Stress Testing

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Introduction: Increasing Importance of Stress Testing

• Microprudential/supervisory
  – Risk management, supervision
  – Basel II, IFRS, limiting pro-cyclicality

• Macroprudential (system-focused)
  – IMF (Financial Sector Assessment Program)
  – Central banks, supervisory agencies (Financial Stability Reports)

• Crisis management tool
  – Recent examples (United States, Europe)
Part I: Stress Test—Overview and Examples
Integrated ST Framework

**Micro-prudential analysis**

- **Firms’ own stress testing**
  - Capital
  - Liquidity
  - Reverse stress-testing

- **Supervisory stress testing**
  - Stress testing of specific firms
  - Assessment against minimum specified capital and liquidity requirements

**Macro-prudential analysis**

- **System-wide stress testing**
  - Simultaneous stress testing
  - Financial stability purposes

**Policy Objectives**

- Supervisors
- Policy
- Setting stress testing policy
- Setting scenarios
- Monitoring and aggregation

*Note: Adapted from UK FSA.*
Stress Testing: Micro

- ST supplements other risk management tools
- Provides forward-looking assessment of risks
- Facilitates development of mitigation/contingency plans
- BCBS Principles for Sound ST Practices & Supervision
  - 15 principles for banks
    - Use of ST and integration in risk governance
    - ST methodology and scenario selection
    - Specific areas of focus (risk mitigation techniques, complex products, pipeline and warehousing risks, reputational risk, leveraged counterparties)
  - 6 principles for supervisors
    - Regular ST, corrective action, assessment of scope/severity, Pillar 2, common scenarios, systemic vulnerabilities
Stress Testing: Pillar 2 Capital

• “In their Pillar 2 capital planning, firms should consider a range of scenarios.”
  – They should include a severe downturn scenario …
  – … based on forward-looking hypothetical events …
  – … calibrated against the most adverse movements in individual risk drivers …
  – …experienced over a long historical period.
• Supervisory agencies often publish a common (macro) scenario, against which firms can benchmark severity of own scenarios
• ST results used to size capital planning buffer – additional capital (pillar 2) held above minimum capital requirements
  – UK FSA definition: “…the amount of capital that should be held now, so that it is available to absorb losses and meet higher capital requirements during adverse external circumstances after allowing for realistic management actions.”
Stress Tests in FSAPs

Risk assessment including stress tests

Stability module

Crisis management and resolution

Financial stability policy framework

Usually a combination of top-down and bottom-up approaches
# Stress Tests in FSAPs: Risk Assessment Matrix

<table>
<thead>
<tr>
<th>Country X</th>
<th>Overall Level of Concern</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Main Threats</strong></td>
<td>Likelihood of severe realization of threat in the next 3 years</td>
</tr>
<tr>
<td>Threat #1</td>
<td>High</td>
</tr>
<tr>
<td>Threat #2</td>
<td>Low</td>
</tr>
<tr>
<td>Threat #n</td>
<td>Medium</td>
</tr>
</tbody>
</table>
Stress Tests in FSAPs

Source: FSSAs.
Stress Tests in FSAPs: Illustration

- Based on IMF WP 07/59
  - “Introduction to Applied ST”
- Streamlined exercise based on FSAP tests in smaller/less complex systems (“ST 101”)
- Excel file (Stress Tester 2.0.xls) downloadable from IMF website
  - [http://www.imf.org/external/pubs/cat/longres.cfm?sk=20222.0](http://www.imf.org/external/pubs/cat/longres.cfm?sk=20222.0), click on “link to data…”
- Fictional FSAP-like data (“Bankistan”)
ST and Central Banks

- Number of CBs publishing ST results
## ST and Central Banks

<table>
<thead>
<tr>
<th>Element</th>
<th>Price Stability</th>
<th>Financial Stability</th>
</tr>
</thead>
<tbody>
<tr>
<td>General definition</td>
<td>Clear</td>
<td>A range of definitions</td>
</tr>
<tr>
<td>Operational definition</td>
<td>Clear (variable and target), especially in inflation targeting</td>
<td>Typically not specified</td>
</tr>
<tr>
<td>Legal base for central bank’s role</td>
<td>Based on law</td>
<td>Based on an interpretation of law</td>
</tr>
<tr>
<td>Scope of central bank’s responsibility</td>
<td>Full responsibility</td>
<td>Partial/shared responsibility, exact boundaries in some countries unclear, in others delineated by MOU</td>
</tr>
<tr>
<td>Frequency of interventions</td>
<td>Regular, relatively high</td>
<td>From time to time, low</td>
</tr>
<tr>
<td>Research</td>
<td>Well developed</td>
<td>Developing</td>
</tr>
</tbody>
</table>
## ST and Central Banks: Effects of Monetary Policy

**Losses in households and enterprises – deviation from baseline scenario***

<table>
<thead>
<tr>
<th></th>
<th>No MP response</th>
<th>MP response (Taylor rule)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demand shock</td>
<td>0.7</td>
<td>0.3</td>
</tr>
<tr>
<td></td>
<td>1.8</td>
<td>0.7</td>
</tr>
<tr>
<td>Supply shock</td>
<td>0.0</td>
<td>0.2</td>
</tr>
<tr>
<td></td>
<td>0.0</td>
<td>0.3</td>
</tr>
</tbody>
</table>

* Losses over 3 years in stress test scenario less losses in baseline scenario. Percent of loans in the sector.

*From: Evjen et al. (2005), BIS paper no. 22.*
Case Study: Iceland

- The largest banking crisis (relative to GDP) in modern history
- Banking sector: 900% of GDP in ‘08.
- Financial Supervisory Authority (FME) regularly performed and published ST of Iceland’s banks.
- Landsbanki Islands: the country’s 2nd largest bank, assets of 235% of GDP.
  - October 7, 2008: nationalized, receivership.
Case Study: Iceland

- Parameters applied by FME in the 2007 ST:
  - 35% fall in domestic stocks, 25% fall in foreign stocks
  - 20% loss in value of NPLs and appropriated assets
  - 7% fall in bond prices
  - 20% depreciation of ISK

- Results:
  - CAR = 10.5 % (from 11.7 %)
  - Tier 1 ratio = 8.8 % (from 10.1 %)

- Actual shocks:
  - 40% deposit run from U.K. Icesave accounts
  - 25%–50% fall in equity portfolios
  - 35%–55% depreciation of ISK
  - 700 bp increase in bond portfolio yields.
Case Study: Iceland

• Lack of use of comprehensive data
  – Focused on P&L and BS data.

• Limited imagination
  – Focused on solvency, not liquidity.
  – Shocked market risk and credit risk only

• Did not necessarily “think the unthinkable”
  – Size and speed of shocks
  – Global rather than just domestic shock (e.g., unlike the Iceland “mini-crisis” in early-2006)
  – Did not incorporate conventional deposit runs; deposits considered a very stable source of funding.
# Case Study: Iceland
## Summary of Results

<table>
<thead>
<tr>
<th>LANDSBANKI: SUMMARY OF LIQUIDITY STRESS TEST OUTCOME (UP TO 12 MONTHS)</th>
<th>ISK millions</th>
<th>USD millions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iceland GDP (4 quarters to 30 September 2008)</td>
<td>1,400,452</td>
<td>14,500</td>
</tr>
<tr>
<td>Liquidity shortage at Landsbanki after shocks as at 7 October 2008</td>
<td>-733,722</td>
<td>-7,597</td>
</tr>
<tr>
<td>Liquidity shortage after shocks as percentage of GDP</td>
<td>52.4</td>
<td></td>
</tr>
<tr>
<td>Liquidity shortage (liquid assets only) after shocks</td>
<td>-1,703,941</td>
<td>-17,643</td>
</tr>
<tr>
<td>Liquidity shortage (liquid assets only) after shocks as percentage of GDP</td>
<td>121.7</td>
<td></td>
</tr>
</tbody>
</table>

*Ong and Cihak (2010), IMF WP 10/156*
ST in Crisis Management: United States

- **Supervisory Capital Assessment Program (SCAP)**
  - ST has long been part of supervisory process
  - But this exercise, announced in Feb 2009, was unprecedented
  - “Horizontal review” of 19 largest BHCs (assets >US$100 bn)
  - 2/3 of the U.S market

- **SCAP results (May 2009):**
  - 10 participating BHCs require injections (total=US$185 billion)

- **Participating banks able to take action to improve capital**
  - Increased Tier 1 common equity by US$77 bn by November 2009
  - Only one institution required an additional public capital injection

- **Bolstered confidence in stability of major financial institutions during a period of heightened uncertainty**
ST in Crisis Management:
United States

• SCAP considered a success
• Helped improve funding environment, confidence
  – After detailed dissemination of bank-by-bank results, BHCs raised $57 billion in private capital
  – 12 of participating BHCs fully redeemed their preferred shares under CPP; 5 announced/took steps to do so soon
• Clearer list of “systemically important institutions”
• Focus on high-quality “shock-absorbing” capital
• Confirmed the value of aggregation of global risks across complex financial holding companies.
  – U.S. authorities increased emphasis on such “horizontal reviews”
ST in Crisis Management: Europe

• European (EU) stress tests of 2010
  – Major undertaking
  – Publication of results, announcement of actions to address bank capital
  – Important step toward improving transparency of the financial position of European financial institutions

• Complemented by other measures, such as
  – Establishment of the European Financial Stability Facility (EFSF)
  – Improvements in EU’s financial supervisory framework

• Assessed banks vulnerabilities under macroeconomic stress, with additional stress in sovereign debt markets
  – Reduction in values of sovereign debt in trading book
  – No direct impact on sovereign debt in banking book/sovereign default
ST in Crisis Management: Europe

• 7 out of 91 banks w Tier 1 CAR < 6 % hurdle rate.
  – The total capital need to be raised in the markets or provided by public backstopping measures amounts to €3.5 billion. Five of the seven banks that failed the test were Spanish banks, with one Greek and one German bank failing.

• Overall, market reaction positive
  – Positives: disclosure of sovereign exposures, robust loan-loss assumptions for many banks, no unexpected failures
  – Criticism: low hurdle rate for the post-shock Tier 1 capital ratio, non-application of haircuts to sovereign debt in banking books, optimistic earnings and loan loss assumptions for some banks
ST as Crisis Management Tool

• Can clarify financial institutions’ health
  – … if the exercise is credible and transparent

• Can improve confidence
  – … if accompanied by a credible follow up plan
  – needs a good PR strategy

• Issues
  – How stressful? (Credible, but not pro-cyclical)
  – Publish or not? (If so, how much detail?)
  – If mishandled, it could backfire
  – How to reflect contagion risk?
Part II: Stress Tests—Challenges and Further Work
Stress Testing: Challenges

• Reviews of ST practices
  – Central banks’ financial stability reports (IMF WP 06/163)
  – Surveys of ST practices in major banks (BIS…)

• ST useful, but need more:
  – Discussion of limitations implied by data, methodology ("health warnings")
  – Discussion on shocks being analyzed (no “black box”)
  – Integration with other indicators and tools
  – Comparable approaches in peer groups of countries
ST Challenges: Calculated Impacts vs. Reality

Capital injections needed under the worst ST scenario (% GDP)

Fiscal support to the financial sector in the country (as of April 2009)

Note: data for European country FSAPs.
ST Challenges: Assumptions vs. Reality

- **Assumptions vs. Reality**

  - **Actual depreciation/devaluation (%):**
    - 5-9: 0%
    - 10-14: 5%
    - 15-19: 10%
    - 20-24: 15%
    - 25-29: 20%
    - 30-34: 25%
    - 35-39: 30%
    - 40-44: 35%
    - 45-50: 40%
    - 50+: 45%

  - **Assumed depreciation/devaluation (%):**
    - 5-9: 10%
    - 10-14: 20%
    - 15-19: 30%
    - 20-24: 40%
    - 25-29: 50%
    - 30-34: 60%
    - 35-39: 70%
    - 40-44: 80%
    - 45-50: 90%
    - 50+: 100%

  - **Avg for joint banking & currency crises**

- **Percent of FSAPs:**
  - 5-9: 0%
  - 10-14: 5%
  - 15-19: 10%
  - 20-24: 15%
  - 25-29: 20%
  - 30-34: 25%
  - 35-39: 30%
  - 40-44: 35%
  - 45-50: 40%
  - 50+: 45%

- **Percent of countries:**
  - 5-9: 7%
  - 10-14: 3%
  - 15-19: 2%
  - 20-24: 1%
  - 25-29: 1%
  - 30-34: 1%
  - 35-39: 1%
  - 40-44: 1%
  - 45-50: 1%
  - 50+: 1%
Issue #1: ST Preconditions

• Quality of input data
  – ST only as good as input data
  – Data sometimes simply missing or not used
  – ST depend on underlying assumptions

• Scope of the exercise
  – E.g.: off-balance sheet items, “shadow” banking, data on liquidity/funding exposures
Issue #1: ST Preconditions

• Progress so far
  – Tools to assess data quality
  – More caveats about data Q in recent ST
  – Nonbank FIs increasingly included in ST

• Further steps
  – More emphasis on data Q and assumptions
  – Not conducting ST should always be an option
  – Better integrate ST and other tools/indicators
  – Extend scope in some cases
Issue #2: Scenario Design

• What is “exceptional but plausible”?
  – Insufficient explanation of size of the shocks
  – Often no link to macro economy

• Combining shocks in consistent way
  – A challenge given that models break in crises

• Myopia/limited imagination
  – Long time since last crisis; inhibitions to “think the unthinkable”

• Political economy considerations
  – Policy makers prefer to say “financial system is resilient”
  – Risk of ST being perceived as assessment of policy makers
  – Self-fulfilling prophecy
Issue #2: Scenario Design

- Progress so far in FSAPs
  - More emphasis on macrosceenarios
  - More emphasis on explaining shock sizes
  - Longer horizons in assessing shock impacts
  - More likely to discuss sensitive shocks

- Further steps in FSAPs
  - More severe shocks
  - Threshold approach (“reverse stress testing”)
  - Focus more on relative impacts, evolution over time
  - Scope for more standardization, if not uniformity
Issue #3: Methodology

• Improving liquidity ST
• Methodologies need to better account for
  – Full distribution of losses in a scenario
  – Nonlinearities
  – Structural breaks
  – Correlation across portfolios
  – Contagion
  – Feedback effects
Issue #3: Methodology

• Progress so far in FSAPs:
  – Interbank contagion ST more common (incl. cross-border)
  – Scenario analysis more common (linking credit risk to macro)
  – More involvement of authorities, financial institutions

• Further steps for FSAPs:
  – Further work on liquidity modeling (incl. liquidity contagion)
  – Joint analysis of market, credit, and liquidity risk
  – Modeling nonlinearities, structural breaks
  – Better modeling of reaction functions of financial institutions
  – Modeling second round/feedback effects
  – Cross-border transmission channels
Systemic Risk Models

**Accounting Balance Sheet**
- Aggregate FSIs

**Market Equity-based**
- Equity Joint Tail Risk (from returns or from option derived higher moments: SES, MES)
- Equity option implied joint risk

**Market Debt-based (CDS & bond spreads)**
- CDS – Joint Probability of Distress (JPoD)

**Network**
- Interbank Exposures
- Lo–Getmansky model

**Merton-type CCA Joint Risk**
- CDS/spread implied JPoD
- CDS CoRisk

**Systemic Contingent Claims Analysis**
- Systemic Distress Insurance Premium

Source: Gray and Jobst (forthcoming IMF WP)
## Systemic Risk Models

<table>
<thead>
<tr>
<th></th>
<th>Conditional Value-at-Risk (CoVaR)</th>
<th>Systemic Expected Shortfall (SES)</th>
<th>Distress Insurance Premium (DIP)</th>
<th>Systemic Contingent Claims Analysis (CCA)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dimensionality</strong></td>
<td>multivariate</td>
<td>bivariate</td>
<td>bivariate</td>
<td>multivariate</td>
</tr>
<tr>
<td><strong>Frequency</strong></td>
<td>quarterly</td>
<td>quarterly</td>
<td>daily</td>
<td>daily</td>
</tr>
<tr>
<td><strong>Conditionality</strong></td>
<td>percentile of individual default risk</td>
<td>percentile of total default risk</td>
<td>percentile of total default risk</td>
<td>both (individual and joint default risk)</td>
</tr>
<tr>
<td><strong>Dependence measure</strong></td>
<td>linear, parametric</td>
<td>empirical</td>
<td>linear, parametric</td>
<td>non-linear, non-parametric</td>
</tr>
<tr>
<td><strong>Method</strong></td>
<td>panel quantile regression</td>
<td>empirically-derived expected shortfall</td>
<td>conditional correlation (DCC GARCH)</td>
<td>various option pricing and RND estimation methods, multivariate GEV</td>
</tr>
<tr>
<td><strong>Data Input</strong></td>
<td>asset returns</td>
<td>equity returns</td>
<td>equity returns and CDS implied default probabilities</td>
<td>expected losses (&quot;implicit put option&quot;)</td>
</tr>
<tr>
<td><strong>Macro/Micro Control Factors</strong></td>
<td>macro state variables in panel estimation</td>
<td>leverage ratio as scaling factor of SES</td>
<td>n.a.</td>
<td>reduced-form estimation in balance sheet identities of CCA and implicit put option</td>
</tr>
</tbody>
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U.S. FSAP Stress Tests

- IMF’s FSAP assessment for U.S. completed in mid-2010
- Praised the SCAP
- Illustrated that calculated losses are much higher if the potential for spillovers among institutions is reflected
- “Three pillar” approach*
  - Pillar 1: SCAP-like exercise
  - Pillar 2: Macro-financial Stress Testing with Distress Dependence
  - Pillar 3: Systemic Contingent Claims Analysis (CCA)

* Note: this is different from the Basel II “pillars”.

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U.S. FSAP Stress Tests—"Pillar II"

- Macroeconomic Scenario Engine: IMF RES
- Financial Stability Measures
- Marginal Contribution to Systemic Risk
- Financial System’s Loss Distribution
- Financial System Multivariate Density
- Simulation
- LGDs
- Exposures
- GSE PoD
- Insurance PoD
- Bank 1..n PoD
- Macroeconomic Factors
- Financial Factors
- CIMDO Financial System Multivariate Density
U.S. FSAP: Differences in Loss Measurements

Expected Loss (EL) & "regulatory capital"

Unexpected Loss (UL) & "economic capital"

Aggregate (Portfolio) Losses

VaR95%

Mean

VaR95%

VaR99%

ES95%

average density beyond VaR95%

Pillar 1

Pillar 2

Pillar 3

Extreme Loss & "tail risk"
Conclusion

• **ST** a useful macroprudential tool, but …
  - Some did not capture relevant risks
  - Often captured right risks, but relatively small impacts
  - Many just confirmed issues visible otherwise

• **ST also useful as crisis management tool, but …**
  - Needs to be done credibly (relevant scenarios, candid interpretation, high-quality capital, credible government intervention if needed)
  - No substitute for regular ST

• **Three issues**
  - **ST** preconditions (data, coverage, assumptions)
  - Scenario design (“extreme but plausible”)
  - Methodology (liquidity **ST**; loss distribution, contagion, feedbacks, nonlinearities)
Thank you!

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