



EUROPEAN CENTRAL BANK

EUROSYSTEM

# Banking Sector Stress testing – back to basics?

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*The Better Policy Project, webinar, March 2021*

The views expressed are those of the author and do not necessarily reflect those of the ECB.

# Overview

- 1** A typology for designing stress tests
- 2** A case for a special stress test
- 3** A selection of basic modelling ingredients

## 1.1 Some basic definitions...

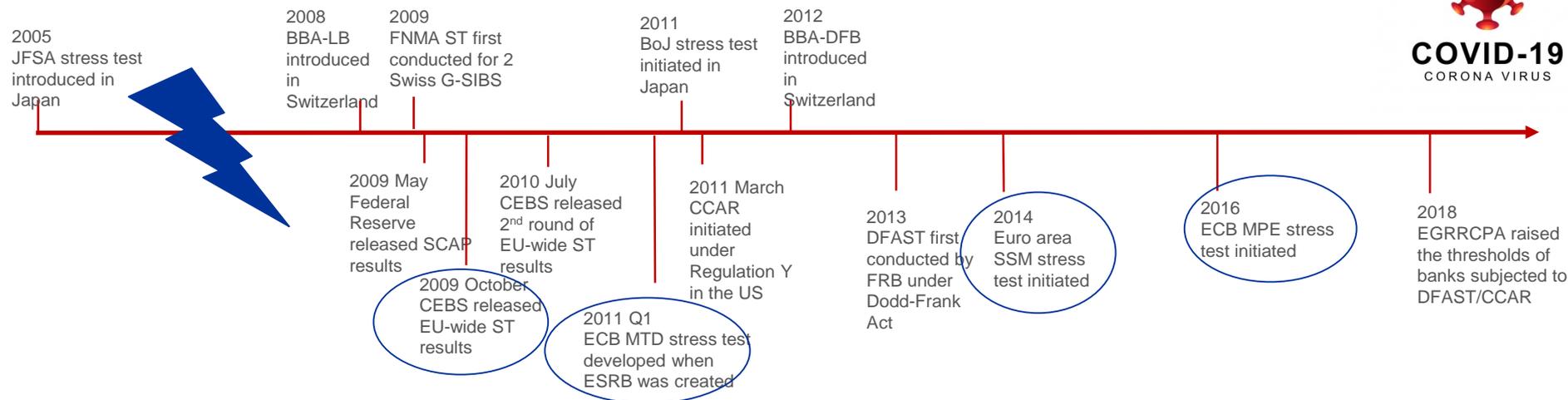
- Stress tests are a **forward-looking assessment** of losses that a bank or a system would suffer under given adverse conditions
- **Bank-level stress tests** can be dated back to early 1990s, for internal risk management purposes
- **System-wide (banking sector) stress tests** were first used by the IMF, and attention increased during the GFC – in particular, the US and EU used **stress tests in response to the crisis**
- Since then, stress tests have become an important **post-crisis supervisory and policy tool**

## 1.2 Significant milestones for banking sector exercises - globally

???



**COVID-19**  
CORONA VIRUS



- **Stress tests post GFC** have been conducted over the last 10 years by many authorities, with **differing purposes and designs**, across and within given institutions
- They have become a standard **supervisory and policy tool** – **during crisis periods as well as during quieter phases**

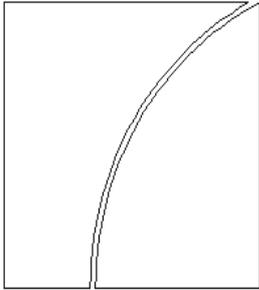
## 1.3 A dedicated BIS FSI team to write a summary report

**Publication** late November 2018

**Authors** BoJ, ECB, FRB, SNB, FSI

- **Granular survey on 4 jurisdictions**  
*(with a detailed stand-alone Annex)*
- **System-wide, banks, solvency ST**
- **Key features, mapped to policy**
- **Drivers to authorities' choices**
- **Lessons and best practices**

<https://www.bis.org/fsi/publ/insights12.pdf>



Financial Stability  
Institute

FSI Insights  
on policy implementation  
*Forthcoming*

Stress testing banks – a  
comparative analysis

By Patrizia Baudino, Roland Goetschmann,  
Jérôme Henry, Ken Taniguchi and Weisha Zhu

November 2018

JEL Classification: E37, E44, G10, G21, G28  
Keyword: stress test, macroprudential, microprudential



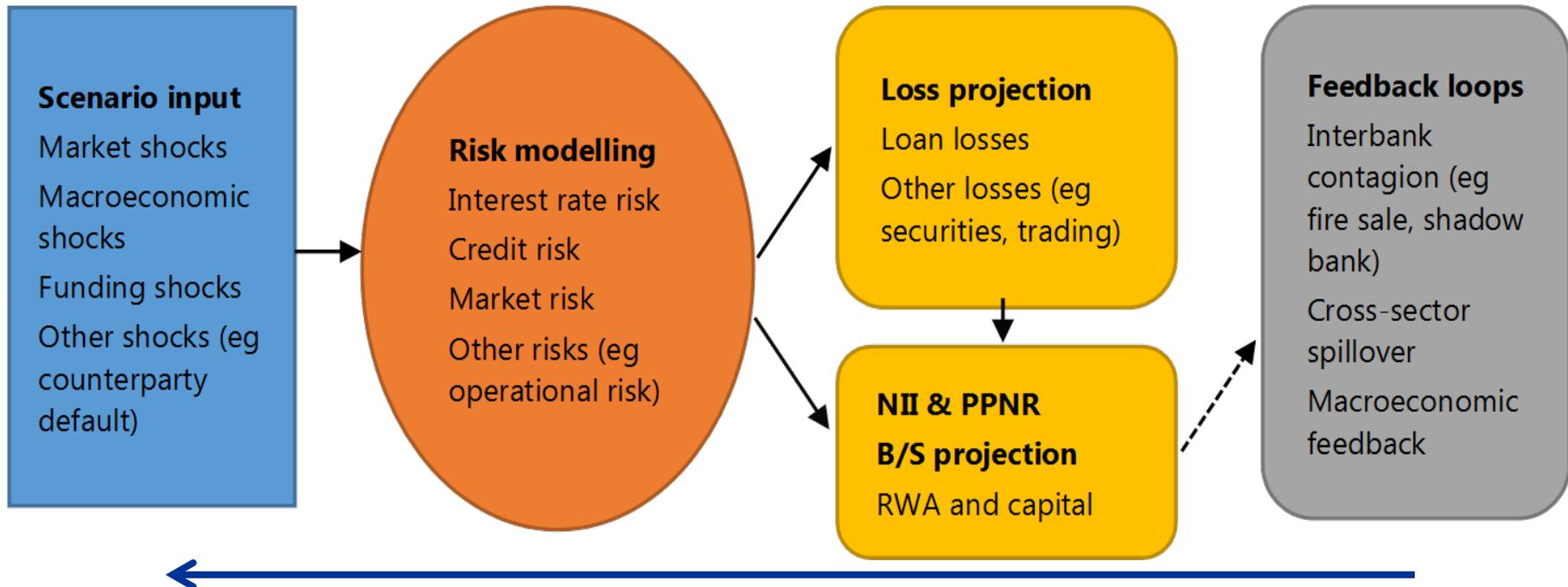
BANK FOR INTERNATIONAL SETTLEMENTS

## 1.4 Stress tests building blocks and further process components

All stress tests (need to) have specified **objectives**

All stress tests involve three **key building blocks, BCBS-consistent**:

- **Governance** (who does what, scope, responsibilities)
- **Implementation** (technical requirements/design - *details below*)
- **Outcomes** (results and publication)



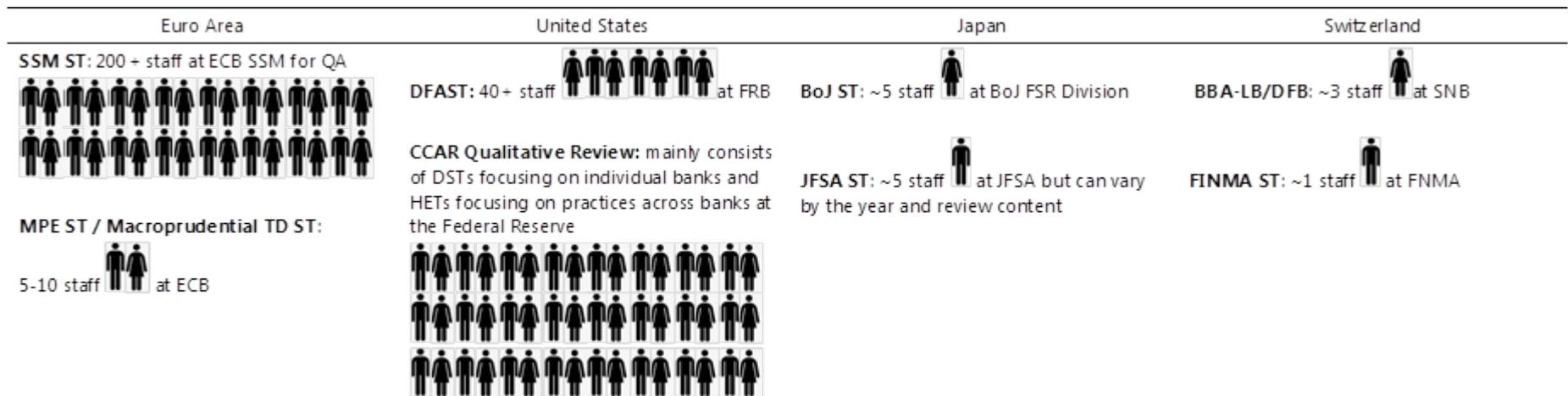
## 1.5 Macroprudential vs microprudential ST // TD vs BU set-up

- **All four jurisdictions run microprudential STs**, as part of a supervisory review process, with broadly similar aims.
- In the **euro area, Japan and Switzerland**, authorities also run **additional exercises that are *primarily* macroprudential**.

	Macroprudential Objective	Microprudential Objective
Top-Down Approach	(2) Euro area ECB Macroprudential Top Down (MTD) ST (3) Euro area ECB Macroprudential Extension (MPE) ST (6) JP Bank of Japan (BoJ) ST (8) and (9) Swiss Building Block Analysis (BBA) – Large Bank (LB) and Domestic Focused Bank (DFB)	4) US Dodd-Frank Act Stress Test (DFAST) (5) US Comprehensive Capital Analysis & Review (CCAR) (8) and (9) Swiss Building Block Analysis (BBA) – LB and DFB
Bottom-Up Approach		(1) Euro area Single Supervisory Mechanism ST (SSM) (7) Japan Financial Services Agency (JFSA) ST (10) Swiss Financial Market Supervisory Authority (FINMA) ST

## 1.6 Survey: Governance – responsibilities (and resources)

- **Microprudential STs** are conducted by the ECB SSM, Japan JFSA, Swiss FINMA and Federal Reserve Board **supervisors**
- **Macroprudential STs** are usually conducted by authorities in charge of the **financial stability** function in a central bank
- **Required resources** (such as data collection, number of staff, and IT infrastructure) largely depend on the implementation approach (**top-down vs bottom-up**)



# 1.7 Survey: Implementation – Scenarios

- All STs consider a **baseline**, and **at least one adverse scenario**. **More scenarios** help explore **vulnerabilities** or incorporate **feedback effects** (in macroprudential ST)
- The **scenario horizon** is usually around 2 to 3 years
- The **severity of the adverse scenarios** is difficult to measure. Some jurisdictions reflect **countercyclical features** in the design process; also **time profiles** can differ across.

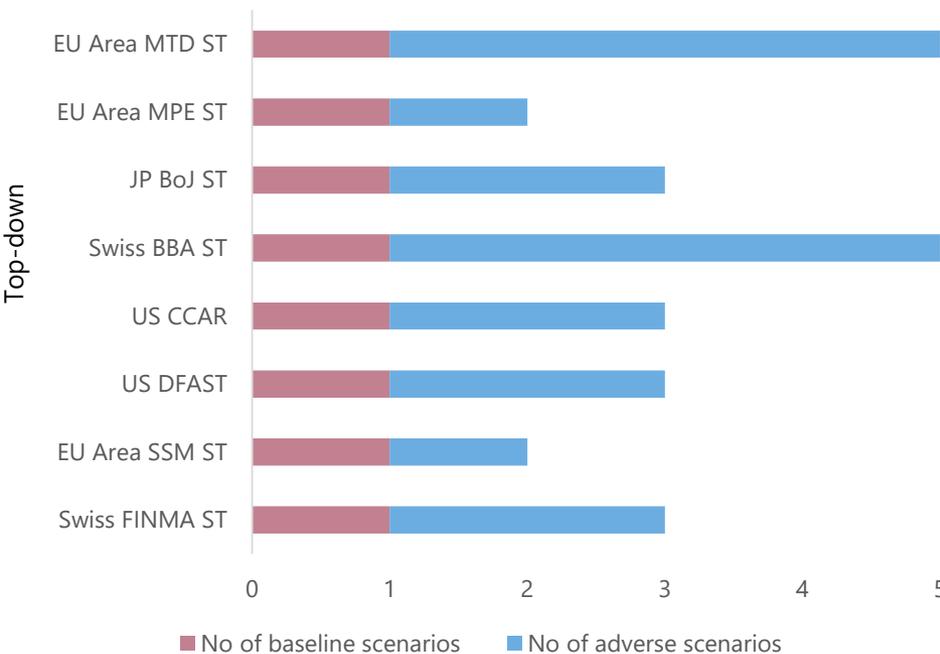


Figure A: EU real GDP deviation from the baseline scenario in EBA ST (%)  
Source: ECB Website

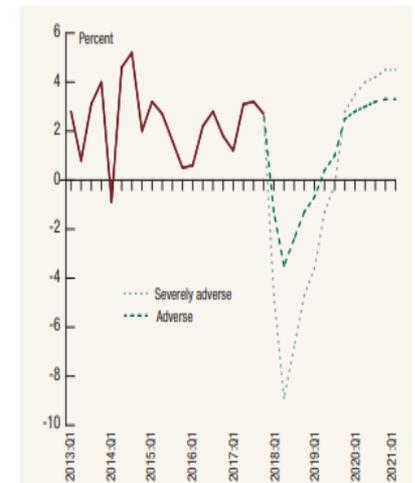


Figure B: US real GDP growth rate in the 2018 DFAST adverse scenarios (%)  
Source: Federal Reserve Publication

## 1.8 Survey: Implementation – a range of modelling strategies

- **1st-round** modelling to a large extent standard; **2nd-round** challenging, mostly relevant to **macroprudential STs**
- Some **microprudential STs** assume a **static balance sheet**, **dynamic B/S** useful to reflect feedback loops for **macroprudential**
- **Modelling techniques and methodologies are updated** – ST results **change** due to model, methodology, scenario or data?

Feedback effect and balance sheet adjustment (macro- vs microprudential ST)

	First-round effect	Second-round effect*	Mostly static B/S	Mostly dynamic B
EA MPE/MTD ST JP BoJ ST CH BBA ST				
EA SSM ST CH FINMA ST US DFAST/CCAR				

\*: see Annex Table 15.

Source: FSI survey.

# 1.9 Aligning Stress-test design features with specific purposes

**CORONA**  
*Stress Test*

(Source: BIS *FSI Insight #12, 2018*)

Illustrative mapping between stress test features and the exercise focus

Key features	1. Macroprudential	2. Microprudential	3. Risk-specific
<b>Governance</b>	Central bank	Supervisor	Not critical
<b>Implementation</b>			
Exercise severity	Not critical	Not critical	Stronger on specific areas
Scenario coverage	Systemic risks	Also idiosyncratic risks	Specific risk factors
Bank coverage	Systemic banks	Broad-based	Specifically exposed banks
Information granularity	Contained	Extensive	Granular for that risk
Top-down / bottom-up	Top-down favoured	Bottom-up helpful	Not critical
Dynamic vs static B/S	DBS favoured	SBS sufficient	Not critical
Second-round effect	Explicit account favoured	Not critical	Not critical
<b>Outcomes</b>			
Results disclosure	Aggregate	Bank-level	Risk-specific metrics

Orange cells indicate that a given decision on a (horizontal) feature is guided by a specific approach in response to a (vertical) perspective dimension.

Source: FSI. Entries in the table are based on FSI staff interpretation of authorities' practices.

## 2.1 Corona crisis – one of its kind

- **Specific features (eg IMF WEO June 2020)**

Not initially financial – not the GFC, financial side impacts still substantial

Severity, from lockdowns – largely unseen, GFC dwarfed-like

World-wide spread – truly global, no secure areas

Trade, coming to a halt – both external and internal

Sector-specific hits (services) – tourism, leisure, transportation...

Policy measures unprecedented – prompt, varied fiscal + monetary + financial, with coordinated moves

- **What is next ??? Still ongoing, even restarting, uncertainty issue!**

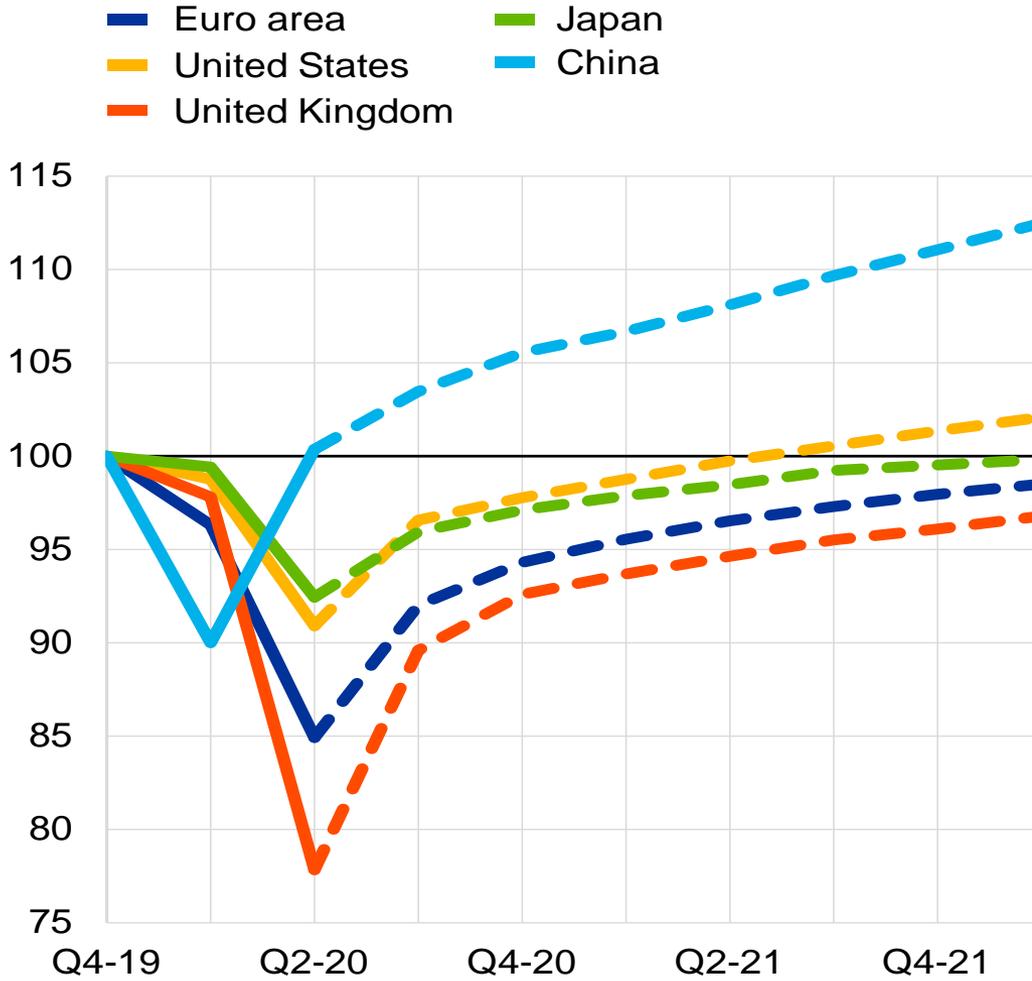
Unknown unknowns, huge uncertainty – eg virus transmission / cure, real side profile going forward, alphabet soup (K, W, ???), banking ???

# 2.2 GDP unseen falls across the world – major revisions to forecasts

Real GDP growth path and expectations

Q4 2019=100

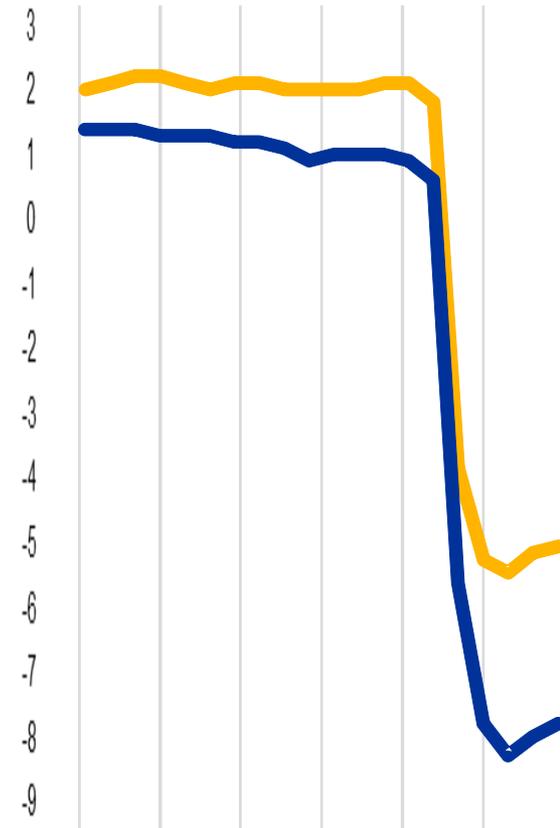
Bloomberg



Sequence of 2020 GDP growth expectations

(EA and US, %) Jan-2019 to Jul-2020

Consensus Economics



## 2.3 Prompt, huge and varied policy responses – GFC lesson learnt

- **Monetary policy** – funding short-long, asset purchases, stabilisation
- **Fiscal policy** – unemployment / furlough, targeted support sectoral + SMEs grants, loan guarantees, recovery funding plans (EU-wide too)
- **Financial policy** – moratoria, CCyB releases, relaxation of regulatory constraints, capital relief

### Objectives:

Cushion the shock – broad-based labour income; targeted for companies

Avoid amplification, esp. via financial intermediation

In particular contain 2<sup>nd</sup> round effects from banks' weakened solvency prospects; preserve sufficient credit supply to accompany a recovery

## 2.4 Quantifying the impacts, tentatively – textbook case for stress-testing

- **Textbook case for a (system-wide) stress test**

forward-looking scenario exercise under (possibly very) adverse conditions

- **3 major authorities with a “special” Corona Stress Test**

Reviewing jointly these 1<sup>st</sup> reactions to assess possibly common features



BANK OF ENGLAND



Assessment of Bank Capital during  
the Recent Coronavirus Event

June 2020

Interim Financial  
Stability Report

May 2020

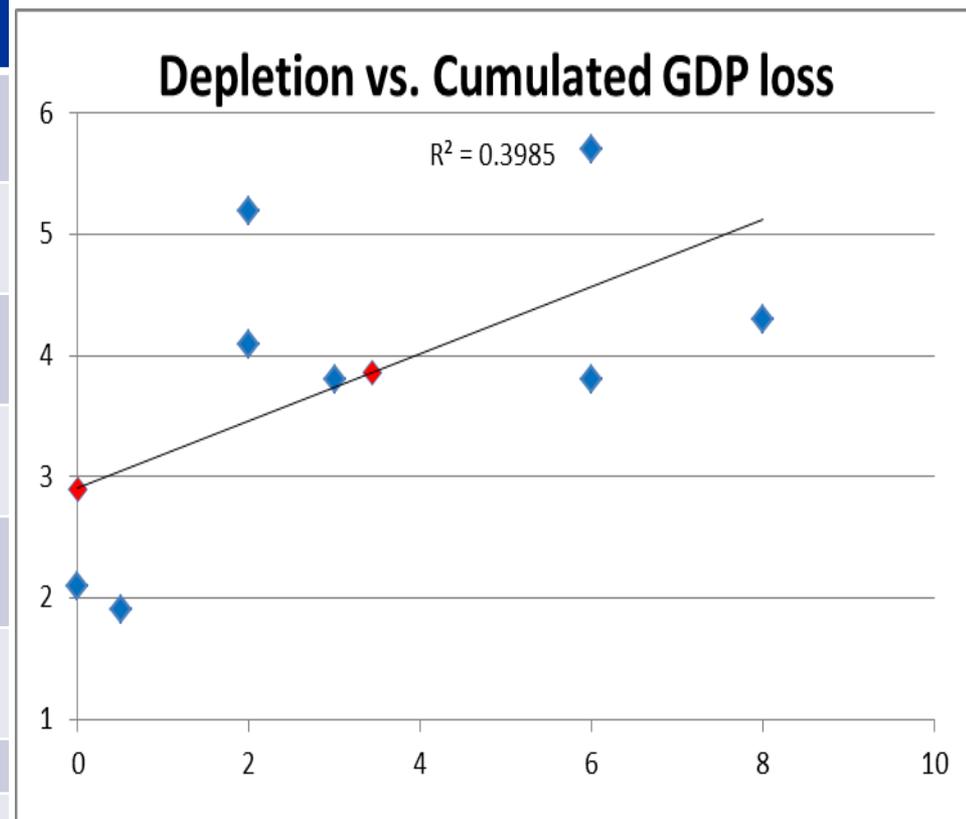
COVID-19 Vulnerability  
Analysis

Results overview

28 July 2020

## 2.5 An apparently consistent link between capital and GDP severity ?

Exercises	Cumulated GDP loss	Maximum GDP decline	CET1 Capital depletion
US V shape	0	10	2.1
US W shape	8	12	4.3
US U shape	6	14	3.8
UK desktop	3	14	3.8
BoE ST 2019	2	2	5.2
€severe VA	6	13	5.7
€mild VA	0.5	9	1.9
EBA 2018	2	3	4.1
Average	3.4	9.6	3.9



Source: Henry (2020), Banking system stress testing and Corona: A first summary appraisal

## 2.6 Special features of these Special issues ST – eg the ECB (inter alia)

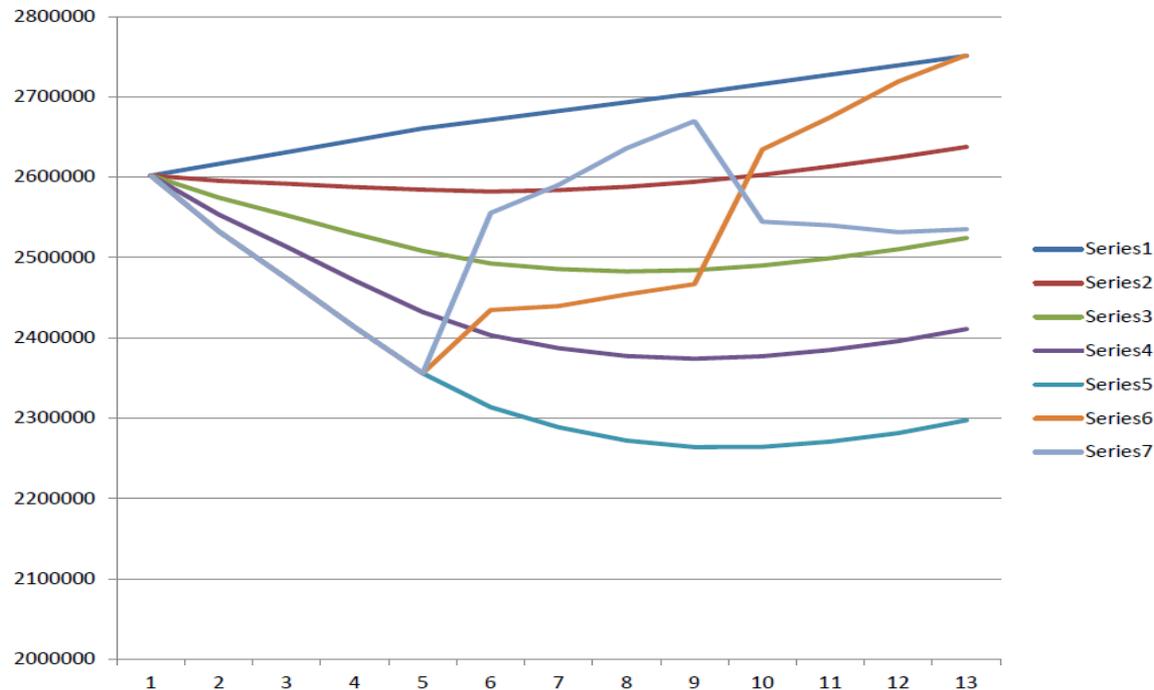
- **Top-Down rather than Bottom-Up** – ECB Model-based work, usually used for microprudential ST Quality Assurance purposes or macroprudential exercises as reported in the ECB FSR
- **3 scenarios** – ECB macro projections and EBA 2020 baseline (pre-Corona); easier with a TD approach to run many alternative scenarios
- **Severity re-gauged** – well beyond previous CEBS-EBA-SSM exercises; baseline coming closer to a stress environment already
- **Impacts of policies** – (via scenarios, but not only) IFRS9, TLTRO, Guarantees... WIP by construction as new steps may / will come...
- **Publication of aggregates – no bank-level info**, no direct link to supervisory review, hence closer to a macroprudential approach

**Further extensions towards a risk-specific approach** – ad hoc granular data, sector-specific focus, business model deeper dive, etc.

## 2.7 Resulting macro-financial scenario range and profiles

Scaling up scenarios – selected GDP path over 3 years incl (U – V – W) profile, with scaling factors from 0 to 2 for U-shape EBA-like

S (1,2,3,4,5) are resp. for shock sizes ( $0, \sigma, 2\sigma, 3\sigma, 4\sigma$ ), applied to all factors. Series 3, corresponds therefore to 5% level individual shock inputs, causing some 9 ppts GDP loss wrt baseline at horizon-end – higher than EBA2018.



Source: Henry (2020) Reflections on macroprudential reverse stress testing

## 2.8 One step beyond, Worst Case Scenario and Reverse Stress Tests

- **Severity with a new “extreme + plausible” benchmark replacing GFC ?**

Extreme (**Worst Case**) **Scenarios**, up to **Reverse Stress Testing** (eg BoE), with methodological challenges – identification of drivers, probability algebra...

- **Definition:** generic inversion of the ST (not necessarily extreme shocks)

$$Output = ST [ Input ] (1)$$

Find  $\{Inputs\}$  such that (1) holds for a given *Output*

- Micro RST for **recovery / resolution planning** – what can go really wrong

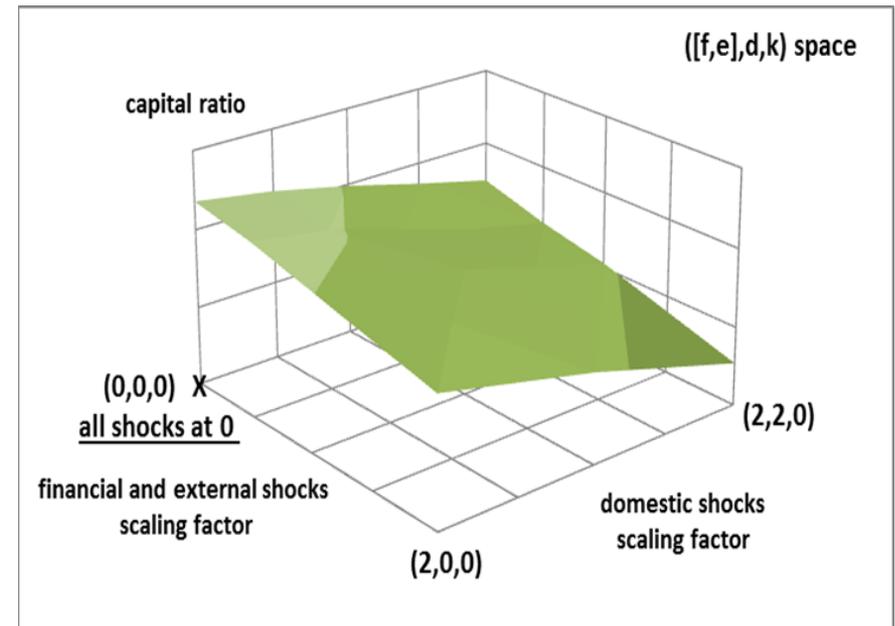
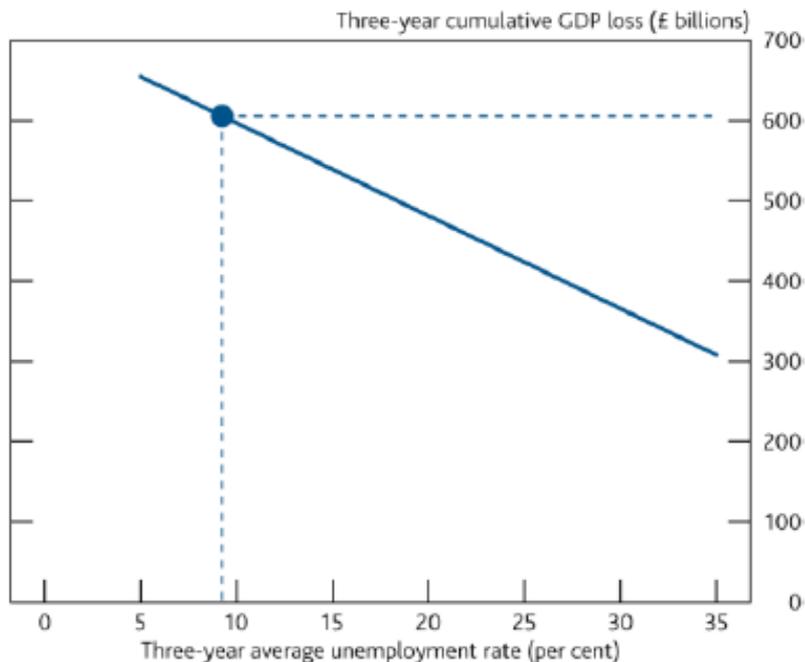
Micro ST (bank) = Bank failure vs **Macro ST (SYSTEM) = Outcome**

**3 Options:** (scalar approach, full Monte Carlo, combination of factors)

## 2.9 Illustrative visualisations of RSTs – eg BoE and own simulations

- **LHS: BoE results** illustrate that many combinations of GDP and unemployment shocks would yield the same capital depletion – an increase in one offsetting a decrease in the other
- **RHS: Experiments with EU bank data** for more shocks are similar, stronger (financial/external) shocks make up for weaker domestic shocks – full surface of outcomes shown in the 3D chart

Shocks to GDP and unemployment that could result in the same level of capital depletion as in the 'reverse stress test'<sup>(a)</sup>



## 3.1 Basics of a simplified Balance Sheet and P&L accounts

### Asset-Liability mix matters (type/duration/counterpart)

Asset	Liability
Loans (ow <b>NPL</b> )	Deposits
Bonds	Wholesale
Stocks	Bonds
Cash	<b>Capital (w/o RW)</b>

Loan dynamics affect NII via  
impairments and provisions

Capital path reflects losses

<b>Net Interest Income</b>	
Dividends	
NFCI	
<b>Credit gains</b>	
<b>Market gains</b>	
<b>Net Operating Income</b>	
admin costs	
<b>provisions</b>	
<b>impairments</b>	
<b>Pre Tax Profits</b>	
Taxes	
<b>Net Profits</b>	

## 3.2 Stress Test channels – Overview from P&L to Capital ratio(s)

- **Credit risk**

Asset-specific loss rates, derived aggregate losses and derived provisions  
Alternatively, aggregate overall credit loss modelling (NPL ratios)

- **Interest Rate risk**

Interest income – expenditures, impairments from credit losses  
Quasi-accounting  $A \times IR$  and  $L \times IR$  vs aggregate income regressions

- **Market risk / traded income**

Valuation (asset price and rate shocks)  
Quasi accounting link to Asset structure vs aggregate income regression

- **Other items: Operational cost (risk) / Taxes / Dividends**

Ratio approach (assumed disconnect wrt macrofinancial scenario).

- **Capital stressed**, after accounting for losses

- **Capital Ratio** – regulatory vs inverted leverage (un-weighted)

Purely accounting – if regulatory, weighted, ie x-product of exposures and  
Risk Weights (function of risk parameters<sup>22</sup>, eg Default proba)

### 3.3 “Satellite” models - Credit Risk parameters

#### The standard credit risk modelling framework

- **All assets in banking book exposed to credit risk**, covering IRB and STA portfolios – banks using models or regulatory tools
- **Expected loss concept:**  $EL_t = PD_t \times LGD_t \times EAD_{t-1}$
- Point-in-Time (PiT) PDs and LGDs stressed conditional on scenario – cyclical patterns
  - PDs via satellite equations (Bayesian model averaging based) linking historical default rates to macro-financial variables covered by the scenario
  - Structural model for LGDs for collateralised exposures
- **Regulatory PDs and LGDs** also stressed (link to PiT parameters – smoothed, ie a “thru the cycle” version of cyclical parameters)

### 3.4 “Satellite” models - Credit Risk benchmarks

#### Satellite equations for $PD_{PiT}$

- Satellite equations for default rates for EU28 and 6 segments: FIN, NFC RE, NFC non-RE, HH for house purchases, consumer credit, sovereign.
- Linking default rates to macro via *Autoregressive Distributed Lag* (ADL) model structure, using Bayesian model averaging to address model uncertainty by considering all possible combinations of predictors (*GDP, U, short-long IR, REP, Stock*)

$$Y_t = \alpha + \rho_1 Y_{t-1} + \dots + \rho_p Y_{t-p} + \sum_{k=1}^{k_i} (\beta_0^k X_t^k + \dots + \beta_{q^k}^k X_{t-q^k}^k) + \varepsilon_t$$

- NPL paths implied by PDs (write-offs  $w_t$  by assumption zero if static balance sheet assumption – usual SSM EBA case)

$$NPL_t = NPL_{t-1}(1 - w_t) + PD_t(L_{t-1} - NPL_{t-1})$$

General case:  $L_t = P_{t-1}(1 - r_t) + NB_t + NPL_{t-1}(1 - w_t) + \Delta Valuation_t + \Delta Classifications_t + \varepsilon_t$

# 3.5 "Satellite" models - Net Interest Income, lending and funding rates

NII - Estimating rates, eg sectoral breakdown

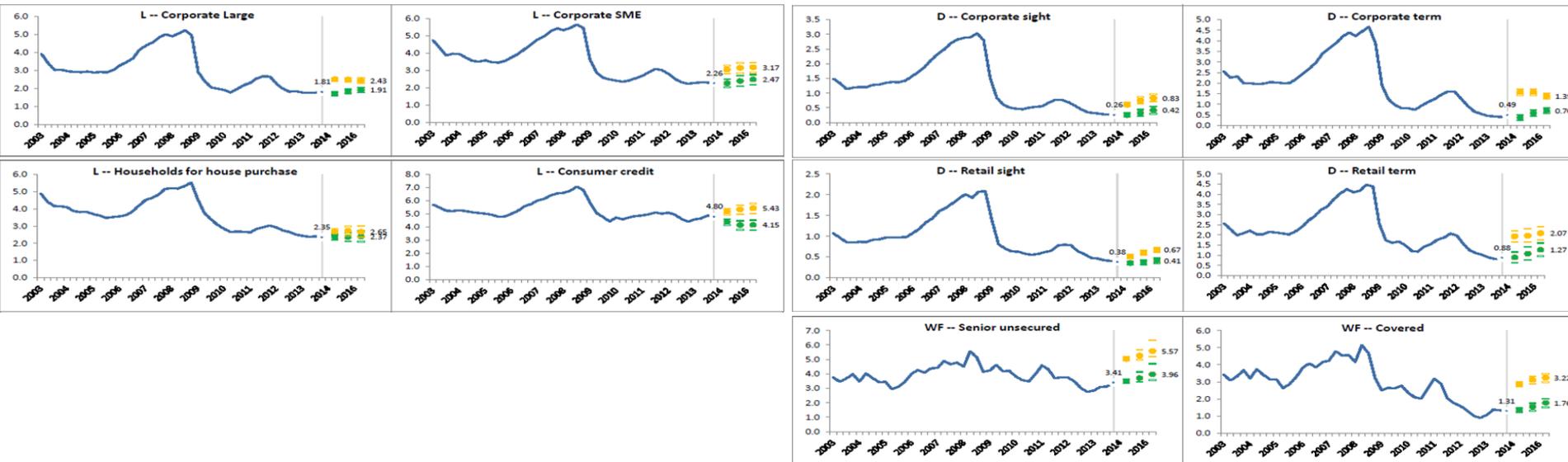
10 asset / liability classes, 28 EU countries, 20 RoW countries/areas

Lending and funding rates function of scenario assumptions

## Assets

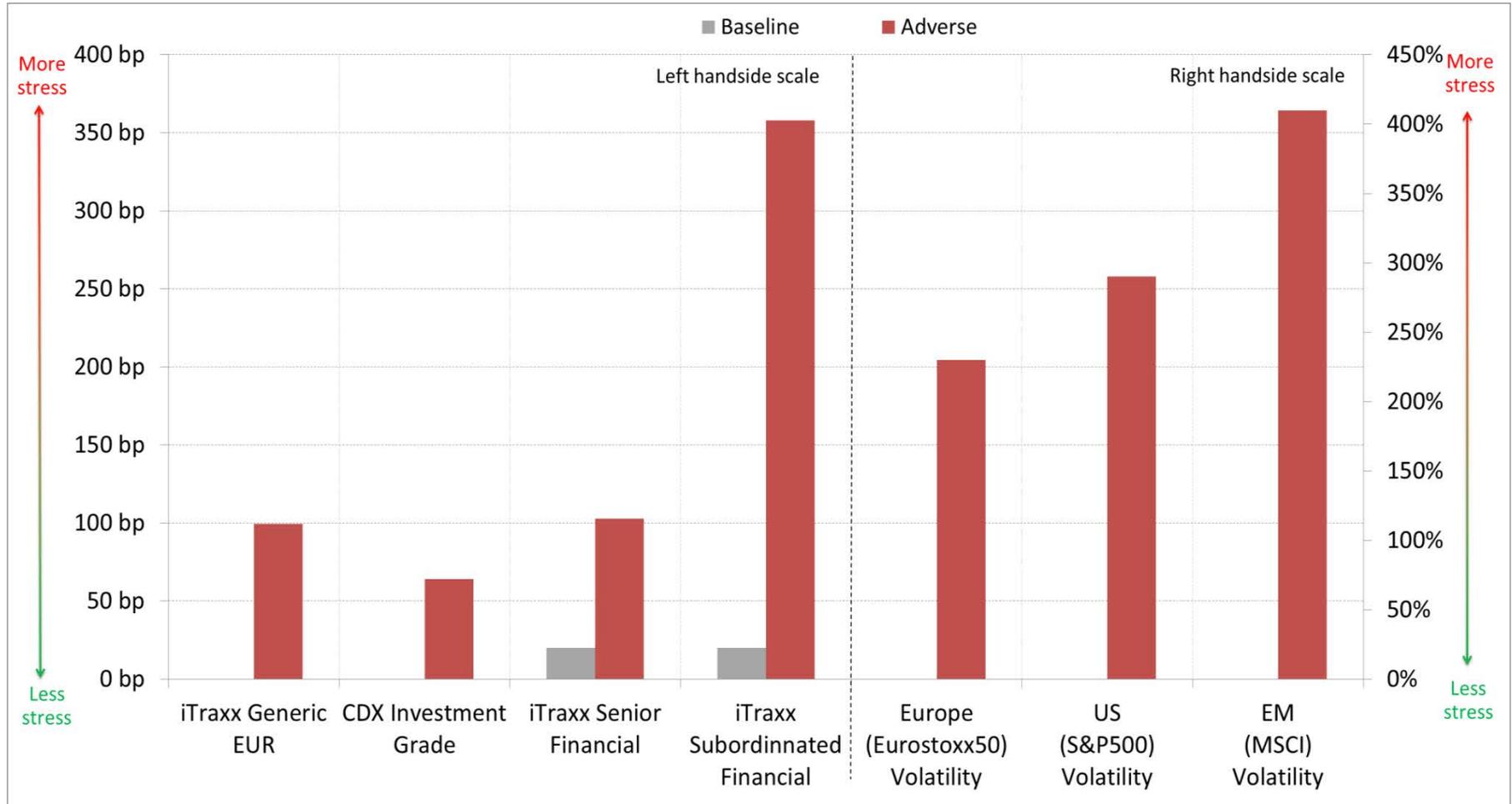
## Liabilities

Interest rate projections in percent. Blue: historical. Green: baseline scenario. Orange: adverse scenario. Bars: Respective upper/lower bounds (75th/25th percentile).



## 3.6 Market risk parameters – “mechanical” link to scenario

Calibrated market risk parameters – valuation shocks MTM  
[return shocks equivalent to a price loss, can be used for all traded assets]



## 3.7 Modelling other income – F&C – bank-level

### Econometric framework for F&C income – Panel

- Dynamic panel data modelling approach is adopted in order to account for the potential persistence of the F&C income over assets:

$$y_{it} = \alpha y_{it-1} + \beta X_t + u_i + \varepsilon_{it}$$

- where  $y_{it}$  is F&C income over assets for bank  $i$  for period  $t$ ,  $y_{it-1}$  is the lagged dependent variable,  $X_t$  is a  $(m \times 1)$  vector of explanatory variables including macroeconomic and financial conditions and lags and  $u_i$  are banks' fixed effects.
- Only optional as otherwise easier to assume constant ratios between NFCI and eg Assets and Liability retail items or trading... exogeneity assumption wrt macrofinancial scenario assumptions
- Same applies to Administrative costs, Operational risk probabilistic?

# Conclusions

- **Well-established frameworks for system-wide stress testing**
- **Covid19 as an additional ad hoc unplanned real experiment**  
2<sup>nd</sup> wave health and real side shocks, expiration of policy effects and policy themselves, lagged (adverse) impacts on P&L and capital...
- **Pin down uncertainties / play with parameters – update results**
  - Be in a position to run and analyse assessments frequently and promptly, update scenarios ; calls for an integrated approach.
  - Stress test toolkit to analyse and assess alternative baselineS; consider also a range of models and configurations
  - Severity and risk factors vary, up to Reverse Stress Testing – challenging methodological and interpretation issues...
- **Rough and robust modelling setup – not immune to accuracy issues**
  - Data inventory / issues mostly on the micro side / map modelling accounting framework with available data or proxies
  - deal 1<sup>st</sup> with 1<sup>st</sup> round if for supervisory purposes / banks' reaction 2<sup>nd</sup> round tougher job for the modeller...

# Background

Baudino, P., Goetschmann, R., Henry, J., Taniguchi, K. and Zhu, W. (2018) 'Stress testing banks: a comparative analysis', FSI Insight #12 and appendix, November, BIS. <https://www.bis.org/fsi/publ/insights12.htm>

Henry (2020) 'Banking system-wide stress testing and Corona: a first summary appraisal', forthcoming in *Journal of Risk Management in Financial Institutions* [https://www.researchgate.net/publication/347453075\\_Banking\\_System-wide\\_stress\\_testing\\_at\\_Corona\\_times\\_a\\_summary\\_appraisal](https://www.researchgate.net/publication/347453075_Banking_System-wide_stress_testing_at_Corona_times_a_summary_appraisal)

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## An ECB e-book, staff tools for “macropru ST”

<http://www.ecb.europa.eu/pub/pdf/other/stampe201702.en.pdf>



### STAMP€:

#### Stress-Test Analytics for Macroprudential Purposes in the euro area

Edited by Stéphane Dees, Jérôme Henry and Reiner Martin

February 2017

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## Macroprudential stress tests: A new analytical tool

Vitor Constâncio

22 February 2017

*The Global Crisis and its aftermath led to greater use of stress tests and to the establishment of macroprudential policy as a new policy area. In this column, ECB Vice-President Vitor Constâncio introduces new suite of analytical tools that support the design and calibration of macroprudential policy. The tools go well beyond the requirements of the traditional solvency stress tests applied to banks, and include a broader set of institutions than just banks, an analysis of the financial cycle, as well as an assessment of systemic risk levels associated with the economic and financial shocks considered in adverse scenarios.*



The Global Crisis and its aftermath led to a greater use of stress tests and to the establishment of macroprudential policy as a new policy area, with the objective being to identify and limit systemic risk. Early identification of risks, supported by thorough surveillance and early warning models to detect potential sources of systemic risk is an essential first

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