Financial Stress Testing using SAS

Wall Street & Main Street Nightmare

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About this presentation

- Presented at Philadelphia-area SAS User Group (PhilaSUG) meeting on October 11th, 2016 at West Chester University.

- This presentation is an introduction to Financial Stress Testing and Modeling. It is about using SAS programs with applications to Financial modeling and Stress Testing

- Tools / background needed: programming skills, Macroeconomics, Econometrics, Statistics, and Machine Learning (ML)

SAS OnDemand for Academics ~ Free SAS software for everyone

- http://www.sas.com/en_us/industry/higher-education/on-demand-for-academics.html
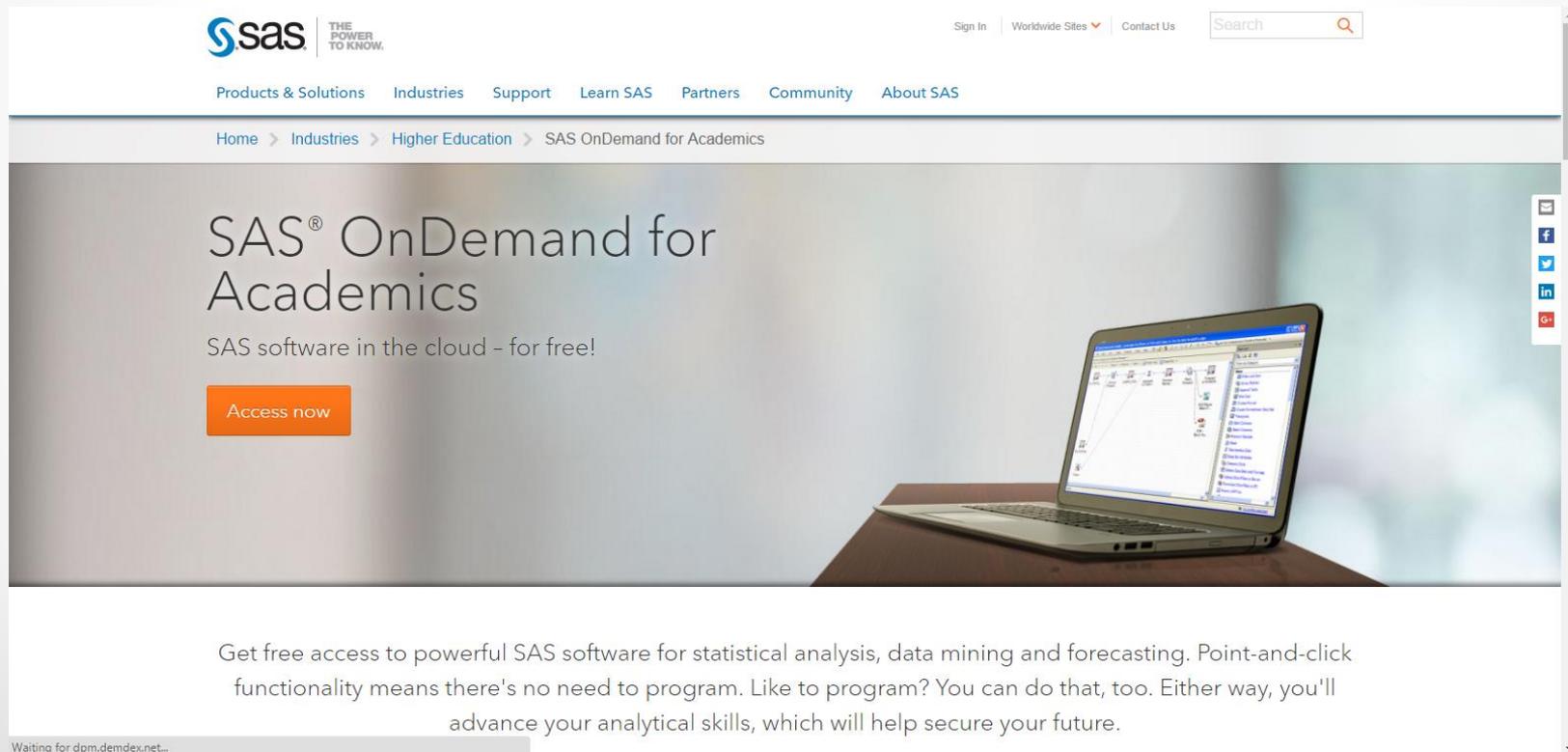
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- Opinion expressed are strictly and wholly of the presenter and not of TD Bank Financial Group, SAS or any of their affiliates

Presentation outline

- **Part I** -- What is Financial Stress Testing
  - ❖ DFAST: Dodd-Frank Acts Stress Testing
  - ❖ CCAR: Comprehensive Capital & Analysis Review

- **Part II** – Analyst toolbox
  - ❖ SAS programming
  - ❖ Statistics / Econometrics / Machine Learning
  - ❖ Macroeconomics

- **Part III** -- Financial Stress Testing Modeling

Part I
What is Financial Stress Testing ?

Wall street and Main street Nightmare

- Some case studies:
  - ❖ Citi Bank (2014)
  - ❖ Deutsche Bank (2016)

Wall street and Main street Nightmare – A Case study
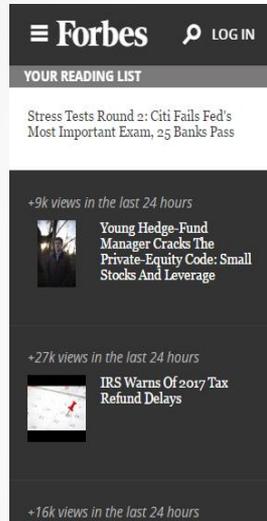
- Citi stock market's shares fell nearly 5%
- Citi can't go ahead and repurchase $6.4 billion shares nor increase its dividend to $.05
- FEDS may block Capital distribution

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Wall street and Main street Nightmare – A Case study

DJIA Futures ▲ 18408 0.07%   U.S. 10 Yr ▼ -8/32 Yield 1.609%   Euro ▼ 1.1139 -0.18%

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U.S. DFAST & CCAR Regulatory Agencies "The Regulators"

- ## The Board
  - ❖ Federal Reserve System
  - ❖ Federal Reserve
  - ❖ The "Feds"

- ## OCC
  - ❖ Office of the Comptroller of the Currency
  - ❖ A division of the U.S. Department of Treasury

- ## FDIC
  - ❖ Federal Deposit Insurance Corporation

Financial Stress Testing, according to the regulators

According to the regulators, the Stress Testing Guidance of 2012 sets forth the following five principles for an effective stress testing regime:

1. A company's stress testing framework should include activities and exercises that are tailored to and sufficiently capture the company's exposures, activities, and risks

2. An effective stress testing framework should employ multiple conceptually sound stress testing activities and approaches

3. An effective stress testing framework should be forward-looking and flexible

4. Stress test results should be clear, actionable, well supported, and inform decision making

5. A company's stress testing framework should include strong governance and effective internal controls.

Financial Stress Testing ~ Scenario Rule Requirement

- Rule Requirement:
  - ❖ A company must use the scenarios provided annually by its primary Federal financial regulatory agency to assess the potential impact of the scenarios on its consolidated earnings, losses, and capital.
  - ❖ Companies must assess the potential impact of a minimum of three macroeconomic scenarios baseline, adverse, and severely adverse—provided by their primary supervisor on their consolidated losses, revenues, balance sheet, and capital. The rule defines the three scenarios as follows:

- **Baseline scenario** means a set of conditions that affect the U.S. economy or the financial condition of a company that reflect the consensus views of the economic and financial outlook.

- **Adverse scenario** means a set of conditions that affect the U.S. economy or the financial condition of a company that are more adverse than those associated with the baseline scenario and may include trading or other additional components.

- **Severely adverse scenario** means a set of conditions that affect the U.S. economy or the financial condition of a company that overall axe more severe than those associated with the adverse scenario and may include trading or other additional components.

DFAST: Dodd-Frank Acts Stress Testing

- The Board, FDIC and OCC, (collectively, the "agencies") are issuing this guidance, which outlines high-level principles for implementation of section 165(1)(2) of the Dodd-Frank Act Wall Street Reform and Consumer Protection Act ("DFA") stress tests, applicable to all bank and savings-and-loan holding companies, national banks, state-member banks, state non-member banks, Federal savings associations, and state chartered savings associations with **more than $10 billion but less than $50 billion** in total consolidated assets (collectively, the "$10-50 billion companies").

DFAST: Key highlights

- Supervisory scenario
- Data sources and Segmentation
- Loss Estimation, LE
- Pre-Provision Net Revenue, PPNR
- Governance and Controls

DFAST: Key highlights

- **Supervisory scenarios**
  - ❖ Assess the potential impact of a minimum of three macroeconomic scenarios (baseline, adverse, and severely adverse) on their Losses, Revenues, Balance sheet and Capital.

- **Data sources and segmentation**
  - ❖ Data source: Internal data preferred but External data could be used as long as it aligns with BHC's risk profile and exposures.
  - ❖ Portfolio segmentation and business activities into categories based on common or related risk characteristics based on the size, materiality, and riskiness of a given portfolio.

- **Loss Estimation**
  - ❖ Estimation of the following for each required scenario: Losses, Pre-provision net revenue (PPNR), Provision for loan and lease losses (PEEL), and Net income.

- **Pre-Provision Net Revenue**
  - ❖ PPNR main components: Net interest income, Non-interest income and Non-interest expense

- **Governance and controls**
  - ❖ BHCs should establish and maintain a system of controls, oversight, and documentation, including policies and procedures.

CCAR: Comprehensive Capital & Analysis Review

- The Federal Reserve's annual Comprehensive Capital Analysis and Review (CCAR) is an intensive assessment of the capital adequacy of large, complex U.S. bank holding companies (BHCs) and of the practices these BHCs use to assess their capital needs.

- The Federal Reserve expects these BHCs to have sufficient capital to withstand a severely adverse operating environment and be able to continue operations, maintain ready access to funding, meet obligations to creditors and counterparties, and serve as credit intermediaries.

- The Board of Governors of the Federal Reserve System's (Board's) capital plan rule requires BHCs with consolidated assets of **$50 billion or more** to submit annual capital plans to the Board.

- Under the rule:
  - ❖ BHC's capital plan must include detailed descriptions of the BHC's internal processes for assessing capital adequacy; the board of directors' approved policies governing capital actions; and the BHC's planned capital actions over a nine-quarter planning horizon.
  - ❖ BHC must report to the Federal Reserve the results of stress tests conducted by the BHC under scenarios provided by the Federal Reserve and under a stress scenario designed by the BHC (BHC stress scenario). These stress tests assess the sources and uses of capital under baseline and stressed economic and financial market conditions.

CCAR: Comprehensive Capital & Analysis Review

- The Federal Reserve's quantitative assessment of a BHC's capital plan is based on the supervisory and company-run stress tests that are conducted, in part, under the Board's rules implementing sections 165(i)(1) and (2) of the Dodd-Frank Wall Street Reform and Consumer Protection Act (Dodd-Frank Act stress test rules).

- The quantitative assessment of a BHC's capital plan includes a supervisory assessment of the BHC's ability to maintain capital levels above each _minimum regulatory capital ratio_, after making all capital actions included in its capital plans, under baseline and stressful conditions throughout the _nine-quarter_ planning horizon.

  - _Capital requirement (also known as regulatory capital or capital adequacy) is the amount of capital a bank or other financial institution has to hold as required by its financial regulator. This is usually expressed as a capital adequacy ratio of equity that must be held as a percentage of risk-weighted assets. These requirements are put into place to ensure that these institutions do not take on excess leverage and become insolvent. Capital requirements govern the ratio of equity to debt, recorded on the liabilities and equity side of a firm's balance sheet._

DFAST vs. CCAR

- *Some of the difference between DFAST and CCAR*
  - ❖ DFAST: $10 - $50 BN, Regulator: OCC (twice a year)
  - ❖ CCAR: $50 BN, Regulator: The Feds (once a year)
  - ❖ CCAR involves capital action planning–what banks do with their capital for shareholders, i.e. offer dividends or buyback stock.
  - ❖ Under CCAR the Fed assesses the quantitative impact of the bank's capital plan and the quality of the bank's qualitative capital planning processes while DFAST does not assess capital plans.

Part II
Analyst Toolbox for
Financial Stress Testing Modeling

SAS programming tools

- SAS DATA step: https://support.sas.com/documentation/cdl/en/basess/58133/HTML/default/viewer.htm#a001290590.htm

- SAS PROC SQL: http://support.sas.com/documentation/cdl/en/sqlproc/63043/HTML/default/viewer.htm#titlepage.htm

- SAS / Macros: http://support.sas.com/documentation/cdl/en/mcrolref/61885/HTML/default/viewer.htm#macro-stmt.htm

- SAS / IML: http://support.sas.com/rnd/app/iml/

- SAS/ STAT: http://support.sas.com/software/products/stat/

- SAS / ETS: https://support.sas.com/documentation/onlinedoc/ets/

Statistics/Econometrics/Machine Learning

- 1--Regression analysis "Box-Jenkins approach"
  - ❖ Model identification
  - ❖ Model estimation
  - ❖ Model diagnostics
  - ❖ Model forecasting

- 2--Multivariate Statistical analysis
- *Also known as Statistical or Machine Learning*
  - ❖ Cluster analysis
  - ❖ Correlation analysis
  - ❖ Random Forest analysis
  - ❖ Principal component analysis
  - ❖ Discrimination analysis
  - ❖ Classification analysis
  - ❖ Resampling methods

- 3--Time series analysis
  - ❖ Model classification
  - ❖ Model calibration
  - ❖ Model stability
  - ❖ Model sensitivity

Time Series Modeling – An overview

- Classification of Time Series models:
    - Static vs. Dynamic model
    - Time vs. Frequency model
    - Univariate vs. Multivariate model
    - Stationary vs. Non-stationary model

- Some commonly used Time Series models
    - Autoregressive, AR
    - Moving Average, MA
    - Finite distributed Lag, FDL
    - Autoregressive distributed Lag, ADL
    - Autoregressive Moving Average, ARIMA
    - Autoregressive Conditional Heteroskedasticity, ARCH
    - Generalized Autoregressive Conditional Heteroskedasticity, GARCH
    - Multivariate Time Series:
        - Vector Autoregressive, VAR
        - State Space Method, SSM

Financial Macroeconomics

- Some macroeconomics indicators:
  - ❖ Gross Domestic Product
  - ❖ Disposable Income, DI
  - ❖ Unemployment rate
  - ❖ Consumer Price Index
  - ❖ M1 / M2 Money stock
  - ❖ Inflation rate
  - ❖ 10-Yr Treasury rate,
  - ❖ Federal Fund rate
  - ❖ BBB Yield
  - ❖ 3-month Treasure Bill
  - ❖ 1-Month London Interbank Offered Rate (LIBOR)
  - ❖ S&P 500
  - ❖ Moody's Seasoned Baa Corporate Bond Yield
  - ❖ etc.
  - Source: https://fred.stlouisfed.org/

Financial Stress Testing Modeling

Case study: Using SAS PROC AUTOREG

Modeling Process

- Data management
- Model selection

Data source and Data management

- Dependent variable, DV
- Independent variables, IV
  - ❖ Macroeconomic variables provided by the Regulators
  - ❖ Company's specific, internal variables
  - ❖ External variables

Model Development using Box-Jenkins approach

- Model identification:
  - ❖ Linear, Polynomial, etc.
- Model Estimation
  - ❖ OLS, GLS, PLS, etc.
- Model Diagnostics
- Model Forecasting
- Model Stress Testing (as specified by the Regulators)
  - ❖ Baseline scenario
  - ❖ Adverse scenario
  - ❖ Severely adverse scenario

Stationarity

- SAS PROC AUTOREG
- With any Time-series modeling, your must check stationarity of your variable
- Common test is Augmented Dickey-Fuller (ADF) test
- Other tests are available in SAS

Model Selection process

- Examples of data reduction approach:
  - ❖ Principal component: SAS PROC PRINCOMP
  - ❖ Cluster analysis: SAS PROC VARCLUS
  - ❖ Step-Wise selection: SAS PROC REG with SELECTION=stepwise/forward/backward

Selecting the "Best" model (Statistically speaking)

- Goodness-of-Fit test, e.g. AIC, BIC
- Autocorrelation test, e.g., Durbin-Watson
- Normality test, e.g. Shapiro-Wilk Test, Kolmogorov–Smirnov Test
- Heteroskedasticity test, e.g., White Test
- Multicollinearity, e.g., Variance Inflation Factor (VIF)
- Model significance test, e.g. F-test

Selecting the "Best" model (Business speaking)

- Discuss with business owners to see that your models make business sense

Model validation

- In-sample (in-time) analysis
- Out-of-sample (out-of-time) analysis
- Model Calibration
- Model Stability
- Model Sensitivity

Sample "Champion" model #1 – Forecast by Stress Testing Scenarios


Base Line Scenario
Severely Adverse Scenario
Adverse Scenario
Historical Default Probability

Source: Kamakura Corporation, Federal Reserve

SOURCE: http://kamakuraco.com/
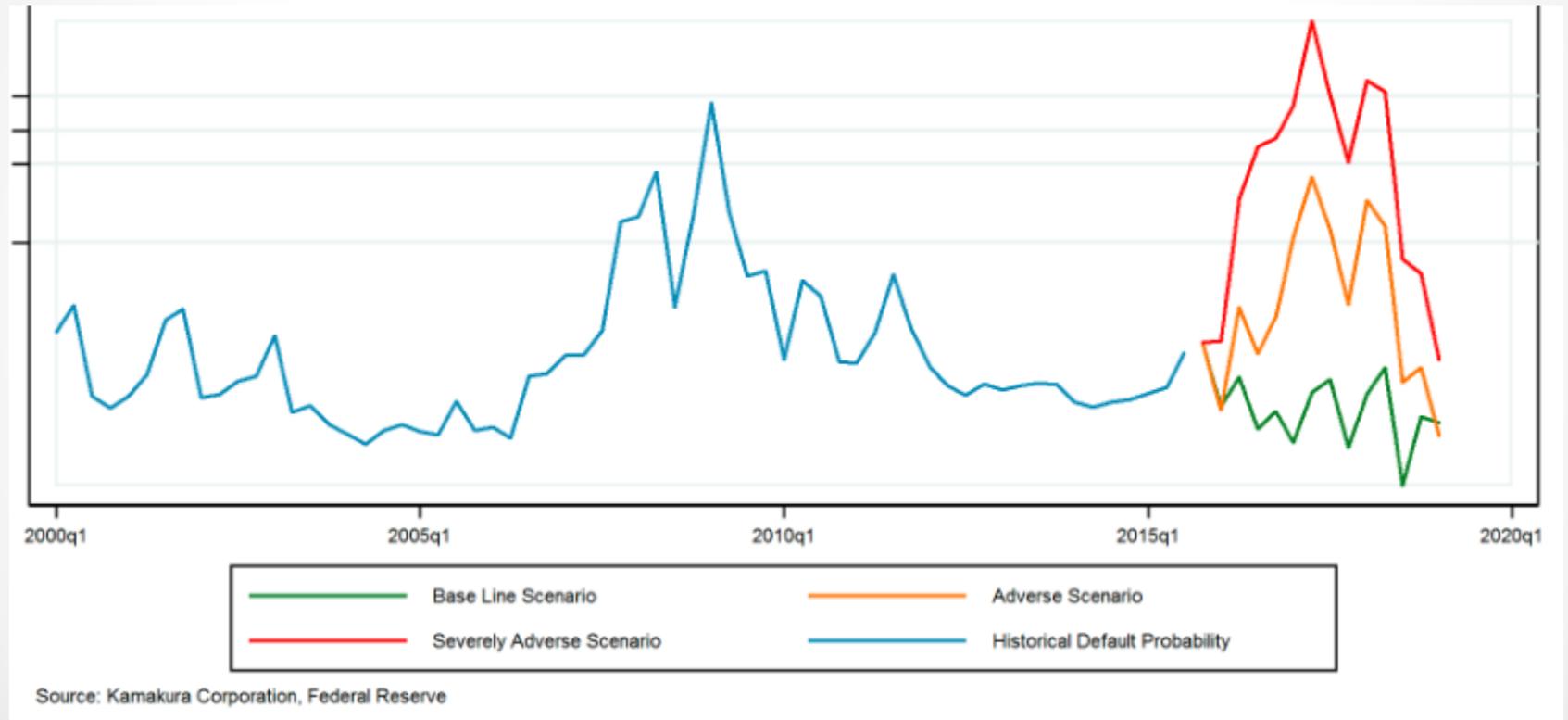
Sample "Champion" model #2 – Forecast by Stress Testing Scenarios
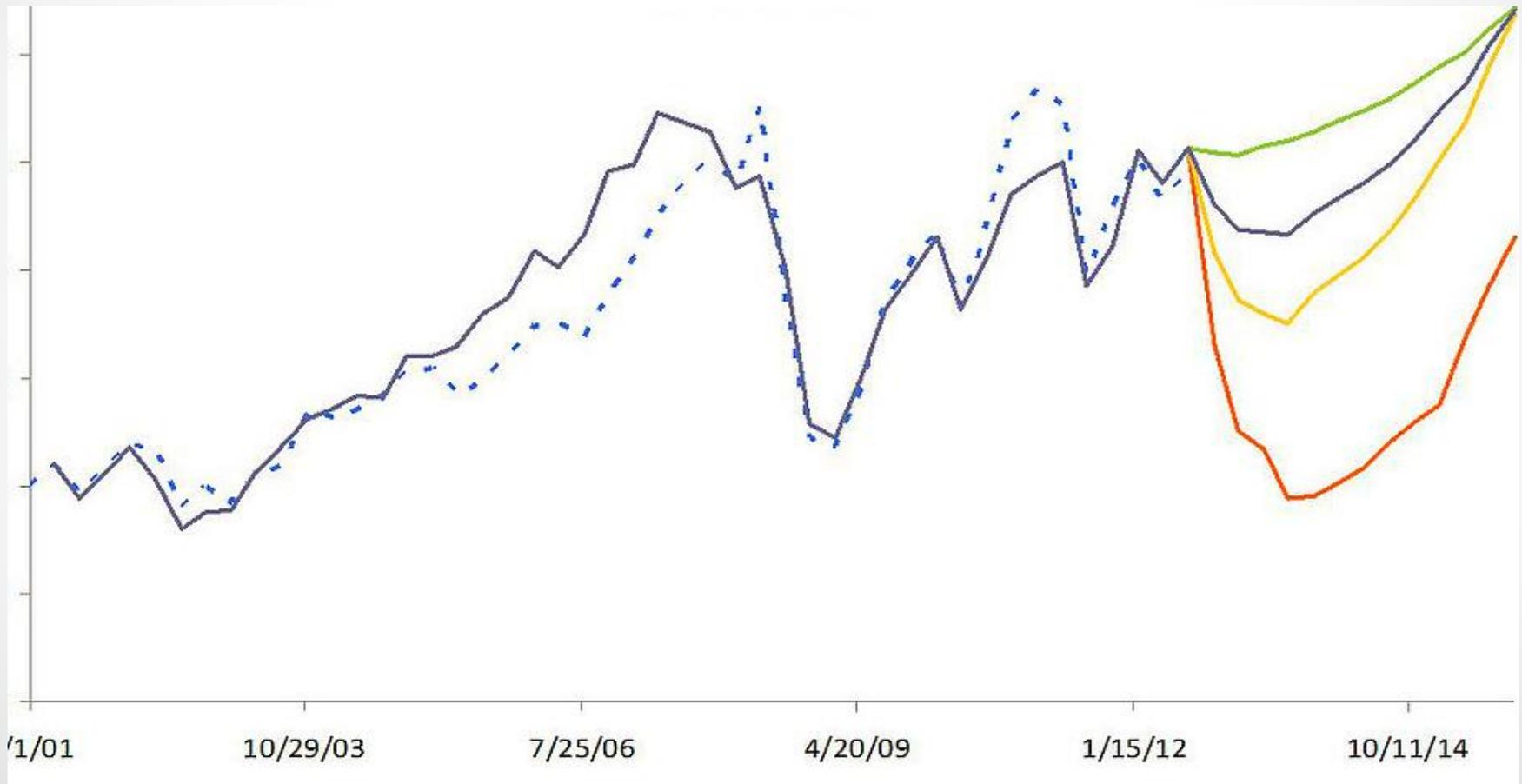
Potential independent variable: U.S Prime Rate

Kamakura Corporation
U.S. Prime Rate
Federal Reserve CCAR 2015 Stress Testing

Legend:
- Actual Data
- Base Line Forecast
- Adverse Forecast
- Severely Adverse Forecast
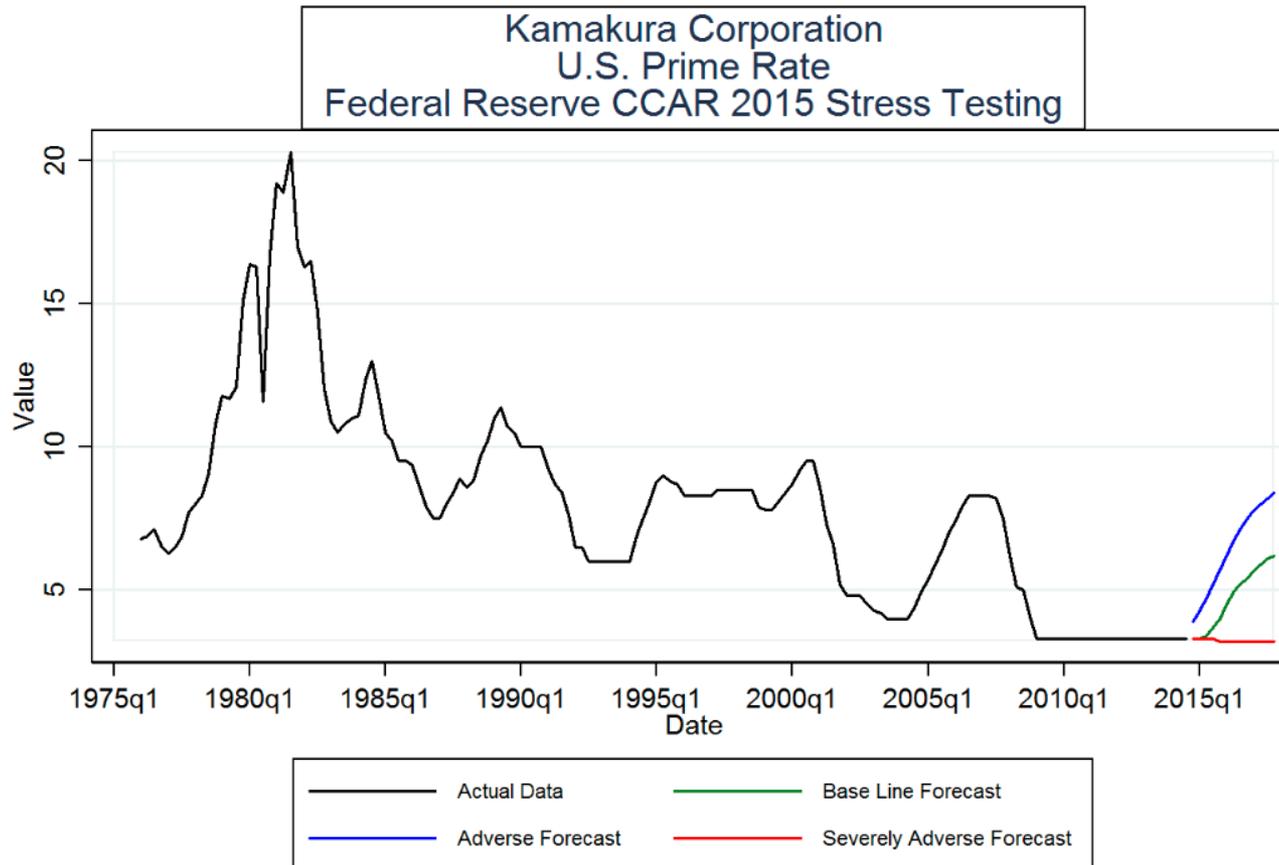
Source: Kamakura Corporation, Federal Reserve

Potential independent variable – U.S. BBB Yield

Kamakura Corporation
U.S. BBB Bond Yield
Federal Reserve CCAR 2015 Stress Testing
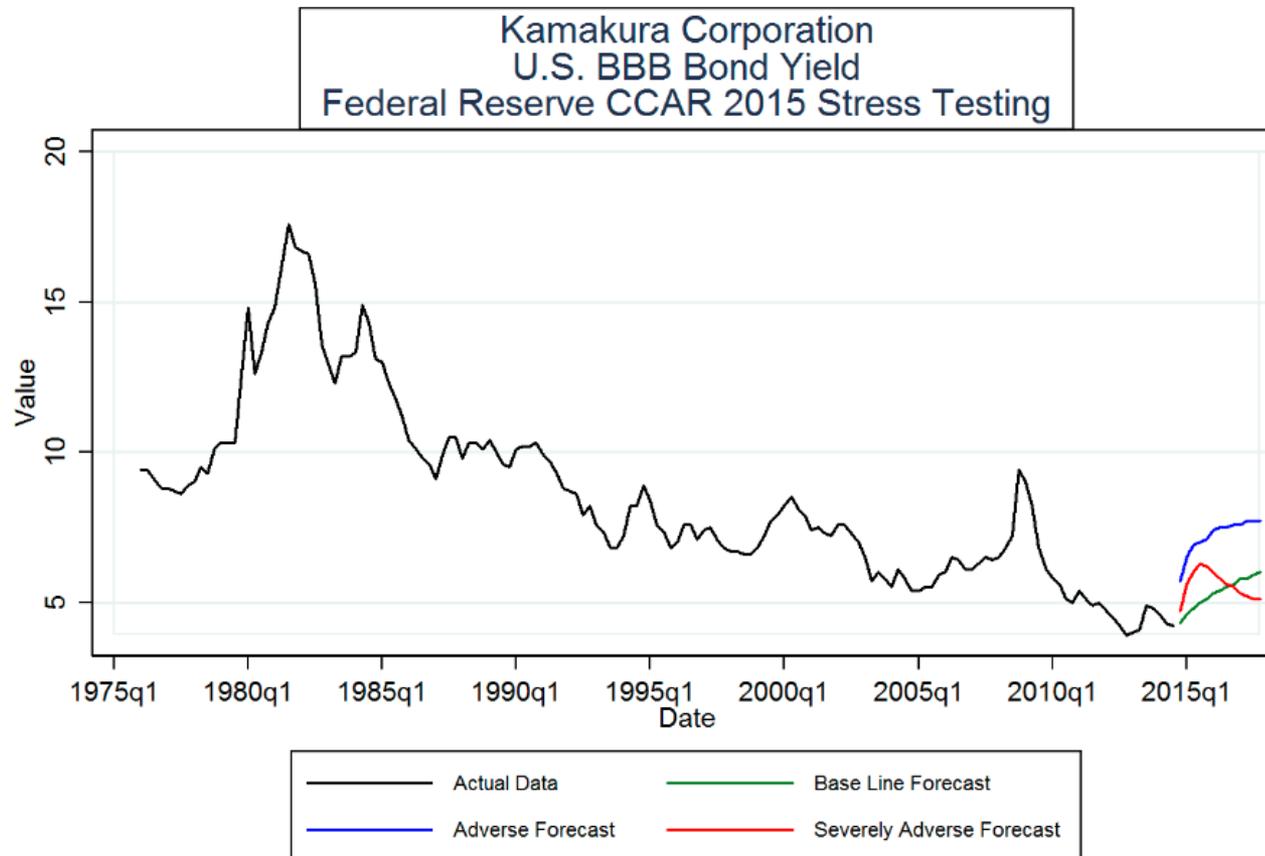
Source: Kamakura Corporation, Federal Reserve

Potential independent variable: GDP (transformed, QoQ)

Percentage Change in GDP: Historical and by CCAR 2016 Scenario

SOURCE: https://sperorisk.com/

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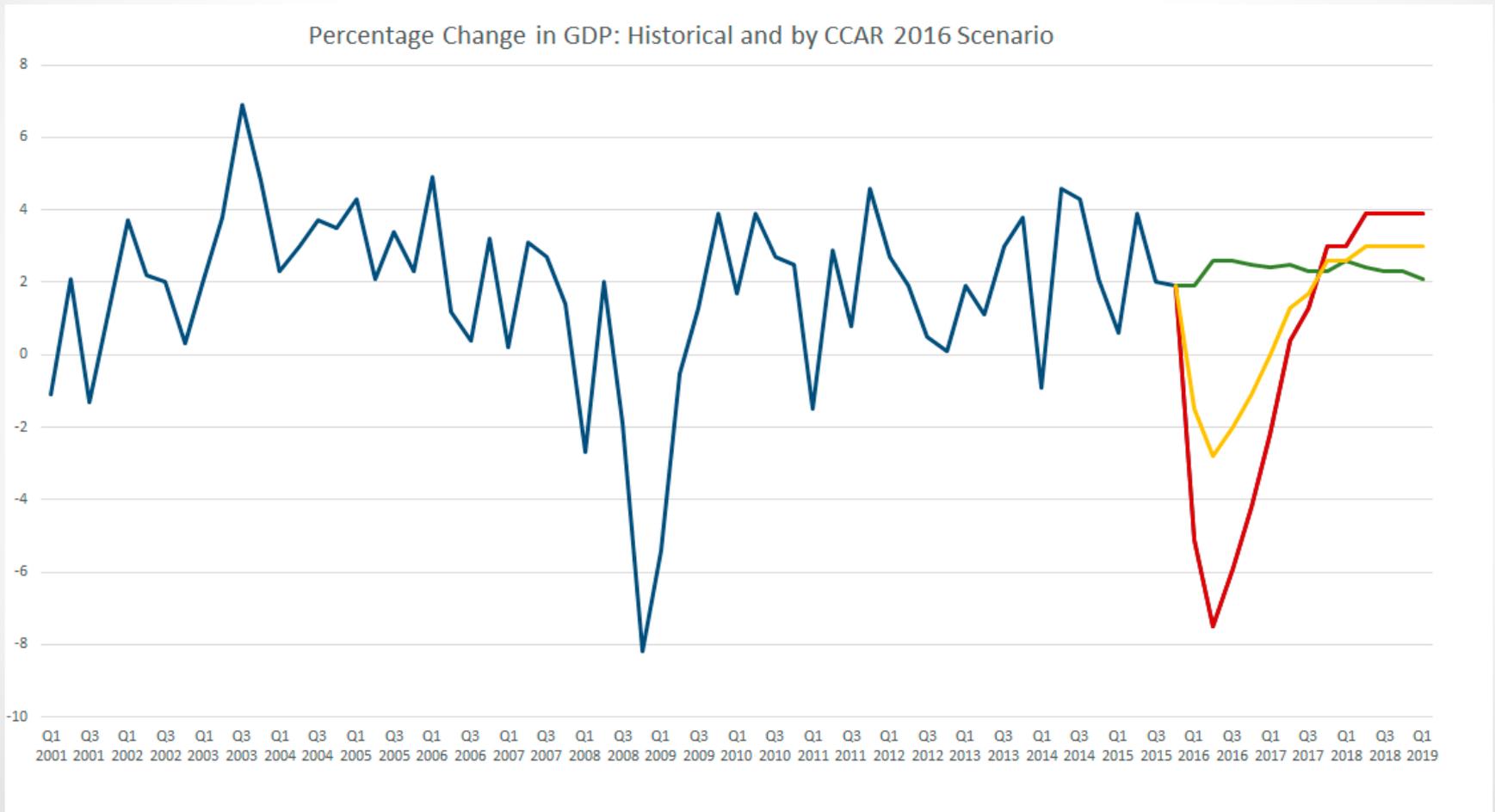
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