Stress Testing

Credit Risk Management

Definition

- A stress test is a comprehensive process where statistical tools are used as a guide to assess how adverse macroeconomic scenarios may affect a bank's resilience.

- Federal reserve United States, European National Bank, Bank of England etc. do an annual stress testing assessment and publish the results based on the scenarios provided the authorities,

Types of Stress Tests

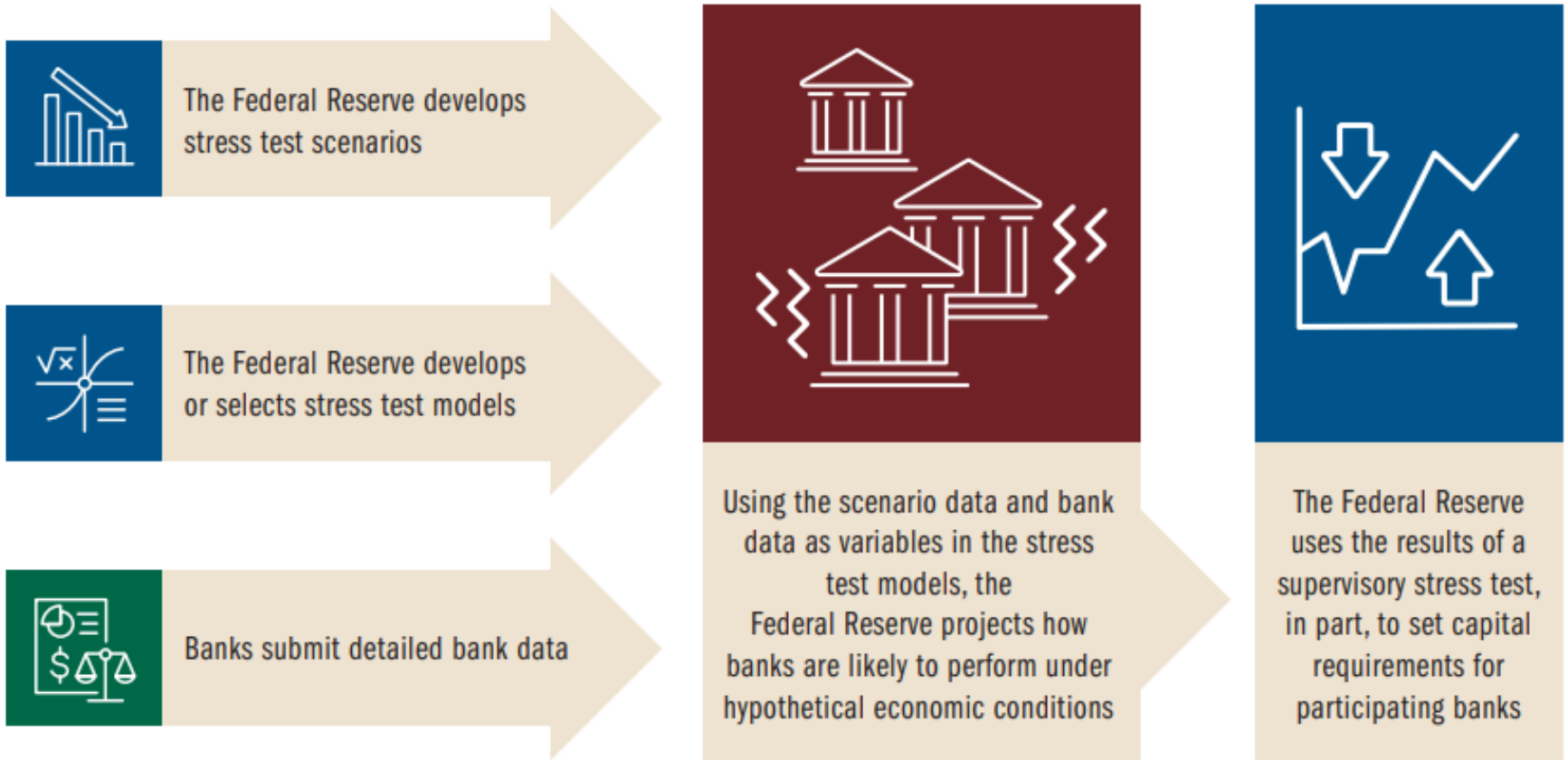
- Scenario Analysis
  - Developing Stress Scenarios
    - Identifying and creating adverse scenarios based on historical data and expert judgment.
  - Evaluating Scenarios
    - Assessing the impact of scenarios on different variables.
- Sensitivity Analysis
  - Identifying Key Variables
    - Determining which variables have the most significant impact on outcomes.
  - Analyzing Impact
    - Varying key parameters to observe changes in results.

Different Approaches to Stress Testing

Aspect	Bottom-Up Stress Test	Top-Down Stress Test
Who is carrying out the test?	By the firm itself	By regulatory authorities / central banks
Who's assumptions is it based on?	Firm's own assumptions or scenarios, with possible constrains by authorities	General or systemic (macro-prudential) assumptions or scenarios designed by regulators and applicable to all relevant institutions
What data granularity does it require?	Based on the firms's own data and a high level of data granularity (possible use of external data)	Based mostly on aggregate institution data and less detailed information
How comparable is it across firms?	Little comparability as methodologies may differ substantially	Enables uniform and common framework and comparative assessment of the impact of a given stress testing exercise across institutions

Figure 1. How stress testing works for large banks

The Federal Reserve conducts stress tests to ensure that large banks are sufficiently capitalized and able to lend to households and businesses even in a severe recession. The stress tests evaluate the financial resilience of banks by estimating losses, revenues, expenses, and resulting capital levels under hypothetical economic conditions.



Reforms and Stress/Shock Scenarios

- Regulatory bodies like Bank of England, Federal Reserve, European Banking Authority hand out Stress scenarios to the banks annually

Stress Testing – Example: Loss Estimation for a bank in SAS

Alphabetic List of Variables and Attributes

#	Variable	Type	Len	Format
3	credit_score	Num	8	
5	debt_to_income_ratio	Num	8	
7	default	Num	8	
9	gdp_growth	Num	8	
4	income	Num	8	
10	interest_rate	Num	8	
6	loan_amount	Num	8	
2	loan_id	Num	8	
1	month	Num	8	YYMMDD10.
8	unemployment_rate	Num	8	

- Simulated a table that contains loan portfolio with a few macro economic indicators

Analysis of Maximum Likelihood Estimates

Parameter	DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept	1	1.4168	0.9438	2.2535	0.1333
credit_score	1	-0.00633	0.000890	50.6047	<.0001
income	1	-0.00001	6.798E-6	2.2147	0.1367
debt_to_income_ratio	1	0.6484	1.1489	0.3185	0.5725
unemployment_rate	1	0.0876	0.1623	0.2913	0.5894
loan_amount	1	-2.07E-6	1.772E-6	1.3670	0.2423
gdp_growth	1	-6.3812	7.7605	0.6761	0.4109
interest_rate	1	1.9429	10.0051	0.0377	0.8460

- Logistic Regression model of the simulated variable data

Stress Scenario Simulation

```
data stress_scenario;
  set loan_portfolio;
  unemployment_rate = unemployment_rate + 2;
  gdp_growth = gdp_growth - 3;
  interest_rate = interest_rate + 1;
run;
```

Stress Scenarios shared by regulators: 2024-Table_3A_Supervisory_Baseline_Domestic.csv

- Source: https://www.federalreserve.gov/supervisionreg/dfa-stress-tests-2024.htm

Obs	month	loan_id	credit_score	income	debt_to_income_ratio	loan_amount	default	unemployment_rate	gdp_growth	interest_rate	_LEVEL_	prob_default
1	2020-02-01	31	548	39303	0.21	78770	0	4.9	0.02	0.01	1	0.10377
2	2020-02-01	39	372	26534	0.13	152717	0	4.9	0.02	0.01	1	0.24643
3	2020-02-01	45	661	42595	0.37	229164	0	4.9	0.02	0.01	1	0.04259
4	2020-02-01	82	676	38801	0.14	178868	0	4.9	0.02	0.01	1	0.03864
5	2020-02-01	127	603	36367	0.12	75931	0	4.9	0.02	0.01	1	0.07399

- Baseline Scenario

The SAS System

- Severe Scenario

Obs	month	loan_id	credit_score	income	debt_to_income_ratio	loan_amount	default	unemployment_rate	gdp_growth	interest_rate	_LEVEL_	prob_default
1	2020-02-01	31	548	39303	0.21	78770	0	6.9	-2.98	1.01	0	0.90982
2	2020-02-01	39	372	26534	0.13	152717	0	6.9	-2.98	1.01	0	0.75225
3	2020-02-01	45	661	42595	0.37	229164	0	6.9	-2.98	1.01	0	0.95167
4	2020-02-01	82	676	38801	0.14	178868	0	6.9	-2.98	1.01	0	0.95897
5	2020-02-01	127	603	36367	0.12	75931	0	6.9	-2.98	1.01	0	0.93555

Calculating Expected Loss over Loan Portfolio

```
data expected_losses;
  set stressed_pd;
   loss_given_default= 0.60;
  expected_loss = loan_amount * prob_default *loss_given_default;
run;
```

Variable Information Value	
Variable	Information Value
credit_score	1.29051
income	0.12312
debt_to_income_ratio	0.13698
loan_amount	0.14001
unemployment_rate	0.25403
gdp_growth	0.11064
interest_rate	0.00713

Total Expected Losses under Severe Stress Scenario

Obs	_TYPE_	_FREQ_	expected_loss
1	0	974	76781157.64

Total Expected Losses under Baseline Stress Scenario

Obs	_TYPE_	_FREQ_	expected_loss
1	0	974	10982255.91

Assumptions:

- Loss given Default is *0.6* (Hardcoded)
- Banks expect to lose 60% of the loan amount(exposed amount) considering 40% covered by collateral
- Exposure at default is *total loan amount* in this case.

Expected loss = PD *LGD *EAD

Other Statistical Concepts in Stress Testing:

- Monte Carlo Simulations
- Statistical Techniques in *Macro Economic Scenario Analysis* – VAR and GVAR
  - Vector Autoregressive Model
    - The vector autoregressive (VAR) model is a workhouse multivariate time series model that relates current observations of a variable with past observations of itself and past observations of other variables in the system.
    - Proc VarMax in SAS
  - Global Vector Autoregressive Model
    - The Global Vector Autoregressive (GVAR) approach provides a relatively simple yet effective way of modelling interactions in a complex high-dimensional system such as the global economy.
- Reverse Stress Testing

Benefits of Stress Testing

- Risk Management:
  - Identifying vulnerabilities
  - Enhanced risk awareness
- Regulatory compliance
- Strategic planning
  - Informed decision making
  - Scenario analysis
- Stakeholder confidence
- Quantitative insights
  - Loss estimation
  - Impact assessment
- Credit risk mitigation
  - Portfolio optimization
  - Risk based pricing

Sources

- https://www.openriskmanual.org/wiki/Bottom-Up_versus_Top-Down_Stress_Test
- https://www.imf.org/external/np/seminars/eng/2006/stress/pdf/jh.pdf
- https://onlinelibrary.wiley.com/doi/pdf/10.1111/joes.12095

Thank you

- *"The key to effective stress testing is not predicting the future but understanding the range of possible outcomes and preparing for them.“*
- *- Mervyn King (Economist, Bank of England)*