Introduction to Bank Stress Testing

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What is a Bank "Stress Test?"

- A bank "stress test" is a hypothetical "what if" exercise in risk management where we ask how a particular severe, but plausible, scenario would impact a bank's capital adequacy.
  - Provides a forward-looking assessment of risk.
  - Overcomes limitations of historical data.
  - Overcomes limitations of financial models.
  - Facilitates development of contingency plans for dealing with the hypothetical "stress."

Bank Stress Tests

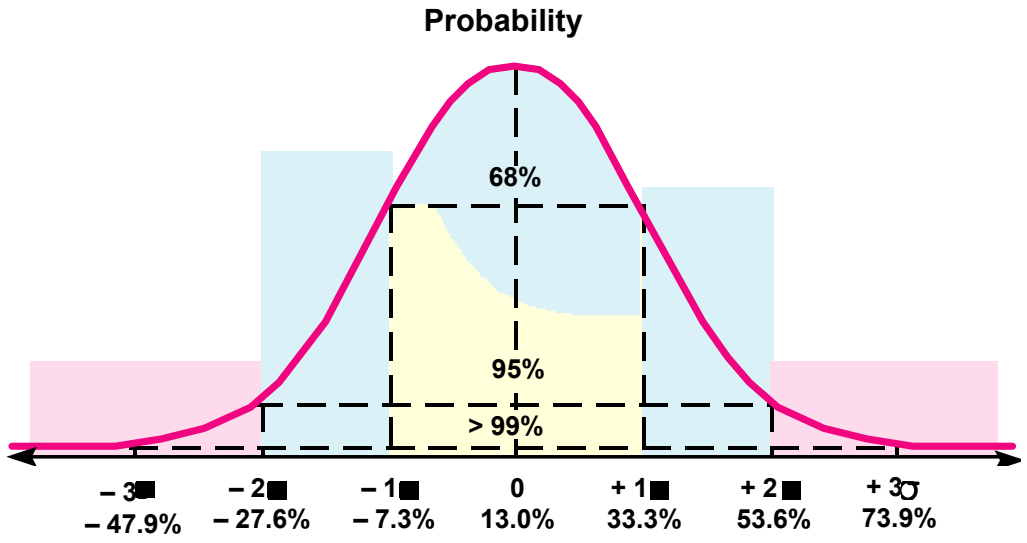
- Stress tests are complements to, but not substitutes for statistical risk-management models, such as Value-at-Risk (VaR), that are based upon the normal distribution.

- VaR: the expected one-day loss that occurs 1 out of 100 times (99% confidence).

- Given 250 trading days per year, this would occur 2.5 times per year.

VaR and the Normal Distribution

In a normal distribution, 99% of the observations fall within 3 standard deviations of the mean.



In this example, the VaR would be: 13.0% – 3 x 20.3% = -47.9%

Problems with Value-at-Risk

- Most applications of VaR are based upon historical values and the normal distribution.
    - Normal may not be appropriate.
    - The recent historical experience may not be appropriate.
    - Distributions are assumed stable over time.

Problems with Value-at-Risk

- In addition, there is a wide confidence interval around an estimated tail probability.
- VaR is data intensive: It requires a lot of historical information.
  - Works well for FX, Interest Rate, Equity risks, but not for credit risk.
  - 10 Years:
    - Daily: 2,500 observations
    - Monthly: 120 observations
    - Quarterly: 40 observations
    - Annual Data: 10 observations

Stress Tests as Complements to VaR

- Focus of Stress Tests is on tail probabilities—the "Tails" of the Normal distribution,
  - especially the "left tail"; negative outcomes.
- Highly unlikely, but possible, adverse events and outcomes.
  - It only takes one "outlier" to wipe out a firm's capital completely.
  - No second chances . . .
    - . . .unless you are BofA, Citibank, DB, UBS, etc.

Types of Stress Tests

- Initially, stress tests were used primarily for "market risks":
  - Interest-Rate Risk,
  - Foreign-Exchange Risk,
  - Equities Risk, and
  - Commodities Risk.
- More recently, stress testing has expanded to cover:
  - Credit Risk, and
  - Liquidity Risk.

Types of Stress Tests

- Within the category of credit stress tests, there also are many flavors.
  - Generic
  - Sectoral, e.g. Real Estate
  - Concentration/Large Exposures
  - Interbank
  - Etc.

Types of Stress Tests

- Sensitivity Test:
  - Shock to a single variable, such as the NPL ratio.
- Multi-Factor Tests:
  - Simultaneous shock to two or more variables, such as the NPL ratio and the FX rate.
- Macro Scenario Tests:
  - Simultaneous shock to two or more macro-economic variables that affect the NPL ratio, such as GDP growth and unemployment.
  - “Black Monday” Scenario: Oct. 1987 Market Crash

Types of Stress Tests: Sensitivity vs. Scenario

- Sensitivity Test:
  - What is the impact of a large movement in a financial variable (such as the interest rate or foreign-exchange rate) on the value of a firm's portfolio?
  - Reason for movement is not specified.
  - Lacks historical and economic content.

Types of Sensitivity Tests

- Generic Credit Shock:
  - NPLs (gross of write-offs) increase by
    - 100 percent
    - 200 percent
    - 300 percent
  - Simultaneous increase in provisioning to:
    - 1 percent for standard loans;
    - 20 percent for substandard loans;
    - 50 percent for doubtful; and
    - 100 percent for loss loans.

Types of Sensitivity:

- Sectoral Credit Shock:
  - Increase in sectoral NPLs (gross of write-offs) in the following sectors:
    - Oil and Gas,
    - Agriculture,
    - Telecom,
    - Real Estate and Construction,
    - General, and General Commerce
  - 100, 200, and 300 percent.

Types of Sensitivity:

- Sectoral Credit Shock:
  - Deterioration of performing sectoral loans in the following sectors:
    - Oil and Gas,
    - Agriculture,
    - Telecom,
    - Real Estate and Construction,
    - General, and General Commerce
  - 10 percent (mild),
  - 20 percent (medium), and
  - 40 percent (severe).

Types of Sensitivity:

- Concentration/Large Exposure Shocks:
  - The largest single borrowerdefaults on its loans.
  - Top three single borrowers default on their loans.
  - Top five single borrowers default on their loans.
  - Top 10 single borrowers default on their loans.
  - The largest single group defaults on its loans.
  - The largest three groups default on their loans.
  - The largest five groups default on their loans.

Types of Sensitivity:

- Reverse Stress Testing/Stress til it breaks:
  - Haircut on performing loans that cause the banking sector CAR average to fall below 10 percent regulatory requirement.
  - Haircut on performing loans that cause 50 percent of the system to fall below 10 percent minimum capital.

Types of Sensitivity:

- Direct Interest Rate Shocks
  - Parallel upward shift of the LC yield curve by
    - 500 b.p.
    - 1,000 b.p.
    - 1,500 b.p.
  - Parallel downward shift of the LC yield curve by
    - 250 b.p.
    - 500 b.p.
    - 1,000 b.p.
  - Steepening of LC yield curve from 0 to 1000 b.p.
  - Parallel shift of the USD yield curve by 100 b.p.

Types of Sensitivity:

- Foreign Exchange Shock:
  - The shocks refer to the impact of the LC deprecation against all key currency exposures:
    - 15 percent depreciation of LC.
    - 30 percent depreciation of LC.
    - 40 percent depreciation of LC.

Types of Sensitivity:

- Equity Shock:
  - Equity price index drops by 40 percent.
  - Equity price index drops by 70 percent.

Types of Stress Tests: Sensitivity vs. Scenario

- Scenario Tests:
  - What is the impact on the value of a firm's portfolio from simultaneous movements in several financial variables, driven by some event,
    - Historical
    - Hypothetical.
  - The tie to a historical/hypothetical event provides historical and economic content

Historical Scenarios

- Model shocks based upon actual extreme historical events:
  - 2008 global financial crisis.
  - 1987 “Black Monday.

Types of Stress Tests: Scenarios

- Example:

  The “Black Monday” Scenario (Oct. 1987)

  when U.S. equities lost 25% of their value on that single day.

  What would be the impact of a similar event today, not only for equities, but for other bank exposures?

Stress Tests: Scenarios

- Example: The “Black Monday” Scenario
- Assumption: Equities fall by 25% in one day.
- What follows?
  - a downward spike in the interest rates as the Central Bank responds.
    - => Interest-Rate Risk Rises
  - As rates fall so will the value of the dollar.
    - => FX Risk Rises
  - Equity losses hit investors
    - => Credit Risk Rises

Historical Scenarios

- Drawbacks
  - Plausibility of repeating a past scenario is questionable.
  - The financial system and financial institutions change over time.
  - Some instruments, markets, and financial institutions did not exist at the time of the historical event.

Hypothetical Scenarios

- Can be more realistic, particularly if the financial structure has changed considerably over time.
- Allows for a more flexible formulation of potential events.
- Encourages risk managers to be forward-looking.
- “Stress to Failure:” Simulation techniques can be applied to search for scenarios that would cause losses that exceed the threshold.

Stress Tests: Scenarios

- 2001 BIS Survey of Stress-Testing Practices at 38 Large Financial Institutions
  - Very few ran such scenarios with multiple simultaneous shocks.
  - Outcome of recent crisis is therefore not very surprising.
  - VaR and the relative calm of the past few years had lulled risk managers into a sense of complacency.

Stress Tests: Scenarios

- Shock 1 (mild):
  - Aggregate NPL increase by 50 percent,
  - 15 percent depreciation of LC over 30-day period, and
  - 500 b.p. upward parallel shift of the LC yield curve.

Stress Tests: Scenarios

- Shock 2 (severe):
  - Aggregate NPL increase by 100 percent,
  - 30 percent depreciation of LC over 30-day period, and
  - 1,000 b.p. upward parallel shift of the LC yield curve.

Stress Tests: Scenarios

- Shock 3 (severe):
  - Aggregate NPL increase by 200 percent,
  - 40 percent depreciation of LC over 30-day period, and
  - 1,500 b.p. upward parallel shift of the LC yield curve.

Macro Stress Testing

- "***Macro***" stress tests are aggregated versions of individual bank stress tests, often performed by treating the banking system like an individual bank.
  - Macro stress tests focus on the stability of the whole financial system, rather than on the viability of individual firms.
  - Test the sensitivity of the financial system to major shocks in the economic and financial environment.
  - Increased in prominence after onset of the global financial crisis back in 2008.

Complexity of Macro Stress Testing

- Complexity should mirror that of a country's financial system.
  - In less complex systems, sources of risk on bank balance sheets can be readily measured at an aggregate level.
    - A relatively simple mechanical approach can suffice.
  - For more complex systems, participation of banks is essential.
    - Complex risk exposures of large international financial institutions are best assessed using the banks' internal risk-management systems.
  - Today, we will focus on less complex systems.

Coverage of Macro Stress Testing

- What type of financial institutions should be included?
- General rule is to include all systematically relevant institutions and exposures.
  - Commercial Banks
    - Domestic
    - Foreign
    - State-controlled
  - Credit Unions
  - Development Banks

On- vs. Off-Balance Sheet Exposures

- Stress tests based exclusively on balance-sheet positions can be misleading.
- Off-balance-sheet position can quantitatively and qualitatively alter on balance-sheet exposures.
- It may not be clear where credit and market risks reside due to credit derivatives activities of large financial institutions.
- Off-balance-sheet funding vehicles (conduits and SIVs) can also be sources of vulnerabilities.

Identification of major risks and exposures

- Requires detailed knowledge of the country's economic and financial situation.
- Helpful to know the business practices of financial institutions, e.g. the use of funding vehicles.
- The design of stress tests is often an iterative process:
  - Identified risk factors might lead to relatively small impacts, or
  - Other risks originally seen as small may have large impacts if the exposures are substantial.

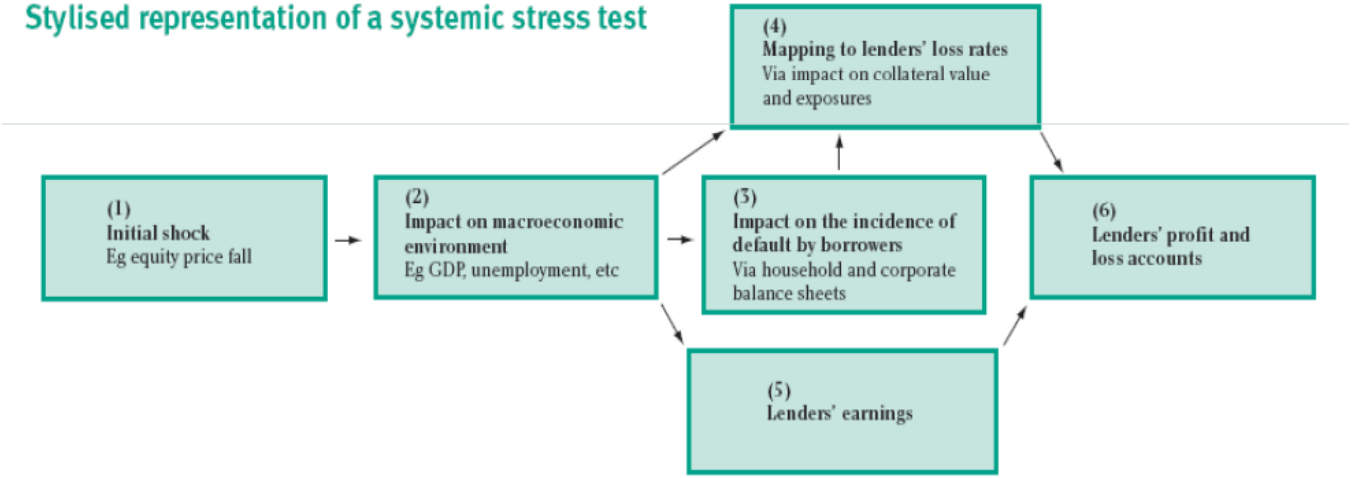
Why link stress tests to the macro-economy?

- By linking stress tests to the macro economy, we can let an econometric model guide us in how to conduct scenario analysis.
- For example, we can use historical data to measure how changes in GDP growth and the FX rate affect bank NPL ratios.
- We can then choose the size of the credit shocks based upon real-world data.

Macro-Linked Stress Testing

Chart 1

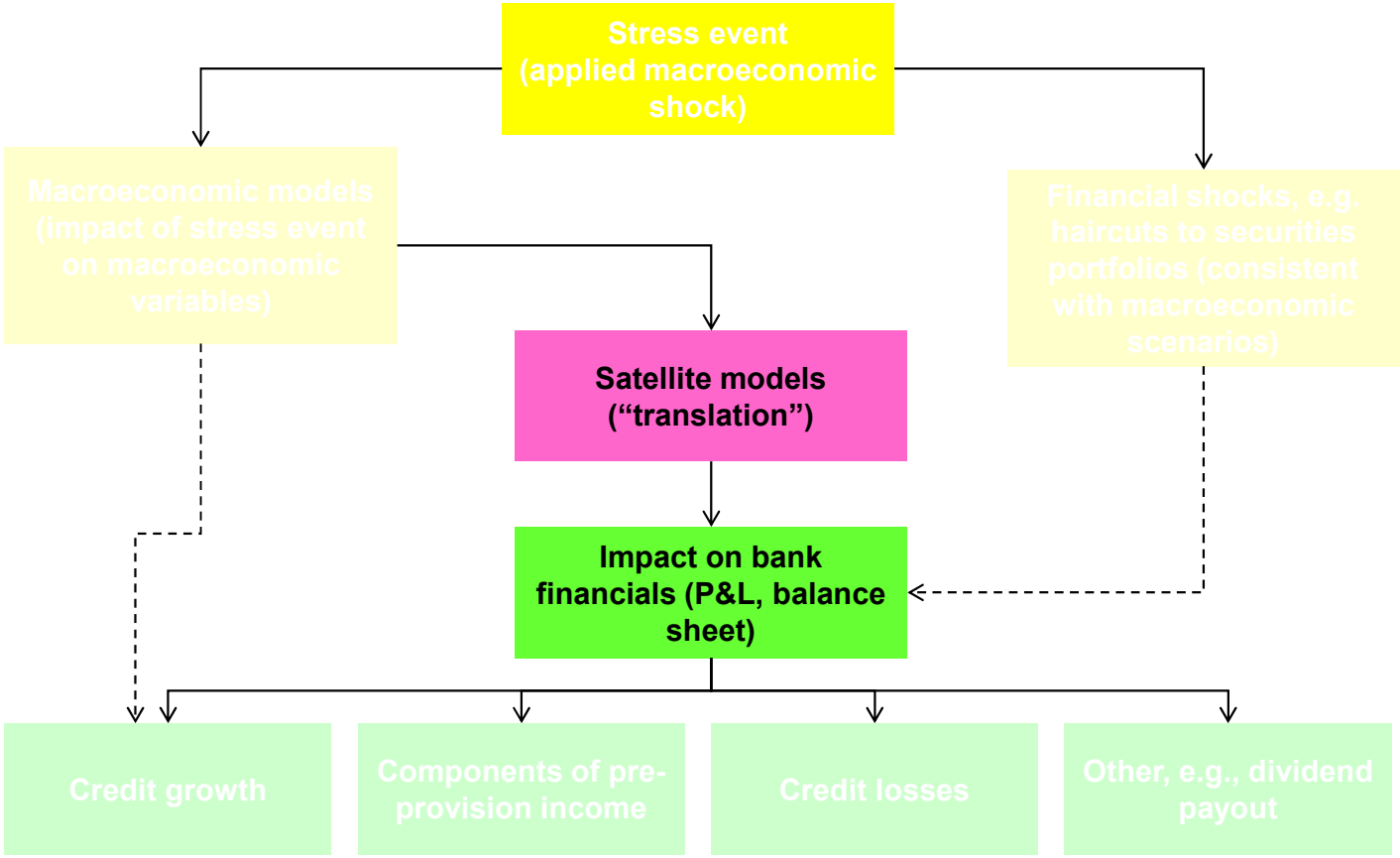
Stylised representation of a systemic stress test

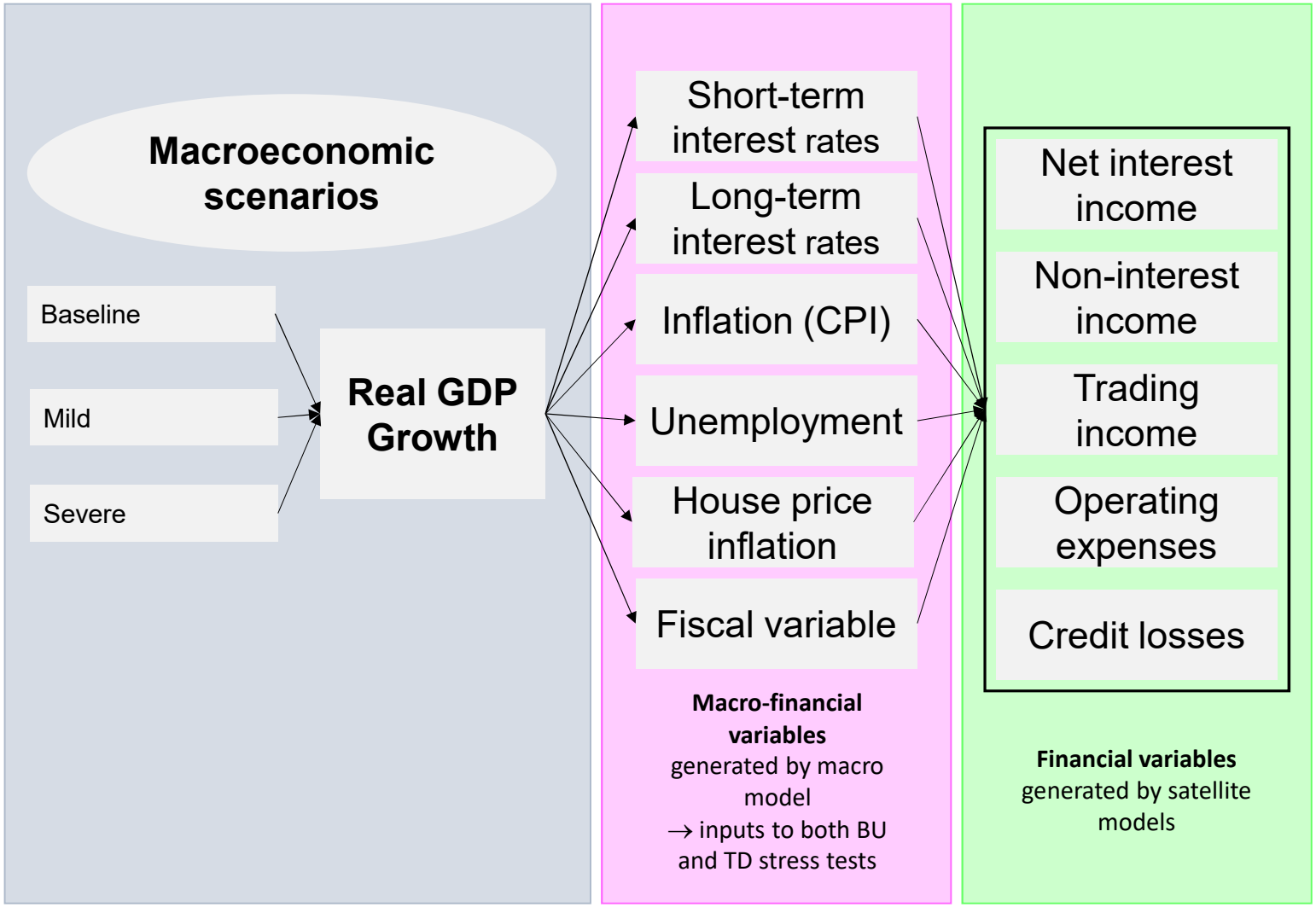


Credit Stress Testing in Practice

- Most credit stress tests follow a basic model.
- Specify a “baseline” that adjusts for under-provisioning, if any.
- Specify a “shock” that leads to a rise in the bank’s NPL ratio.
- Increase loan-loan reserves to cover the new NPLs, by transferring capital to LLRs.
- Reduce the bank’s capital by amount transferred to LLR.
- Recalculate CAR(s) and assess whether it meets the regulatory minimum capital requirements.

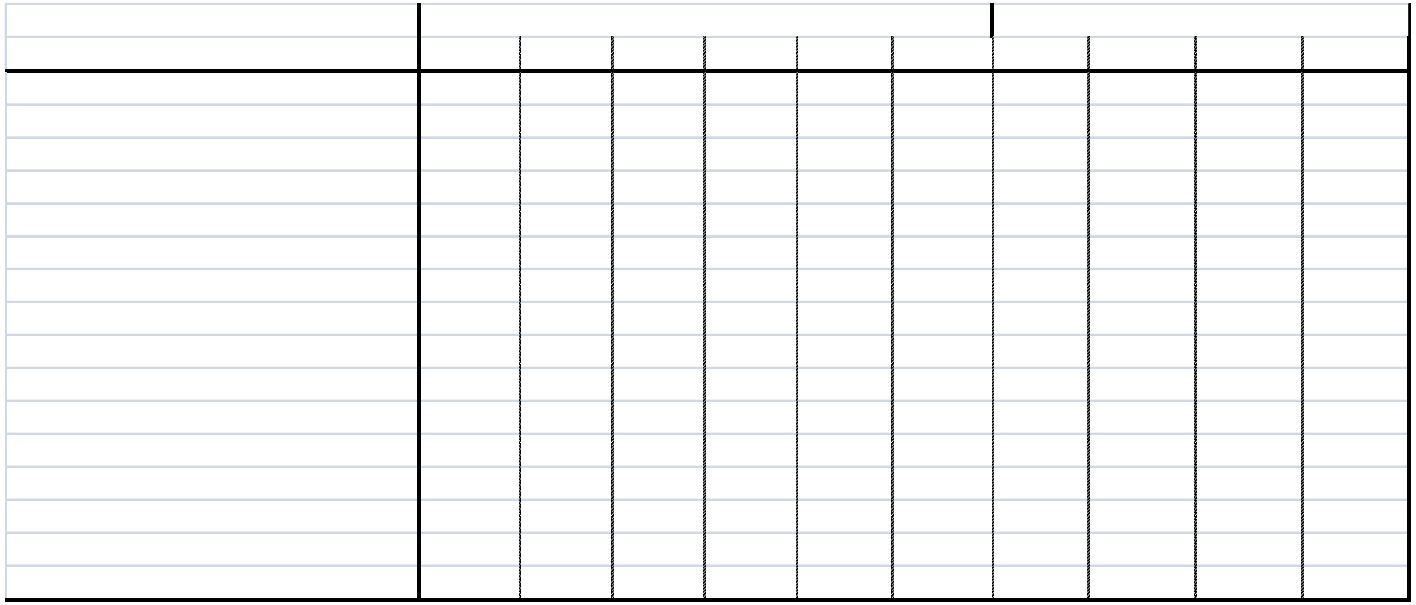
Where Do the Satellite Models Fit?




Macroeconomic scenarios
Baseline
Mild
Severe
Real GDP Growth
Short-term interest rates
Long-term interest rates
Inflation (CPI)
Unemployment
House price inflation
Fiscal variable
Macro-financial variables generated by macro model → inputs to both BU and TD stress tests
Net interest income
Non-interest income
Trading income
Operating expenses
Credit losses
Financial variables generated by satellite models

Example of a Multi-Period Macro Scenario

Severely Adverse Scenario: U.S. Dodd-Frank Stress Test



Satellite Model for NPLs

Dependent variable:

- NPLs

Independent variables:

- NPLs lagged
- MACRO:
  - Real GDP growth
  - Long-term bond yield
  - Fiscal variables
  - Etc
- Banks:
  - Bank specific variables

Estimation period=2001-2011
Number of banks: 21 banks
Unbalanced panel, small T, large N

Satellite Model for ROA

Dependent variable:

- ROA ratio

Independent variables:

- ROA lagged
- Macro:
  - Real GDP growth
  - Difference between real long-term bond yield and real 3-month euribor
- Banks:
  - Bank specific variables

Estimation period=2001-2011
Number of banks: 21 banks
Unbalanced panel, small T, large N

How macro-linked stress tests work in practice

- Prepare input data
  - NPLs, Profits from Banking Supervision Data
  - Macro variables from Research Dept.
  - Merge by date
- Generate macro scenario forecasts for Macro Variables.

How macro-linked stress tests work in practice

- Estimate Satellite Model.
- Apply coefficient from satellite model to macro forecasts to generate forecasts of NPLs and ROAs for each bank.
- Calculate provisions and new CAR.
- Determine if bank is undercapitalized.

Macro Stress Testing: Second-Round Effects

- Potential **second-round effects** are often ignored:
- Weakened banks might face increased funding costs and deposit withdrawals, which could reduce their profits further.
- Faced with deteriorating credit worthiness, banks might tighten credit, with adverse effects on aggregate demand.

Banks' Responses and Policy Reactions

- Most stress tests assume there is no realignment of portfolios and exposures in response to risk factors
  - Might be valid at short-time horizon
  - If the stress test focuses on one year or more, the assumption of no behavioural response becomes harder to justify.
- Moreover, the policy environment may also change over longer horizons--as monetary and supervisory authorities react to shocks.

Interpreting Results from Stress Tests

- Particularly useful if they are conducted on a regular basis; they can provide information about changes in the risk profile of the system
- But, interpretation has to take account of limitations
  - Stress tests have a large margin of uncertainty about the absolute level of risk that they indicate
  - If the underlying model is mis-specified, the stress test results can be invalid
  - Are unlikely to capture the full range of interactions between risk factors and exposures
  - They typically consider only part of the banks' income generating operations

Public Dissemination of Results

- Ideally, results of the macro stress tests should be disseminated to the public.
- Many countries accomplish this using an annual or semi-annual Financial Stability Report.
- According to a recent IMF working paper, forward-looking stress tests are an important component of Financial Stability Reports, which often are criticized as backwards looking.
- Macro stress tests also are an integral part of the IMF's Financial Stability Assessment Program (FSAP), which typically are made public.

Public Dissemination of Results

Appendix Table 1.6. Nigeria: Sensitivity Analysis—Multi-Factor Shocks

		Top Down Stress Test							
		System Level			Outlier Banks (CAR < 10%)		Outlier Banks (Core CAR < 6%)		Insolvent Banks
		CAR	Core CAR	Losses (% of Total Capital)	Number of Outlier Banks	Shares in Total Assets	Number of Outlier Banks	Share in Total Assets	Number of Outlier Banks
Baseline:		**18.5**	**18.4**		**1**		**1**		**1**
Shock 1:	Aggregate NPLs increases 50 percent, Naira depreciates against all currencies by 15 percent and parallel upward shift of the Naira yield curve by 500 bps	17.9	17.8	3.8	0	0.0	1	0.0	1
Shock 2:	Aggregate NPLs increases 100 percent, Naira depreciates against all currencies by 30 percent and parallel upward shift of the Naira yield curve by 1000 bps	17.0	16.9	10.9	2	3.9	1	3.9	1
Shock 3:	Aggregate NPLs increases 200 percent, Naira depreciates against all currencies by 40 percent and parallel upward shift of the Naira yield curve by 1500 bps	14.8	14.7	30.3	4	11.6	3	11.6	2

Source: Top Down: CBN and IMF staff calculations.

Public Dissemination of Results

- Public dissemination presents difficulties with regard to confidentiality and interpretation of results.
  - Some observers may interpret the chosen scenarios as reflecting an "official view" on the most likely or the most problematic scenarios.
  - Disclosure of summary information has proven informative for market participants and individual institutions wishing to benchmark their own results against those of their competitors
  - Disclosure of the scenarios can also raise awareness of different risks for institutions to consider and incorporate into their own stress-testing programs.

Thank You!

Questions . . . ?