regression models:

Regression models are commonly used to capture the dependency between operational losses and macroeconomic conditions. As a result, regression models have emerged as the prime candidate structural model forms for stress testing of operational losses. Exhibit 3 shows an example of the relationship observed between operational loss frequency and macroeconomic conditions for a sample event type (EDPM). There are several types of regression models to consider for operational loss estimation, namely:

#### A. Ordinary Least Square (OLS)

**regression:** OLS is a simple method for investigating functional relationships between one or more explanatory variables and the outcome of interest. To generalize OLS regression to account for explanatory variables, loss frequency is assumed to vary across observations, having a linear relationship with explanatory variables. Note that such regression could be used for both frequency and severity within operational

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## Exhibit 2: Overview of the Federal Reserve Board Operational Risk Models

### 1. PANEL REGRESSION MODEL

- Projection of losses are the product of two primary components
  - Loss frequency
  - Loss severity
- Expected loss frequency is the estimated number of operational loss events under the supervisory scenario
  - Loss frequency modeled as function of macroeconomic variables and BHC-specific characteristics
  - Macroeconomic variables are included directly in panel regression model and/or used to project certain firm-specific characteristics
  - Separate models used for each category
- Loss severity is the estimated loss per event in each category

### 2. LOSS DISTRIBUTION APPROACH

- Expected losses are proxied by losses at different percentiles of simulated, annualized loss distributions
- Loss frequency assumed to follow a Poisson distribution specific to each event type and BHC
- Loss severity distribution is fit for each event type and BHC
- Distribution of aggregate annual losses is simulated, and the macroeconomic scenario is implicitly incorporated in the results through the percentile choice (based on analysis of historical loss data for all BHCs)

Typically used for Op Risk AMA capital models

### 3. HISTORICAL SIMULATION APPROACH

- Distribution of aggregate annual losses are simulated
  - By repeatedly drawing the annual event frequency from the same distribution used in Loss Distribution Approach (LDA)
  - Severity of events drawn from historical realized loss data rather than an estimated loss severity distribution
- Losses from the same percentile of the distribution as in the LDA are used to approximate the supervisory scenarios
- Losses are used as a floor for AMA calculations in the US

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Source: Capital Planning at Large Bank Holding Companies: Supervisory Expectations and Range of Current Practice, Board of Governors of the Federal Reserve System, August 2013

loss modeling. However, OLS regressions should not be used for frequency projections because of the potential to occasionally generate negative frequencies.

- B. **Poisson regression:** Poisson regressions generalize the Poisson distribution to account for explanatory variables. The Poisson intensity parameter is assumed to vary across observations, having a log-linear relationship with explanatory variables. Note that such regression is mainly used for frequency within operational loss modeling.
- C. **Generalized AutoRegressive Conditional Heteroskedasticity (GARCH) processes:** Financial markets data often exhibit volatility clustering, where time series show periods of high volatility and periods of low volatility.

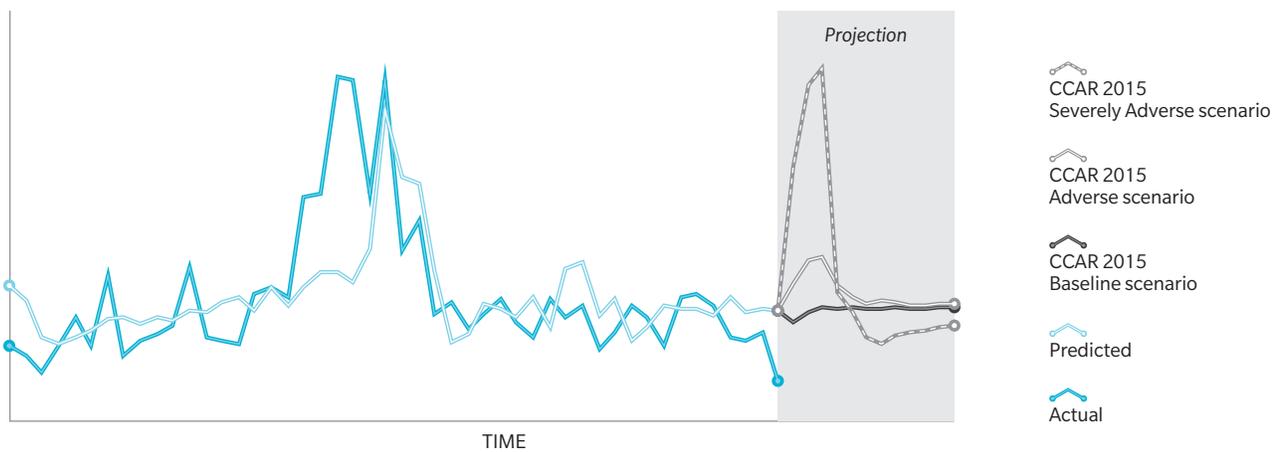
GARCH time series models have randomly varying volatility and are therefore becoming more common.

**2. Loss Distribution Approach (LDA) models:**

LDA models are frequency/severity models, where losses are projected based on Monte Carlo simulations of a frequency model and a severity model. These models are widely used under the AMA approach for regulatory and economic capital modeling, but are typically fragile and result in unstable output.<sup>7</sup> One common variation of the LDA models is a “modified LDA”, or “conditional” LDA (e.g. frequency as function of macroeconomic variables). However, full implementation of the LDA as a basis for stress testing, while intuitive in theory, requires significant analysis to back up any adjustments.

**Exhibit 3: Example of relationship between frequency of EDPM and macroeconomic conditions (VIX and GDP)**

QUARTERLY FREQUENCY: ACTUAL VS. MODEL PREDICTION  
LOSS EVENTS



**MODEL SPECIFICATIONS**

PARAMETER	COEFFICIENT	P-VALUE	PSEUDO R <sup>2</sup>
Intercept	Positive	<.0001	
VIX (YoY % change)	Positive	<.0001	37%
Real GDP (YoY % change)	Negative	<.0001	

Source: Oliver Wyman Analysis

<sup>7</sup> Mark Ames, Til Schuermann, and Hal Scott, “Bank capital for operational risk: A tale of fragility and instability”, Journal of Risk Management in Financial Institutions, March 2015, 8:3, pp. 227-243

In practice, we acknowledge that a number of CCAR financial institutions use LDA models for operational risk stress testing given the lack of data to obtain statistically robust results with a regression-based approach. One key assumption that financial institutions need to carefully justify is the percentile used to inform the stressed losses based on the LDA model output. While regulatory capital models have relied on the 99.9<sup>th</sup> percentile output from LDA models, operational loss estimates under stressed conditions are more frequent than a 1-in-1000 year event. As a result, financial institutions should test alternative percentiles and compare to benchmarks from previous economic stress conditions to determine a reasonable percentile to use for operational loss estimation under different macroeconomic conditions.

### 3. Legal losses:

Legal losses can generally be divided into multiple categories. An example of such categorization is:

- A. Unknown
- B. Remote
- C. Reasonably possible without reserve
- D. Probable with reserve

The first 2 categories of legal losses will typically be picked up by the general operational risk stress testing approach. However, the last 2 categories should be addressed by a specific legal losses estimation approach.

Legal losses should typically include a) normal litigation costs incurred from conducting regular business activities (under both normal and stressed macroeconomic conditions), b) pending litigation costs usually captured under the legal reserve (which could materialize differently into losses under normal and stressed macroeconomic conditions), and c) potential

future litigation costs expected to occur under normal and stressed macroeconomic conditions.

Recent guidance from US regulators is that financial institutions are expected to estimate legal costs (including expenses, judgments, fines, and settlements) associated with base and stress scenarios. Under base scenarios, financial institutions should use expected litigation losses. Under stress scenarios, financial institutions should estimate potential losses by assuming unfavorable, stressed outcomes on current, pending, threatened, or otherwise possible claims of all types. Estimates of stressed legal losses and other costs/expenses should be well supported by detailed underlying analysis and, while considered as a part of operational losses, should be broken out in their own subcategory, to the extent possible. The challenges primarily stem from the uncertainty related to a) the probability that a given legal case materializes into a loss, and b) the amount of loss incurred when a given legal case materializes into a loss.

The estimates of legal losses under stressed macroeconomic conditions should be guided by analysis from the Legal department. In particular, the Legal department should assign probabilities of occurrence to each open legal case. These probabilities need to be backed up by historical data and/or some type of data analysis and not just rely on estimates made by the Legal department with no real supporting evidence. These probabilities could be incorporated, for instance, into the parameter estimation process (e.g. through the use of weighted Maximum Likelihood Estimation) to account for the possible impact of potential legal costs on model parameters, or into the estimation of expected losses for a given UoM (primarily through the expected severity as expected frequency estimation is

challenging given the unknown timing of the settlement of future losses). In addition, the Legal department should provide enough information on each open legal case to allow for an estimation of the final legal losses. However, given the confidential nature of these cases, the Legal department could be asked to map them to event types for use in modeling of legal losses.

Financial institutions should use the current legal reserves as a basis for quantification of legal losses and most importantly expected/projected changes to these legal reserves, since the reserves themselves are losses impacting the P&L. Financial institutions should consider the potential for additional losses in excess of the legal reserves to materialize. Such situation will happen under normal and stressed macroeconomic conditions. The difference is by how much the reserve will change. For example, in case the economy deteriorates, many more plaintiffs might join a class action lawsuit, whereas in case the economy remains good, the number of additional plaintiffs may remain limited. In all cases, financial institutions should be careful to avoid potential double-counting given the relation between legal reserves and legal losses.

## ENSURE APPROPRIATE TREATMENT OF RECOVERIES

One question for financial institutions to consider is whether to use gross or net historical losses for any quantitative historical analysis used to support operational loss estimation for stress testing purposes. Recent guidance from US regulators is that financial institutions are expected to use gross losses in the operational loss estimation under

CCAR. However, financial institutions typically expect some non-insurance recoveries over the projection horizon. The use of losses net of such recoveries must be very well-supported, such as through an assessment of the likelihood and timing of claims fulfillment in stressed macroeconomic conditions during the projection horizon.

In instances where gross losses net of recoveries (e.g. rapid recoveries, non-insurance recoveries, etc.) are used, financial institutions should conduct additional analysis on the impact of these recoveries. In order to enhance the justification of including recoveries as part of the operational loss data, financial institutions should conduct additional assessment of the likelihood and timing of recoveries under stressed macroeconomic conditions. For instance, financial institutions could consider, in addition to the model with gross losses net of recoveries, models where a) no recoveries are used, or b) only recoveries occurring within, e.g. one year of the event date are used.

## ASSESS REASONABILITY OF OBSERVED RELATIONSHIPS

Financial institutions should conduct analysis and testing on the model to understand the direction of the observed relationship and whether such direction is reasonable. Such analysis and testing should be conducted during different stages of the model development process and consists of the following steps:

- Conducting exploratory data analysis to understand historical operational losses trends and identify periods of high loss amounts or loss frequency.

Note: In cases when a Unit of Measure (UoM) cumulative loss count data displays stationarity, financial institutions typically utilize the average annual loss count of the UoM as the intensity parameter estimate. When non-stationarity is observed in a UoM cumulative loss count data, financial institutions review the usage of OLS and Poisson regression models. Typically, when a UoM exhibits low quarterly loss counts (e.g. – the preponderance of the counts are 0 or close to 0), a Poisson regression model is preferred over an OLS regression model because these models result in non-negative frequency predictions.

- Note that an analysis will help form an initial high-level view on the types of relationships that could be expected between macroeconomic variables and operational losses. During this stage, financial institutions also obtain an initial indication of any time lags to be expected between macroeconomic variables and operational losses.
- Assessing the appropriateness of time lags in the relationship between macroeconomic variables and both legal and non-legal operational losses; there is a tradeoff between the use of lags and the loss of time series data in a small historical data set. In order to avoid excessively shrinking the usable historical data set, financial institutions could limit themselves to fairly small lags (1 or 2 quarters max). Financial institutions should assess the appropriateness of any time lags between macroeconomic variables and operational loss occurrence. Such lags are likely to be different between legal and non-legal operational losses.
  - For legal operational losses, institutions could find lagging correlation between economic downturn and legal losses. In other words, there is a delay between economic downturn and legal losses.
  - However, for non-legal operational losses, the extent of such time lags is likely not as well understood and observed in the empirical data. The time lags between economic downturn and changes to the operational loss profile should be carefully considered.
- Analyzing statistical quality of regressions and statistical significance of coefficients
- Identifying any spurious correlations between macroeconomic variables and operational losses given data sparsity and scarcity, data aggregation, and the use of different dates for modeling purposes.
- Understanding how the impact of changing macroeconomic conditions on frequency and severity eventually materializes into an impact on projected operational losses. Note that only linking the frequency of operational loss events to macroeconomic conditions has a limited impact on operational loss projections given event severity is typically the main driver of operational losses.
- Calculating impact of changes in macroeconomic conditions on operational losses using sensitivity analysis and backtesting.
- Finding cases where operational loss projections show limited relationship to macroeconomic conditions.

## RESPONSE TO LACK OF MACROECONOMIC RELATIONSHIPS

In some instances, relationships between event types and macroeconomic conditions are either not found or deemed weak. However, for stress testing purposes, financial institutions are aiming to find some relationship between operational losses and macroeconomic conditions. In these situations where a relationship is expected, but not confirmed by the data-driven models, financial institutions should resort to alternative approaches such as macroeconomic scenarios in order to show such sensitivity and could conduct additional analysis such as model benchmarking to inform and supplement projected operational losses. For cases where a macroeconomic relationship was not expected, an idiosyncratic scenario could be used (or some other ad-hoc non macroeconomic stress) to stress operational losses.

## USE OF ALTERNATIVE APPROACHES

Financial institutions should consider alternative approaches to show appropriate sensitivity of operational loss estimates to macroeconomic conditions.

1. Rely on historical loss events to inform assumptions. For instance, frequency under different macroeconomic conditions can be informed by historical frequency.
2. Use scenario analysis to complement data-driven models to ensure operational loss estimations are sensitive to macroeconomic conditions. In practice, US financial institutions subject to CCAR have leveraged scenarios, especially in the wake of the greater acceptance by regulators of expert based quantitative assessments of operational losses.<sup>8</sup>

Financial institutions should consider scenario analysis framed both a) in the context of macroeconomic conditions, and b) in the context of one-time “stress” events that could generate significant losses. These scenarios should be developed using a credible, transparent, and well supported process. Scenarios used within the context of operational risk stress testing could be categorized into:

- **Macroeconomic scenarios:** Macroeconomic scenario overlays are applied for event types where no significant relationship is found between macroeconomic conditions and frequency/severity models, but where a relationship between operational losses and macroeconomic conditions is expected. Macroeconomic scenarios should be viewed as a different exercise from the scenarios used for regulatory and economic capital AMA models, which focuses on the macroeconomic

relationships instead of the tail catastrophic events. These scenarios should be driven, to the extent possible, by macroeconomic assumptions. However, we acknowledge the risk of “scenario fatigue” that can occur when too many scenario workshops are run. As a result, the engagement level of scenario participants can drop.

- **Idiosyncratic scenarios:** Idiosyncratic scenario overlays related to operational risk are applied as add-ons to the output and any legal losses add-on. Idiosyncratic overlays pertain to events which are specific to the financial institution. These overlays account for emerging risks with no historical losses, but identified as significant going forward. Financial institutions should leverage the output of the Risk Identification process to demonstrate a detailed understanding of the operational risks facing the organization and to identify the top emerging risks for consideration as idiosyncratic scenario overlays.

The scenario selection process should take multiple considerations into account when choosing the selected scenarios. Multiple scenarios are usually considered for selection, and the selection process could be based either a) on voting by committee following an iterative review and challenge process, or b) on sophisticated scorecards developed using relevant criteria such as frequency and severity. Some considerations for scenario selection involve:

- Whether certain scenarios are more or less plausible given the macroeconomic conditions defined in the prescribed narratives for the stress testing scenarios
- Which scenarios are most relevant given the existing bank operating environment and any planned changes to the bank operations

<sup>8</sup> “Capital Planning at Large Bank Holding Companies: Supervisory Expectations and Range of Current Practice”, Federal Reserve Bank, August 2013

## CONDUCT SUPPORTING ANALYSIS

Financial institutions could conduct supporting analysis to inform and supplement the modeled operational loss estimations under different approaches. Such analysis will be critical when the relationships between macroeconomic conditions and operational losses are weak. For instance, financial institutions could develop benchmark models to check the projection results. Some examples of benchmarks for consideration involve:

- **AMA LDA model with different confidence intervals:** Financial

institutions could consider different percentiles from the AMA LDA model and compare to the stress testing model output (e.g. median or 50<sup>th</sup> percentile, 90<sup>th</sup> percentile, 95<sup>th</sup> percentile) for benchmarking purposes. In addition, in case a regression-based approach is used, we recommend benchmarking of results against the LDA model as a check on the reasonableness of the regression.

- **Historical losses:** Financial institutions could consider several combinations of historical losses (e.g. average over nine quarters, rolling nine quarters over history, worst nine quarters over history) and compare to projected operational losses under different macroeconomic conditions for additional benchmarking purposes.

## CONCLUSION

Going forward, we expect operational risk stress testing to receive increased attention across the world from financial institutions and regulators. US regulators have gone furthest to date in setting expectations around operational risk stress testing. In response, US financial institutions have developed a range of approaches to capture the impact of macroeconomic conditions on operational risks, using a variety of model forms for projecting such risks. So far, none of the observed approaches used within the US for operational risk estimation achieves all the objectives of stress testing. As European regulators are making operational risk stress testing mandatory for financial institutions, the US offers important lessons to be learned: A structured, analytical, and comprehensive process along the lines described in this report will go a long way to achieve a credible result. The process includes leveraging multiple potential approaches to operational risk estimation to develop both a solid champion model and an appropriate challenger model,

and conducting reasonableness tests on the results and resorting to alternative approaches such as scenario analysis to ensure appropriate differentiation between operational risk estimations under normal and stressed macroeconomic conditions.

In addition, the evolution of operational risk stress testing approaches will potentially have a positive impact on operational risk modeling more broadly, as we are seeing more institutions considering factor-based modeling and exposure-based modeling for non stress testing purposes. Finally, operational risk stress testing can be relevant for financial institutions far beyond regulatory compliance. For instance, operational risk stress testing can help provide a more complete understanding of risks, inform data collection, and allow for issue identification based on scenario analysis output. Last but not least, any strong evidence of macroeconomic relationship will likely challenge fundamental assumptions underlying the AMA model, which will require a deep dive.

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