Risk to Buffer: setting Cyclical and Structural Capital Buffers through Banks Stress tests

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Cyclical and Structural buffers

- Basel III framework introduced the distinction between:
  - Cyclical buffers: varying with the financial cycle (e.g. indebtedness), quarterly set $\longrightarrow$ Counter-Cyclical Buffer
  - Structural buffers: constant across the financial cycle and covering banks' vulnerabilities, set at lower frequency $\longrightarrow$ Capital Conservation Buffer, G-SIB, Pillar 2 Guidance (P2G)
- NB: Structural buffers (e.g. CCB and P2G) can ensure resilience against economic downturns, but are not quarterly set to counter (financial) cyclical risks, i.e. financial cycle factors as such as excessive leverage of financial agents or over-evaluation of asset prices

Buffers calibration and Stress Tests

- In prudential policy, buffers can be calibrated via banks' Stress Tests
- Macroeconomic Adverse scenario $\longrightarrow$ Banks' Stress test $\longrightarrow$ Capital shortfalls $\longrightarrow$ Capital buffers
- Starting from the shortfall, how can we disentangle cyclical and structural buffers?
- How does the evolution of the financial cycle can affect the calibration of cyclical buffer?
- Risk of overlap between Cyclical and Structural buffers $\longrightarrow$ Inefficient and not transparent use of the capital framework

This project

- We provide a new conceptual framework to jointly calibrate Cyclical and Structural buffers : the Risk-to-Buffer
- Integration of a non-linear macro model - Cyclical Amplifier- and a banks' Stress test model
  1. State-dependent macro model that generates scenarios whose severity depends on the level of cyclical risk
  2. Multiple scenarios are generated by using the same set of shocks in different state of the economy (i.e. standard/medium risk, current risk)
  3. A stress test model is used to obtain banks losses for each scenario
- We fix a certain level of cyclical risk as the "reference" one: the reference risk losses will be used to set the Structural buffer
- The current cyclical risk losses will be associated to the Cyclical buffer

The Risk-to-Buffers

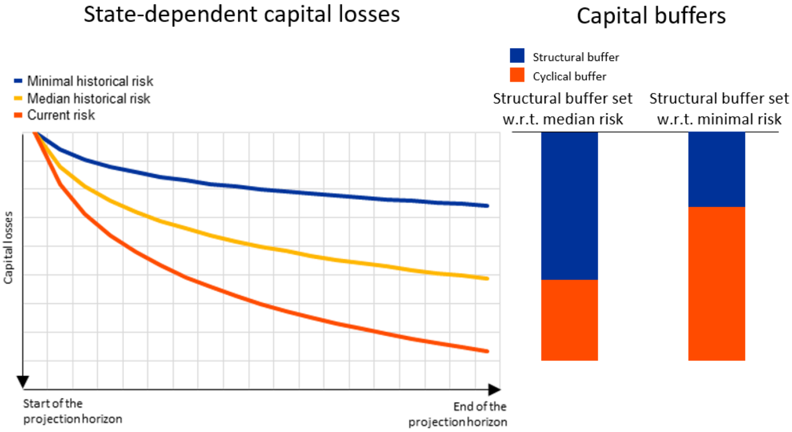

Figure: Illustration of the Risk-to-Buffer.
Note: The chart illustrates the Risk-to-Buffer approach. Thanks to the state-dependent nature of the Cyclical Amplifier, the same set of shocks produces different scenarios, triggering different results for each levels of cyclical risk: the low risk (blue), the median risk (yellow) and the current risk (red). The policymaker chooses the level of the reference risk used to calibrate the structural buffer, while the cyclical buffer covers the additional losses (if any) due to the current level of risk.

Literature

- Stress test literature to calibrate capital buffers: Bennani et al. [2017], Budnik et al. [2019], Camara et al. [2015], Coffinet and Lin [2010], Dees et al. [2017], Henry et al. [2013]
- Non-linear macro models: Aikman et al. [2016], Alpanda and Zubairy [2019], Barnichon and Matthes [2016], Carriero et al. [2018], Cheng and Chiu [2020], Franz [2017]
- Setting the severity of the scenario: Growth at risk Adrian et al. [2019], Prasad et al. [2019]

The macroeconomic model for scenarios design: the Cyclical Amplifier

- Why Cyclical amplifier? $\longrightarrow$ dynamics of the model depend on the level of cyclical risk (e.g. DSR)
- Multivariate Smooth transition regime switching model estimated on Euro Area data
  - We identify a set of macroeconomic shocks (Choleski decomposition): e.g. Housing shock, Spread shock.
  - State effects: the propagation of economic shocks is affected by the level of cyclical risk (e.g. Indebtedness measure)

The Cyclical Amplifier: the econometric model

- Multivariate Smooth transition regime switching model - Local Projections (thereafter LP) by Jordà [2005] and Tenreyro and Thwaites [2016]

- For period $t = 0, ..., T$, with horizon $h = 0, ..., H$, with n the number of endogenous variables, p the number of lags, our econometric setting is:

$$\begin{aligned} Y_{t+h} = \; & F(z_t)(\alpha_h^U + \beta_h^U Y_t + \Sigma_{\ell=2}^{p} L_{h,\ell}^U \, Y_{t-\ell}) \\ & + (1 - F(z_t))(\alpha_h^D + \beta_h^D Y_t + \Sigma_{\ell=2}^{p} L_{h,\ell}^D \, Y_{t-\ell}) \\ & + u_{h,t}, \end{aligned} \tag{1}$$

where Y_t is the $(n, 1)$ vector of endogenous variables at time t, z_t is the scalar interaction variable at time t and $u_{h,t}$ is the $(n, 1)$ vector of errors at horizon h at time t.

IRF

The transition function

- The state effect is given by $F(z_t)$, that is the scalar function governing the transition between the high and the low regime. As standard, the transition function is the logistic transformation of the original z_t:

$$F(z_t) = \frac{1}{1 + exp\left(-\theta\left(\frac{z_t - v}{\sigma_z}\right)\right)} \tag{2}$$

- We construct confidence intervals using the block-of-blocks bootstrap approach, suggested for LP by Kilian and Kim [2011]

Estimation of the macroeconomic model

- Endogenous variables
  - Real GDP growth;
  - Inflation;
  - Unemployment rate
  - Short term interest rate
  - Real house prices
  - Spread between Sovereign 10 years bond rate and risk free rate
- Measure of cyclical risk used as Interaction variable: Debt Service ratio of NFPS
- Sample: 1999Q1-2018Q2
- EA and country level estimation
- Structural identification: Choleski

Debt Service Ratio for Non-financial private sector

- The state variable is the Debt Service Ratio as computed by Drehmann et al. [2015]:

$$\frac{D_t}{Y_t}\frac{i_t}{1-(1+i_t)^{-m}}, \tag{3}$$

  where Y_t is income, D_t is debt, i_t is the lending interest rate, m maturity.

- The DSR is the fraction of revenue that agents have to pay in the current period in order to repay a debt of m maturity in equal portion

- The use of Debt Service Ratio allows directly capturing the effects of financial vulnerability on the impulse responses

Results: the Housing shock

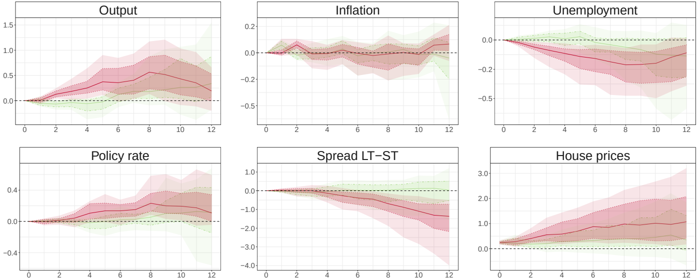

Figure: Impulse responses of our endogenous variables to a housing shock.
Note. The responses of output growth, inflation and house prices are cumulated, while the responses for the interest rates, spread and unemployment rates are in levels. The red (green) lines are the impulses when leverage is high (low). Shaded areas represent the 67% and 90% confidence intervals.

Results: the Spread shock

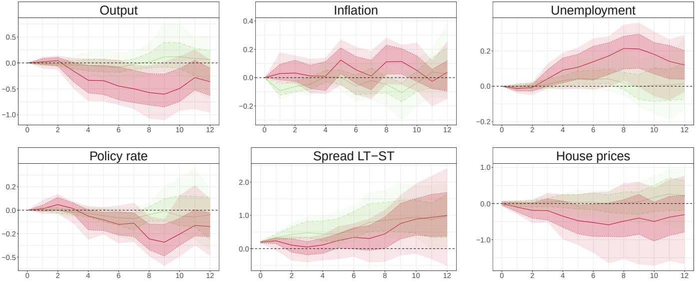

Figure: Impulse responses of our endogenous variables to a spread shock.
Note. The responses of output growth, inflation and house prices are cumulated, while the responses for the interest rates, spread and unemployment rates are in levels. The red (green) lines are the impulses when leverage is high (low). Shaded areas represent the 67% and 90% confidence intervals.

Application to the Euro Area

- Application on a fictional Stress test: we estimate the relation between the EBA macroeconomic scenarios and the EBA Stress test results:

$$\Delta CET1\_ratio_t = -0.87 + 0.45 \Delta GDP_t. \quad (4)$$

- We use the Cyclical Amplifier to generate multiple scenarios with the same set of shocks, but with different risk levels

- We use our Stress test equation to obtain banks' losses for each risk level

- Once we define a refrence risk, we calibrate the structural and the cyclical buffers

Results: the scenarios

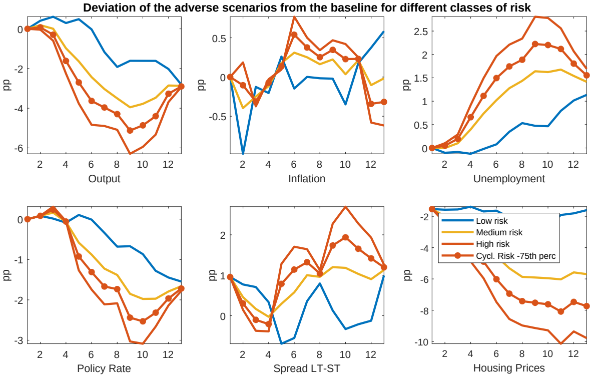

Figure: Deviation of the adverse scenarios from the baseline scenario. Note. The deviation between central and adverse scenario corresponds to the sum of the impulse responses of the macroeconomic variables to the set of housing shock (-4 standard deviation), spread shock (4 standard deviation shock). Impulse responses are obtained for the low risk scenario (blue), medium risk scenario (yellow) and high risk (red) for the three years of projections. Variables are reported in percentage points.

Results: Capital buffers for each level of risk

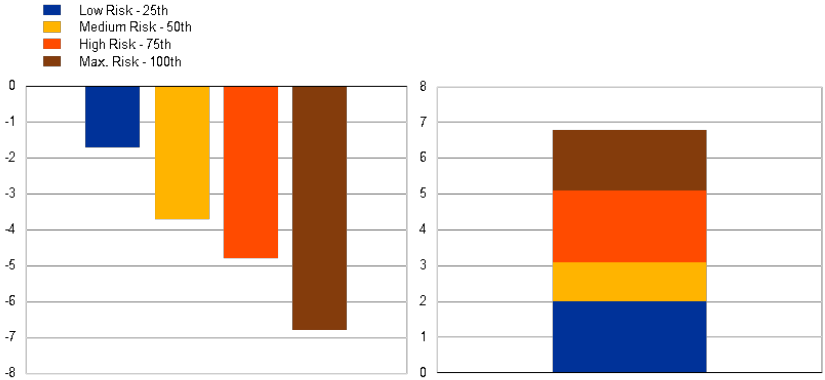

Figure: CET1 and Buffers. Note. Aggregate CET1 ratios variation for three years of the projection are reported on the left hand side in % ratios. The buffer corresponding to each losses are reported on the right hand side. These buffers are the reference to set structural and cyclical buffer.

Conclusion

- We provide a criterion to jointly calibrate cyclical and structural buffers
- Integration of Stress tests and a non-linear model, the Cyclical Amplifier, to obtain risk-related scenarios, the risk of the overlap is diminished
- We can use this framework also to study how borrower's based measures (e.g. DSTI) and capital measures interact
- The Cyclical Amplifier can also complement the Growth at Risk type of analysis.

GaR

Appendix: The Growth at Risk

- The Growth at Risk (Adrian et al. [2019], Prasad et al. [2019]) is an alternative method to assess cyclical risk
- A set of quantile regressions model the link between output growth and economic and financial variables, generating a density forecast for GDP growth
- Adverse economic scenario can be targeted to the output growth forecast for some exogenous low threshold of the distribution (e.g. 5%)
- To complete the scenario, a multivariate auxiliary macroeconomic model is used to generate the path for macroeconomic and financial variables, matching the target output loss defined by the GaR.

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Appendix: Differences between the Growth at Risk and the Cyclical Amplifier

- Narrative:
  - GaR: agnostic approach on risk
  - Cyc. Amp.: scenarios severity is narrative dependent
- Structure:
  - GaR: Univariate- the main non-linearity is detected for output growth
  - Cyc. Amp.: Multivariate - different possible non-linearity depending on the combination variable/shock
- The state effect in GaR is related to the position of the economy in the business cycle, rather than on the evolution of cyclical risks (i.e. financial cycle)

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Appendix: P2G and Stress test

- From the Newsletter article of ECB 16/11/16: EBA Stress tests are used to calibrate P2G: "*P2G is not determined mechanistically; it relies on a wide range of information. One important factor is the quantitative outcome of supervisory stress tests, in particular: the fall in the Common Equity Tier 1 (CET1) ratio that a bank experiences over the stress test period in the adverse scenario.* "
- From Stress test 2018 FAQ: "*The qualitative outcome of the stress test will be included in the determination of the Pillar 2 requirement (P2R), especially in the risk governance element of the SREP. The quantitative results, namely the depletion of capital in the hypothetical adverse scenario, serve as a starting point for determining the level of Pillar 2 guidance (P2G). In defining P2G, the ECB will use a wide range of information. [...]*

Appendix: Capital buffer and Stress test in UK

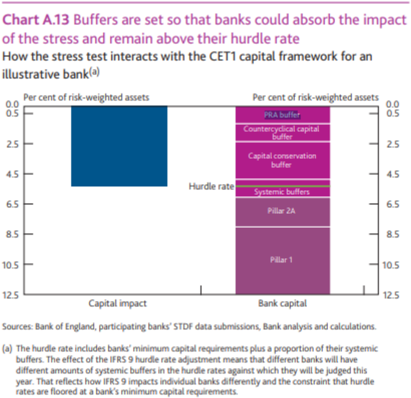

Figure: UK Integrated approach. Note. Buffers jointly calibrated based on the Stress test results. PRA buffer-Pillar 2 Buffer- absorbe losses avoiding the overlapping with CCyB. from "Statement of Policy, The PRA's methodologies for setting Pillar 2 capital December 2020"

Appendix: Capital buffer and Stress test in US

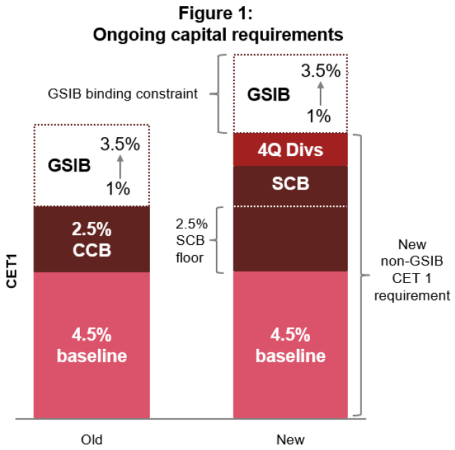

Figure: US Integrated approach. Note: Stressed Capital Buffer approved in March 2020. The SCB will replace the CCB and will have a lower bound equal to 2.5. The difference between SCB and its lower bound plays the role of P2 buffer.

Impulse Response Functions

- Sign restrictions (Canova and De Nicolo [2002], Rubio-Ramirez et al. [2010], Uhlig [2005]) to identify structural shocks for IRF
- Restrictions only on impact (Canova and Paustian [2011])
- Impact matrix is computed from the variance covariance matrix Ω_1 of residuals at $h = 1$
- For each projection horizon $h = 1, ..., H$, the IRF is:

$$IRF_{h,t} = E_t(Y_{t+h}|Y_t + \epsilon_t) - E_t(Y_{t+h}|Y_t) = F(z)(\beta_h^D \epsilon_t) + (1 - F(z))(\beta_h^U \epsilon_t) \quad (5)$$

- Compare IRF at low $(F(z_t) = 0.15)$ and high $(F(z_t) = 0.85)$ states

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Structural shocks for impulse response functions

- Sign restrictions (Canova and De Nicolo [2002], Rubio-Ramirez et al. [2010], Uhlig [2005]) to identify structural shocks for IRF
- Γ pinned down as the eigendecomposition of the covariance matrix of residuals at $h = 1$, so that $\Gamma\Gamma' = \Omega_1$
- The matrix of reduced-form error $U = (u_1, ..., u_N)$ can be written as a linear combination of structural shocks $\xi = (\epsilon_1, ..., \epsilon_N)$:

$$U = \Gamma\xi \tag{6}$$

- ξ is drawn so that (i) it is orthogonal and (ii) each column $\Gamma\epsilon_p$ of the impact matrix Γ satisfies some sign restrictions derived from economic theory
- Restrictions only on impact (Canova and Paustian [2011])

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Algorithm for sign restrictions

From Rubio-Ramirez et al. [2010]

1. Recover the variance covariance matrix of the reduced form error $\hat{\Omega} = \hat{u}\hat{u}'$ from equation 1
2. Compute the eigendecomposition of the covariance matrix Ω so that $\Gamma D \Gamma' = \hat{\Omega}$
3. Draw a matrix $W \sim MN(0, I_{N^2})$ and take the (orthogonal) Q of its QR decomposition
4. Check whether the impulse ΓQ verifies the sign conditions
5. If not repeat 3-4, otherwise store the accepted impulse response
6. Among the acceptable drawns, select the impulse matrix which produces the IRF closest to the median IRF, across horizons and endoenous variabls (Fry and Pagan [2011]).

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An example

- Let us assume that we have a multivariate model with two simple variables y_t and π_t

$$\begin{bmatrix} y_{t+1} \\ \pi_{t+1} \end{bmatrix} = \begin{bmatrix} \beta^1_{11} & \beta^1_{12} \\ \beta^1_{21} & \beta^1_{22} \end{bmatrix} \begin{bmatrix} y_t \\ \pi_t \end{bmatrix} + \dots + \begin{bmatrix} u_{1,t} \\ u_{2,t} \end{bmatrix}$$

- After structural identification:

$$\begin{bmatrix} y_{t+1} \\ \pi_{t+1} \end{bmatrix} = \begin{bmatrix} \beta^1_{11} & \beta^1_{12} \\ \beta^1_{21} & \beta^1_{22} \end{bmatrix} \begin{bmatrix} y_t \\ \pi_t \end{bmatrix} + \dots + \begin{bmatrix} \xi^1_{11} & \xi^1_{12} \\ \xi^1_{21} & \xi^1_{22} \end{bmatrix} \begin{bmatrix} \epsilon_{1,t} \\ \epsilon_{2,t} \end{bmatrix}$$

- For example, the structural Shock 1 is going to have an impact of $\xi^1_{11}\epsilon_{1,t}$ on y_t and $\xi^1_{21}\epsilon_{1,t}$ on π_t

- The impact on these variables is then projected on the first horizon through the β^1_{ij} coefficients:

$$y_{t+1} = \beta^1_{11}\xi_{11}\epsilon_{1,t} + \beta^1_{12}\xi_{21}\epsilon_{1,t}$$

$$\pi_{t+1} = \beta^1_{21}\xi_{11}\epsilon_{1,t} + \beta^1_{22}\xi_{21}\epsilon_{1,t}$$

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