

# Important Steps in the Development and Validation of Stress Testing Models

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The Federal Reserve expects bank holding companies (BHCs) with assets greater than \$50 billion to (1) hold sufficient capital to maintain access to funding; (2) continue to serve as credit intermediaries; (3) meet their obligations to creditors and counter parties; and (4) continue operations, even in an adverse economy.

For this reason, they have developed the Comprehensive Capital Analysis and Review (CCAR). CCAR stress tests are macroeconomic scenario-based stress tests, with three supervisory scenarios (baseline, adverse and severely adverse), as well as additional internal scenarios (severe and severely adverse).

The capital plans rule applies to these BHCs, and they have to develop and submit a capital plan to the Federal Reserve on an annual basis. Consequently, they request prior approval from the Fed before making a capital/dividend distribution to their shareholders.

In this paper, we explain key aspects that risk managers need to consider to develop and validate stress testing models.

The first step is to gain an understanding of the business (or the portfolio) for which the stress testing model has to be developed. This understanding is required because a stress testing framework requires a projection of all of the following:

- 1) Pre-Provision Net Revenue (PPNR);
- 2) Loan losses and changes in allowance for loan and lease losses (ALLL);
- 3) Losses on loans held for sale and measured under the fair-value option;
- 4) Other-Than-Temporary Impairment (OTTI) losses on investment securities in the available-for-sale (AFS) and held-to-maturity (HTM) portfolios;
- 5) For BHCs with large trading and private equity exposures, losses on those exposures resulting from a global market shock; and
- 6) For BHCs with substantial trading, processing or custodial operations, losses from the default of their largest counter party.

Each of the above components has its own respective components and sources of data. Consequently, a top down understanding of the company's business is critical. Reading and understanding form 10-K of the company will be an excellent starting point toward this direction.

The second step would be to understand the data. Typical data types include the following:

1) Loss driven data: Examples are historical Probability of Default (PD), Loss Given Default (LGD), Exposure at Default (EAD). PD data is modeled as time series data, LGD is modeled as cross sectional data and EAD modeling depends on the type of portfolio.

2) Valuation/return based data: Time series data, which is income, return, revenue forecasting. Based on given data sequence a time series model is developed which help in calculation of change in valuation with respect to the given stressed scenarios.

The combination of step 1 and step 2 will involve deep discussions between business leaders and modelers. The output of this step will be an agreement among them about what needs to be modeled. These two steps should take maximum investment of time and resources.

The third step is data development. This step is the most important step in the whole process, because here the bridge is developed to transfer the documents and reports spread all around the organization into a format where a model can be developed using analytical methodology based on business sense.

The fourth step development of a model which predicts the relevant dependent variable using external/internal independent variables. This will require business and statistical due diligence to find relevant independent variables. Generally linear regression based models are developed. Other methodologies which can also be implemented are Transition Probability Matrix (TPM) and Monte Carlo simulation based methodologies. TPM will be involved assigning conditional chances assigned to the scenarios resulting into most probable output. Monte Carlo simulation will involve introducing a random factor in the model and predicting the possible event with the choice of confidence.

It is important to ensure the robustness of the model by using appropriate statistical tests. Some suggestions:

1. If residuals of the model are having heteroskedasticity or auto-correlation, this implies that the relationship between the dependent and independent variables will not be valid when the independent variables are stressed.

2. The relationship strength can be checked by Granger Causality test. If the model relationship satisfies this relationship this means that the independent variables indeed impact the dependent variable and vice-versa.

### **Post- Model Development Analysis**

Once the model has been developed, there are further analytical exercises which help in deriving more insight about the business using model output. These processes when combined with business judgment also help us in authenticating the model output via the following methodologies:

1. *Back testing*. Once a model is designed, back testing checks the validity of the relationship in the past. The model is calibrated using (say) 80% of the data, for rest 20% the actual vs model values are compared.

2. *Backcasting*. This starts with defining a desirable future and then works backwards to identify policies and programs that will connect the future to the present. In the context of CCAR stress testing, future scenarios (values of the independent variables) are predefined. Using the model relationship future value of the dependent variables can be calculated. But for robust risk management, risk managers should not stop at this. The dependent variables as discussed above are composition of other variables. A qualitative (and possibly quantitative) business scenario based theory should be developed on how those constituents are impacted by the change in external macro-economic variables.

### **Other Challenges**

Often, the definition of data and its right source cannot be well defined. In vast organizations that have grown through mergers and acquisitions, there may be multiple sources of data, and it is a challenge to assemble best available level of granularity. Every firm also needs to ensure that it does not double count its data or portfolios.

Finding robust validation framework, once the model is designed, is another big challenge. It is important to find the right statistical tests that a model needs to pass so that all stakeholders are comfortable with the model's authenticity.

Developing a strong model monitoring framework that ensures timely warnings, and takes into account feedback from stakeholders, is yet another hurdle that each firm must climb..

### **The Limited Data Obstacle**

Data is a natural phenomenon, but models are man-made. Consequently, there are no models that can completely capture all available data and predict all future behavior. This problem only gets worse when there is limited and unreliable data. There are a limited number of options available from a modeling perspective to deal with thin data sets. Consequently, modelers and business experts have to analyze business problems from alternative perspectives to achieve the best result. They need to compliment the model with alternative scenarios (through other more similar distributions), similar businesses (through expert judgments and independent studies) to support the output delivered by the model.

### **Parting Thoughts**

CCAR stress test models are last line of defense of the financial systems. This is a concept which is not just about actual model itself but also about the business understanding, understanding about the surrounding and articulating the impact of that surrounding on business in extreme times. All said, by no means we undermine the importance of statistical robustness, but rather emphasize that over and

above that robustness further deeper assessment is required. The purpose of this article is to list out key steps which analyst should consider while developing and validating a stress testing model.

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