BANQUE CENTRALE DU LUXEMBOURG

EUROSYSTÈME

Stress Testing Results: Implications for the Luxembourg Banking Sector

A. Rouabah and J. Theal
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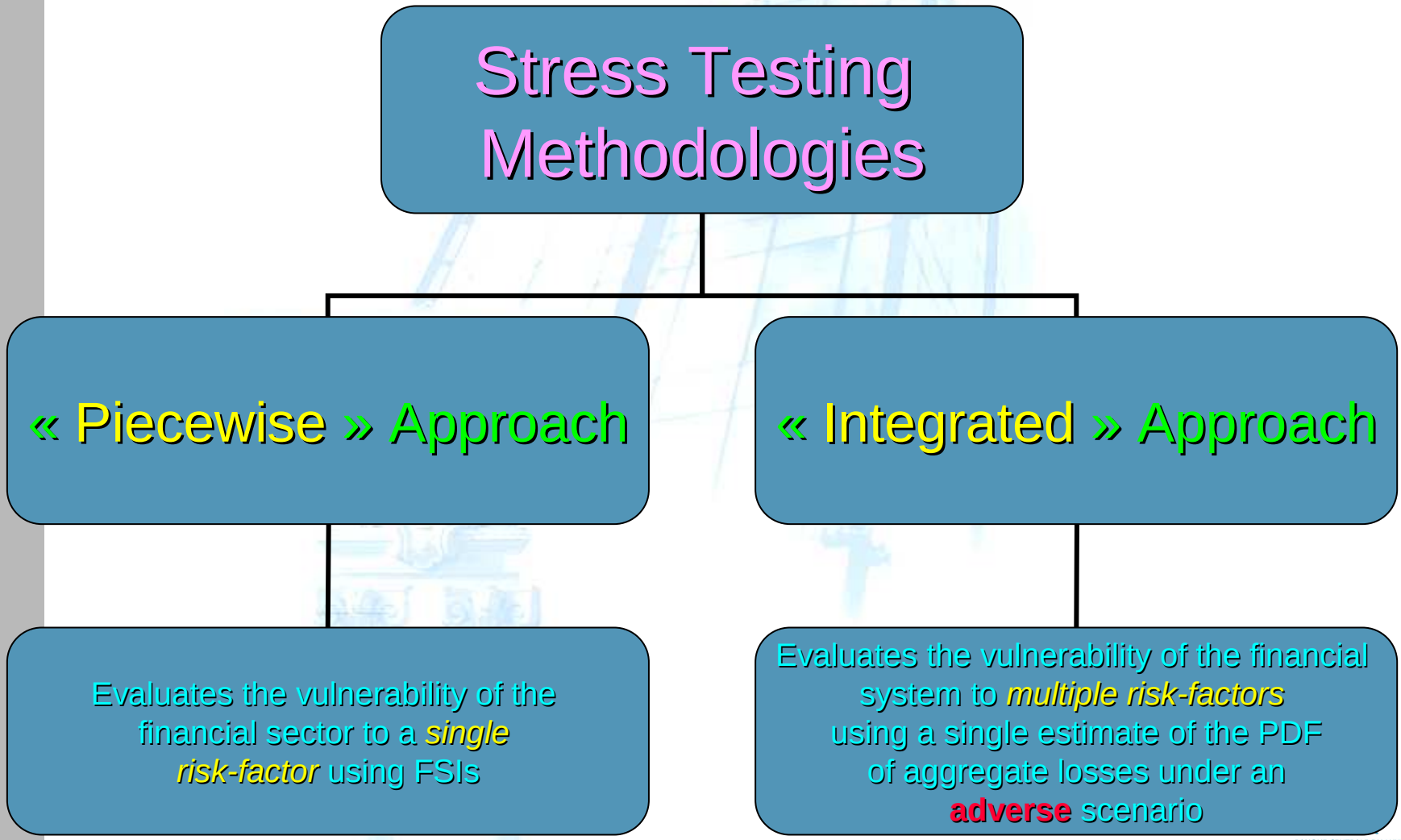
What is Stress Testing?

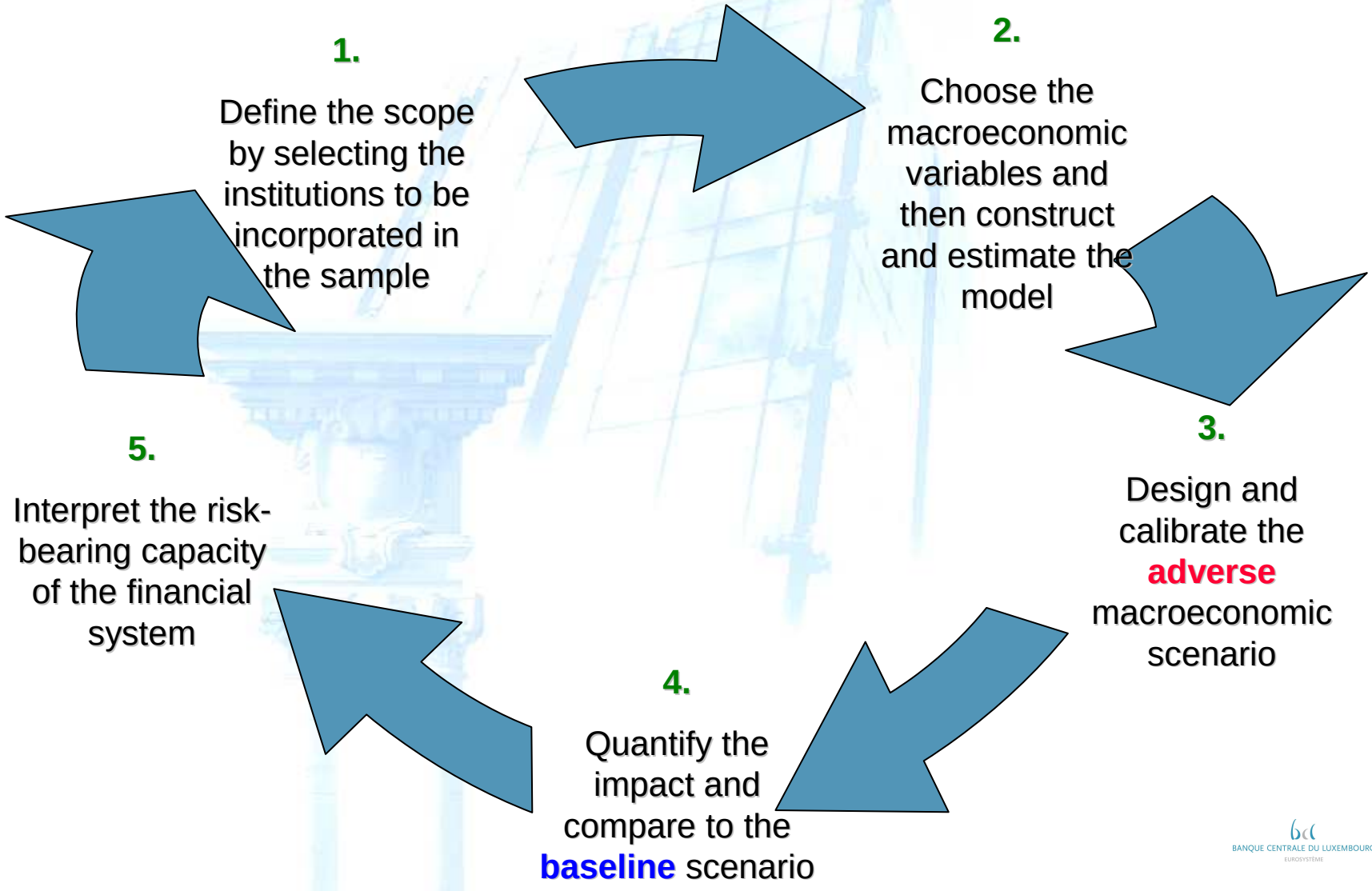
- The recent turmoil has underscored the ***need for improved macroprudential surveillance*** by national central banks
- Stress testing is one supervisory tool that can be used to this effect
- Stress testing refers to a range of techniques used to assess the vulnerability of a financial system to **« exceptional but plausible »** macroeconomic shocks

Methodological Approaches to Stress Testing



Stress Testing: Procedural Overview

Stress testing is performed in the following manner:



Scope of the Economic Model

- To assess the vulnerability of the Luxembourg financial sector, the model incorporates the following macroeconomic equations:
  - **Probability of default**
  - **Luxembourg real GDP growth**
  - **Euro area real GDP growth**
  - **Real interest rate**
  - **Property price index**
  - **SX5E index**

Stress Testing Model

- First we develop a stress testing framework based on the work of Wong, Choi and Fong (2006):
  - ***Wong, J., Choi, K., and Fong, T. (2006) "A framework for stress testing banks' credit risk", Hong Kong Monetary Authority Working Paper***
- We use a SUR system to assess the impact of default in other sectors on the Luxembourg banking sector
- The SUR system allows us to capture any contemporaneous correlation structure between the macro variables used in the model
- The model structure consists of 6 equations that include lagged exogenous variables

Equation Specification

$$\mathbf{y}_t = \mathbf{m} + \mathbf{A}_1\mathbf{x}_t + \ldots + \mathbf{A}_{1+s}\mathbf{x}_{t-s} + \mathbf{\Phi}_1\mathbf{y}_{t-1} + \ldots + \mathbf{\Phi}_k\mathbf{y}_{t-k} + \mathbf{v}_t$$

$$\mathbf{x}_t = \mathbf{n} + \mathbf{B}_1\mathbf{x}_{t-1} + \ldots + \mathbf{B}_p\mathbf{x}_{t-p} + \mathbf{\Theta}_1\mathbf{y}_{t-1} + \ldots + \mathbf{\Theta}_q\mathbf{y}_{t-q} + \boldsymbol{\varepsilon}_t$$

Transform the Default Probabilities

- The default probabilities must be transformed from [0,1] to **R**
- We apply a *logit transform*:

$$y_t = \ln\left(\frac{1-p_t}{p_t}\right)$$

$$-\infty < y_t < \infty$$

- Where:
- So *p* and *y* are *negatively related* (*y* large $\rightarrow$ credit risk is low)

Define the Aggregate Balance Sheet

- We define the aggregate balance sheet to incorporate all banks in the Luxembourg banking sector
- The sample period covers the range from 1995Q1 until 2009Q3
- The observations consist of quarterly proxies for the counterparty probability of default
- These are approximated using a ratio between provisions on loans and total loans over all sectors

Calibrate the Adverse Scenarios

- For each scenario we apply exogenous shocks over 4 consecutive quarters for the period spanning 2010Q1 until 2010Q4
- The respective magnitudes of the shocks used are as follows:

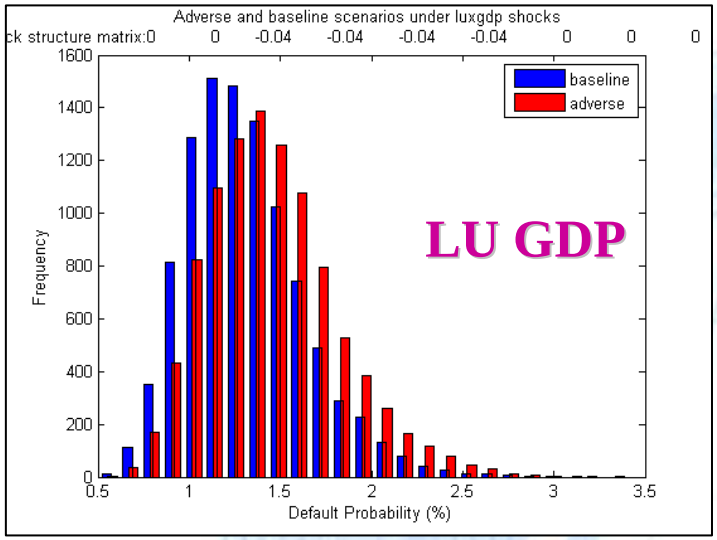
1. Negative shocks to Luxembourg real GDP growth of magnitude:
   - (-0.04, -0.04, -0.04, -0.04)
2. Negative shocks to the Euro area real GDP growth of magnitude:
   - (-0.01, -0.01, -0.005, 0.00)
3. An increase in the real interest rate of magnitude:
   - (0.02, 0.00, 0.01, 0.00)
4. A reduction in real property prices of magnitude:
   - (-0.02, -0.02, -0.02, -0.02)

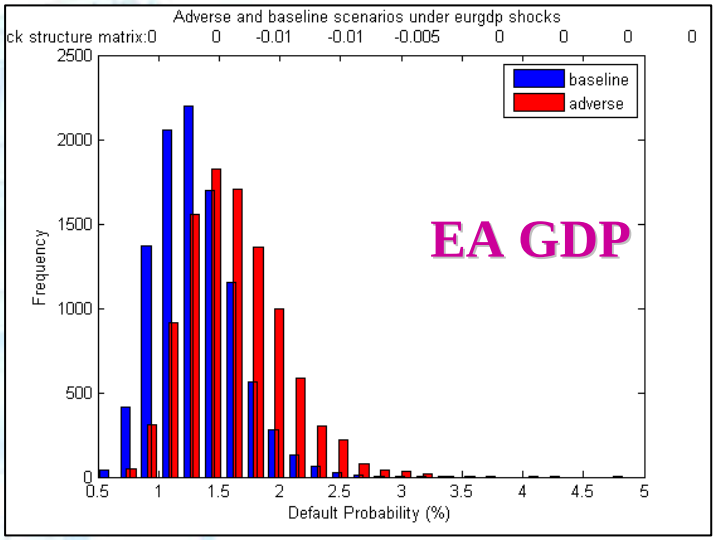
Quantify the Impact on the Aggregate Portfolio

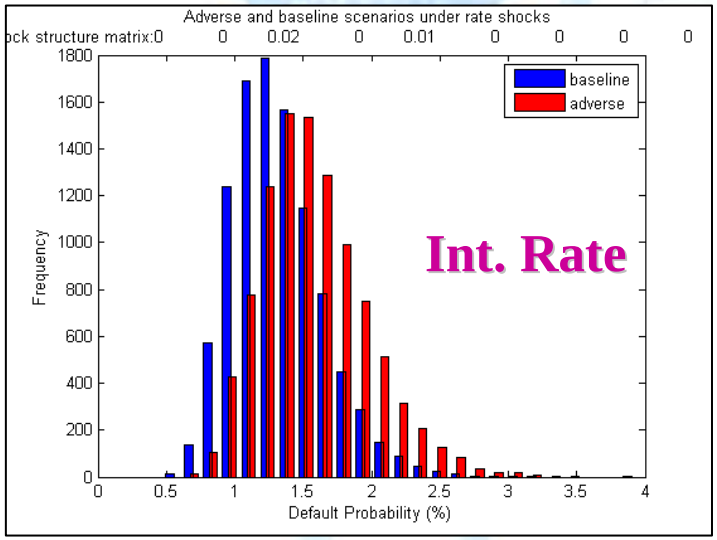
- We perform the stress-testing exercise by simulating 10,000 future paths for the aggregated counterparties' probability of default
- The Monte Carlo simulations begin in the 4th quarter of 2009 and end in the 4th quarter of 2011 (a horizon length of 9 quarters is used)
- End-of-horizon adverse scenario default probabilities are then compared to the baseline values to estimate the effect of macroeconomic variables on the counterparty probability of default

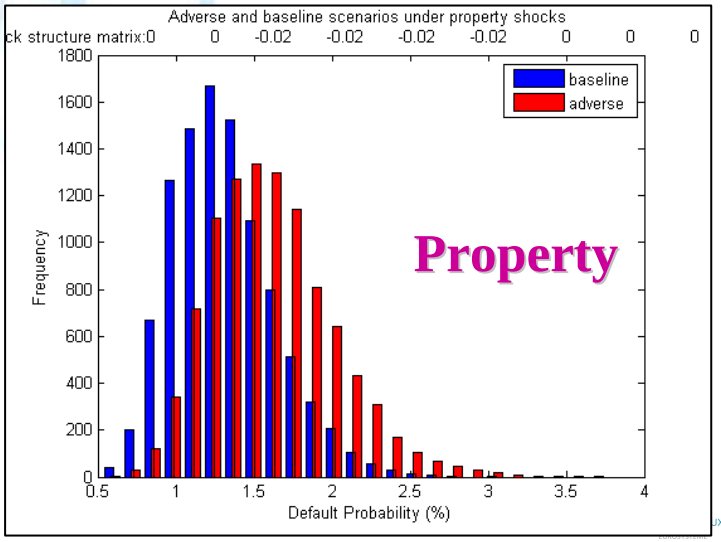
Stress Test Results

Probability of Default Distributions Under Various Shocks









The Effect of the Shocks on the Probability of Default Distributions

- Shocks to Luxembourg real GDP *increase* the mean baseline probability of default from 1.31% to 1.46% under the adverse scenario
- Shocks to Euro area real GDP *increase* the mean baseline probability of default from 1.31% to 1.62% under the adverse scenario
- Shocks to the real interest rate *increase* the mean baseline probability of default from 1.31% to 1.58% under the adverse scenario
- Shocks to Luxembourg real property prices *increase* the mean baseline probability of default from 1.31% to 1.61% under the adverse scenario

Basel II Tier I Ratios

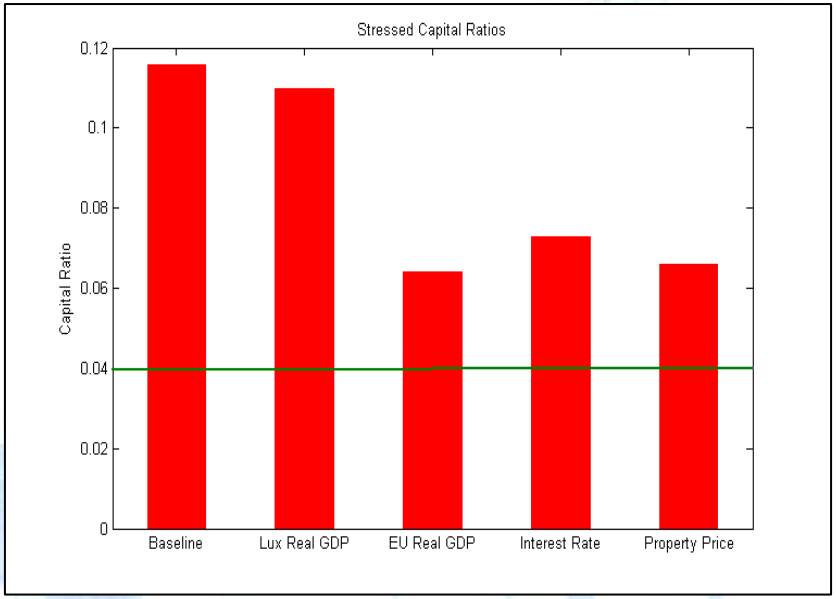
- Capital requirements for corporate exposures under the stressed scenario are calculated using:

$$k_c^* = \left(LGD \times N\left[\frac{G(PD)}{\sqrt{(1-R_c)}} + \left(\frac{R_c}{(1-R_c)} \right)^{\frac{1}{2}} \times G(0.999) \right] - PD \times LGD \right) \times \left(\frac{1}{1-1.5b} \right)$$

- Stressed Basel II capital ratio is given by:

$$capital\ ratio = \frac{K + \Pi}{RWA - 12.5E^c\left(k_c - k_c^*\right)}$$

Effect on Basel II Tier 1 Capital Ratios



- Regardless of the scenario, *all Basel II Tier 1 capital ratios remain above the required minimum of 4%*
- The *largest impact* on capital ratios results from negative shocks to *Euro area real GDP growth*
- Negative shocks to *Luxembourg's real GDP growth* have the *smallest impact* on Basel II capital ratios

Conclusions (Sector Aggregate)

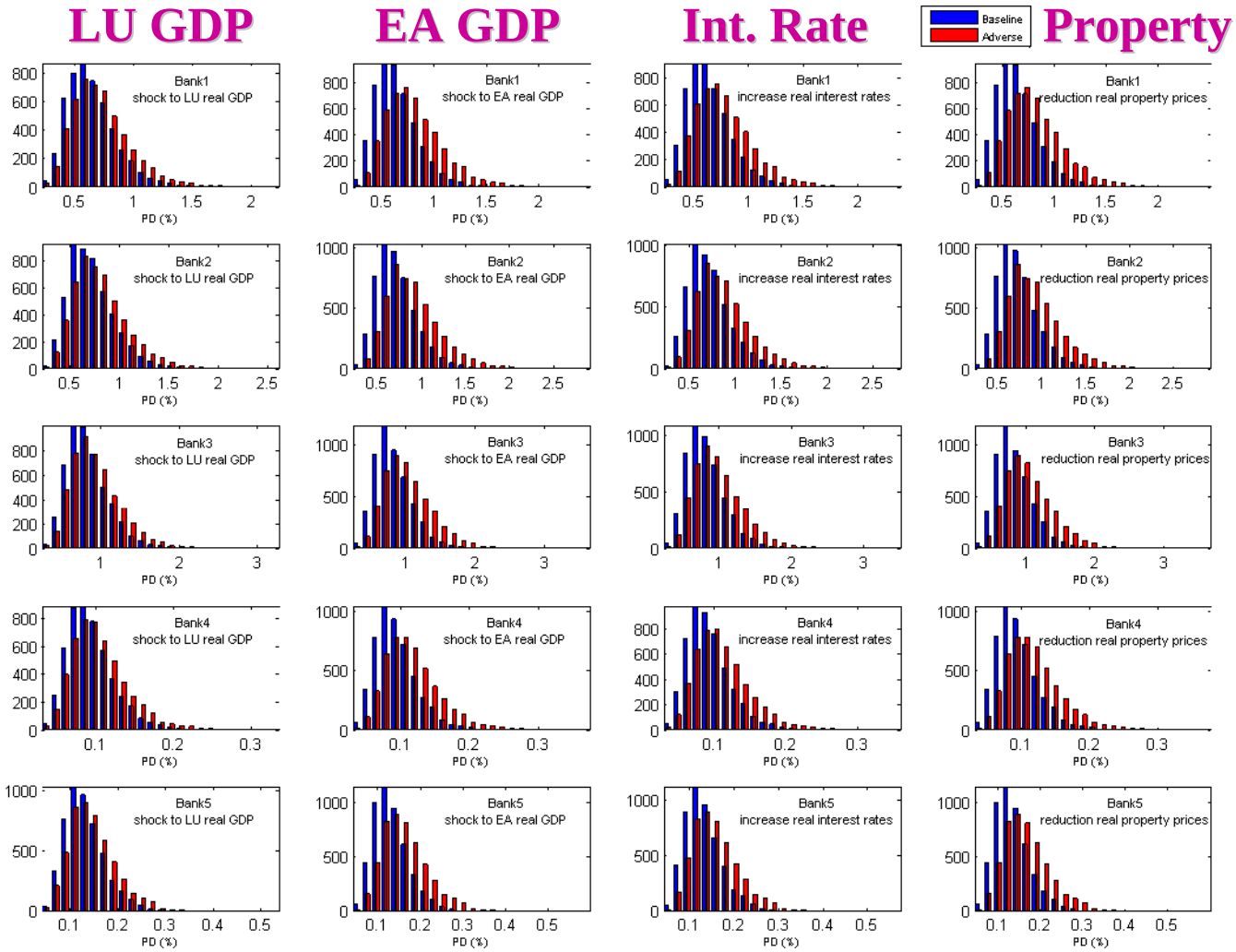
- Under all scenarios, the average probability of default is observed to *increase* in comparison to the baseline scenario average of 1.31%
- Under the exceptional but plausible scenarios utilized, the *Luxembourg banking sector remains robust in terms of Basel II Tier 1 capital ratios*
- Basel II Tier 1 capital ratios for the aggregate financial sector *remain above the required minimum of 4% irrespective of the adverse scenario employed*

Stress Testing of the 5 Largest Banks

The Five Systemic Banks

- The aggregate stress testing framework was applied to the 5 largest banks in Luxembourg
- These banks were ranked based on total assets
- The banks subjected to the stress testing were:
  - Bank 1
  - Bank 2
  - Bank 3
  - Bank 4
  - Bank 5

Performance Under Adverse and Baseline Scenarios



Effect of Macroeconomic Variable Shocks on the Probability of Default

- Bank 4 and Bank 5 have very low probabilities of default - on the order of 0.1% to 0.2%
- All 5 banks remain resilient to exogenous shocks in the Luxembourg real GDP growth rate
- All 5 banks are noticeably affected by shocks to Euro area real GDP growth and a reduction in real property prices
- Probability of default distributions under the adverse scenario are sensitive to the real interest rate

Effect on Basel II Tier 1 Capital Ratios

Bank		Stressed Scenario			
	Baseline	LU GDP	EA GDP	Int. Rate	Property
Bank 1	0.107	0.106	0.100	0.102	0.100
Bank 2	0.137	0.127	0.116	0.120	0.116
Bank 3	0.343	0.332	0.315	0.321	0.315
Bank 4	0.162	0.160	0.154	0.156	0.154
Bank 5	0.154	0.151	0.143	0.146	0.143

Findings

- All banks retain a Tier I capital ratio above the minimum level of 4%
- Adverse shocks to Euro area real GDP growth and a decline in the property price index affect capital ratios the most significantly
- Adverse shocks to the real interest rate affect capitalization ratios, but shocks to Luxembourg real GDP growth have only a small effect on Tier 1 capital ratios
- Bank 1 and Bank 4 appear robust under the adverse scenarios considered
- Differences in individual bank capitalization ratios can be primarily attributed to individual levels of exposure

Thank you for your attention