Macrofinancial Feedback, Bank Stress Testing and Capital Surcharges

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Overview

1. Develop a framework to assess vulnerabilities across the business and financial cycles, and calibrate a countercyclical capital buffer (CCyB) in the context of bank stress tests

2. Use a parsimonious model that quantifies the causal impact of bank capital shocks on financial conditions and downside risks to GDP growth:
   - Estimate the **macrofinancial feedback**: banks' amplification of shocks to the economy
   - Calibrate a **bank capital surcharge**: additional bank capital that offsets the macrofinancial feedback

3. Use a **Growth-at-Risk** based metric as a measure of financial stability risks, and calibrate the CCyB as the extra capital needed to offset the macrofinancial feedback across the business cycle

Outline

1. Related Literature
2. Data and Empirical model
   - Recursive Quantile Regression
   - Endogeneity and Granular Instruments (GIV)
3. Results
   - Replication of CCAR results
   - Macrofinancial feedback
   - Growth at Risk Gap as vulnerabilities metric
   - Implications for setting CCyB
4. Policy implication
5. Concluding remarks

Related literature

- **Effects of financial conditions on downside risks to GDP growth using quantile regressions**: Adrian, Boyarchenko, and Giannone 2019, Prasad et al. 2019, Adrian et al. 2018, Jorda, Schularick and Taylor 2013, and Chavleishvili et al. 2020

- **Lending implications of stress tests**: on jumbo-mortgage loans (Calem, Correa and Lee 2020), consumer loans (Agarwal et al. Roman 2020), commercial and industrial loans (Acharya, Berger, and Roman 2018, Berrospide and Edge 2019), and small business loans (Cortes et al. 2020)

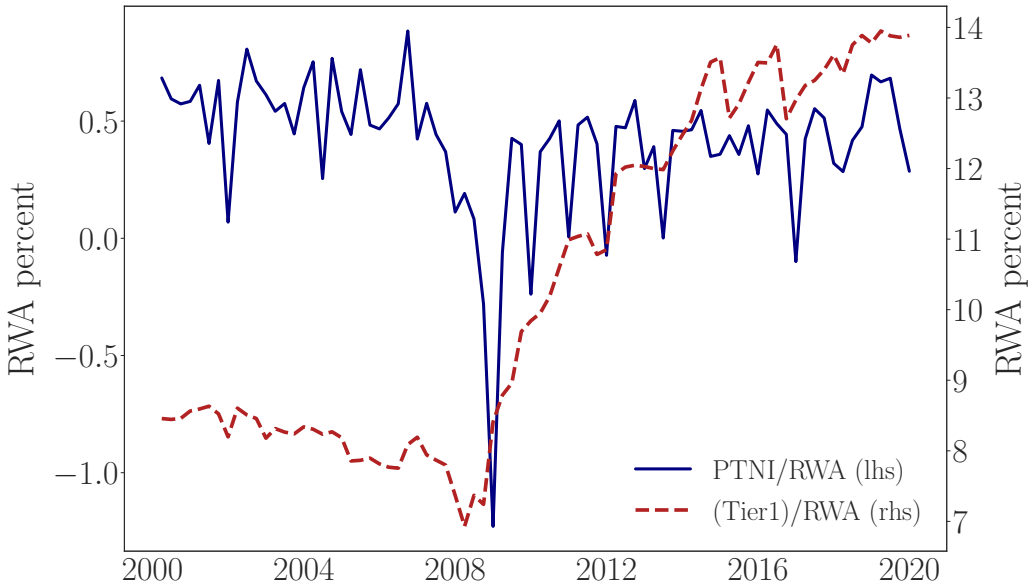
- **Effectiveness of stress tests**: Flannery, Hirtle and Kovner 2017, and Fernandez, Igan, and Pinheiro 2020

Data and Empirical Model

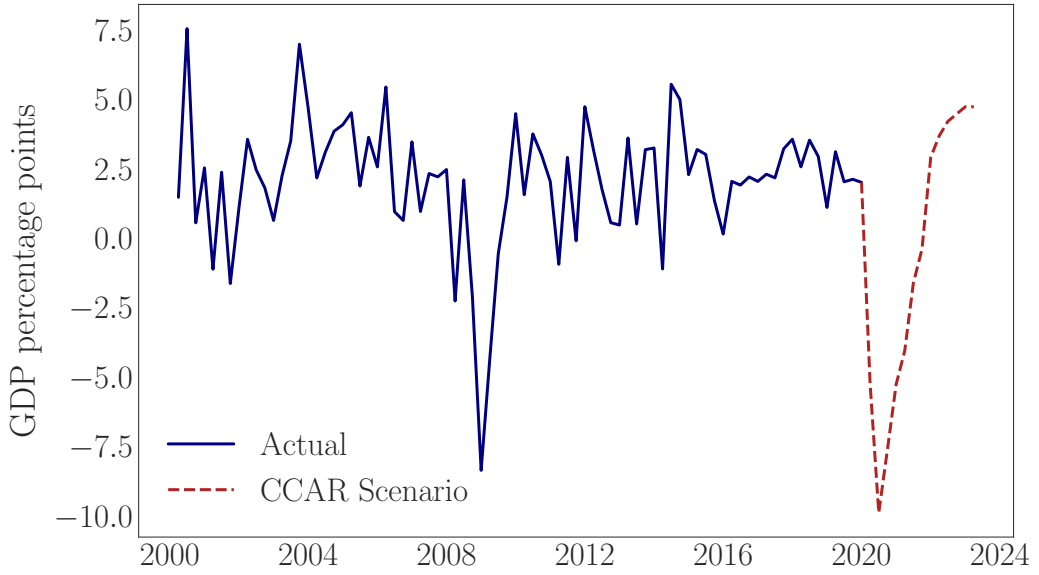
- Contemporaneous and lagged interactions of GDP growth, changes in bank capital (Δc), and a Financial Condition Index:
  - FCI uses financial variables in 2020 CCAR scenario, estimated via partial least squares (or principal components)
  - Δc is Pre-Tax Net Income (PTNI/RWA) for CCAR banks, excluding capital distributions and regulatory items
- Consistent with typical stress testing frameworks, we use:
  - $PTNI = PPNR - Net\ Losses$
  - Evolution of bank capital ratio (as % RWA) follows:

$$Ratio_{i,t} = Ratio_{i,t-1} + PTNI_{i,t} - Tax_{i,t} - Cap.\ Distribution_{i,t}$$

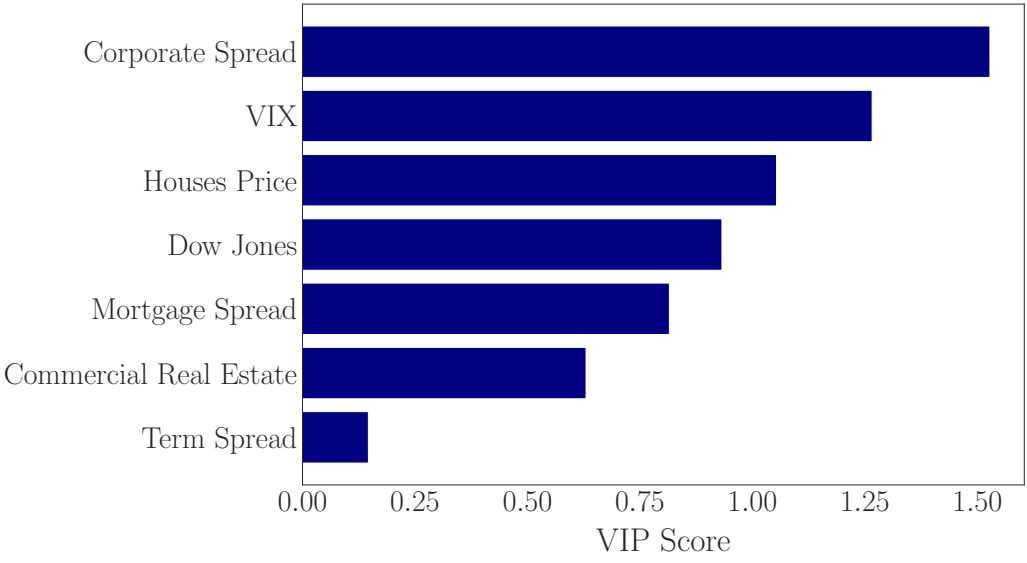
US banks' average PTNI/RWA and Tier1 Capital/RWA



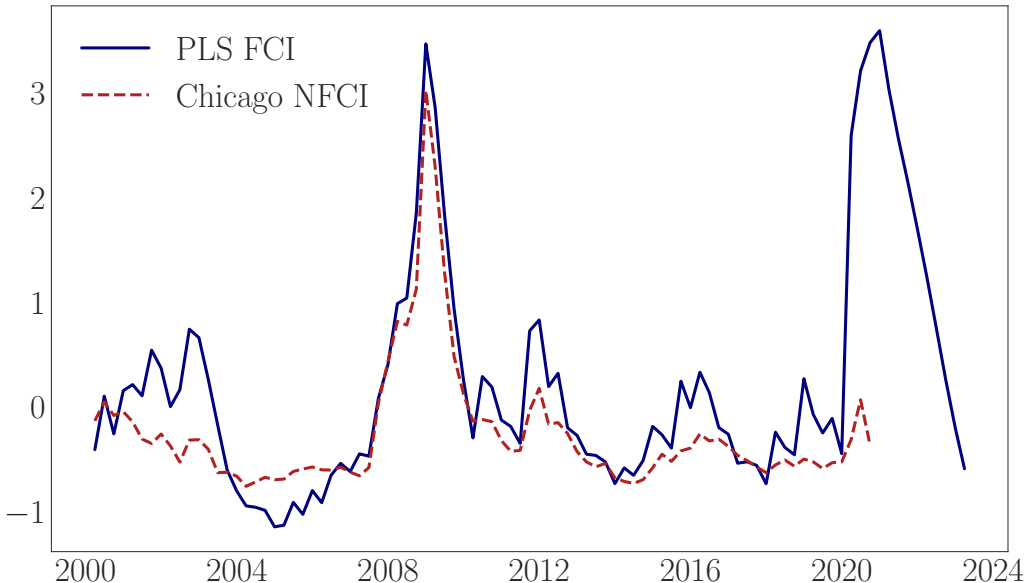
GDP: Historical vs CCAR assumptions



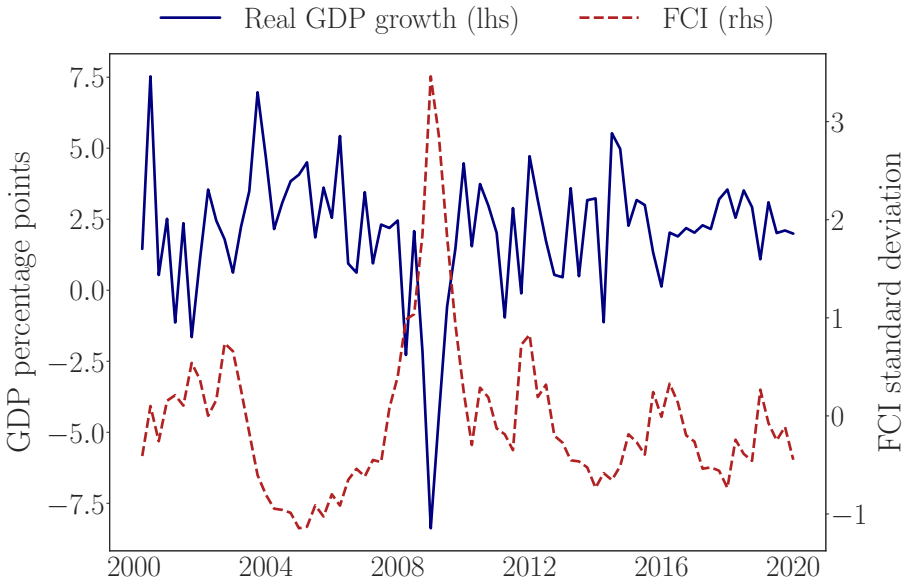
FCI loadings



PLS FCI and Chicago Fed FCI



Real GDP growth and FCI



Main Features of the Empirical Model

- **Parsimonious and dynamic** model estimated on US quarterly data 2000 Q1-2019 Q4
- Framework incorporates nonlinearities in a dynamic set-up:
  - **Causal identification** through granular instruments (Gabaix and Koijen 2020)
  - Based on **quantile regressions** with sign restrictions
  - **Minimum data requirements**: macro and standard supervisory data (GDP, FCI, PTNI, Tier 1 capital, RWA)

Data Generating Process

- Ideally, we want to estimate the joint distribution

$$F(\mathbf{Y_{t+1}}, \mathbf{\Delta C_{t+1}}, \mathbf{FCI_{t+1}}, \mathbf{C_{t+1}} \mid \ Y_t, FCI_t, \Delta C_t, C_t)$$

- Tractable solution: break down the contemporaneous relationship among variables to simplify the problem into estimating **univariate conditional distributions**

$$\begin{aligned} F(\mathbf{Y_{t+1}} \mid & \quad Y_t, FCI_t, \Delta C_t, C_t) \\ F(\mathbf{\Delta C_{t+1}} \mid & \quad \mathbf{Y_{t+1}}, Y_t, FCI_t, \Delta C_t, C_t) \\ F(\mathbf{FCI_{t+1}} \mid & \ \mathbf{Y_{t+1}}, \mathbf{\Delta C_{t+1}}, Y_t, FCI_t, \Delta C_t, C_t) \end{aligned}$$

- The conditional densities are estimated using quantile regressions and quantile sampling (via quantile spacing), following Schmidt and Zhu (2016)

Variables Ordering via Granger Causality Tests

	GDP	FCI	Delta Capital
GDP		0.000	0.000
FCI	0.539		0.324
Delta Capital	0.057	0.010	

Table: Two-by-two P-values of the Granger Test of the system variables
H_0: the variable in index does not Granger-cause the variable in column

- GDP is the most exogeneous variable: can not reject Granger-caused by the two other
- FCI is the most endogenous: can reject that is is not Granger-caused by the two other
- Can not reject that Δ Capital is Granger-caused by GDP but can reject that it is Granger-caused by FCI

Recursive Quantile Regression Model with Contemporaneous Effects

$$y_{t+1} = \underbrace{\beta^q_{y,y} y_t + \beta^q_{\Delta,y} \Delta c_t + \beta^q_{f,y} fci_t + \beta^q_{c,y} c_t}_{\Omega_t} + \epsilon^q_y$$

$$\Delta c_{t+1} = \beta^q_{y1,\Delta} y_{t+1} + \underbrace{\beta^q_{y,\Delta} y_t + \beta^q_{\Delta,\Delta} \Delta c_t + \beta^q_{f,\Delta} fci_t + \beta^q_{c,\Delta} c_t}_{\Omega_t} + \epsilon^q_\Delta$$

$$fci_{t+1} = \beta^q_{y1,f} y_{t+1} + \beta^q_{\Delta 1,f} \Delta c_{t+1} + \beta^q_{c,f} c_{t+1} + \beta_{\Omega,f} \Omega_t \; + \; \epsilon^q_f$$

$$\tilde{c}_{t+1} = \tilde{c}_t + \Delta c_{t+1} \quad \text{(Stochastic law of motion)}$$

- y_t : US Real GDP growth; fci_t: US Financial conditions
- Δc_t: PTNI/RWA; c_t: Tier 1 Capital/RWA
- $\tilde{c}_t$: Counterfactual Tier 1 Capital/RWA only changing with the law of motion

Endogeneity

- Endogeneity between financial conditions and regulatory capital
- $\Delta c_{t+1} = \beta^q_{y1,\Delta} y_{t+1} + \beta^q_{y,\Delta} y_t + \beta^q_{\Delta,\Delta} \Delta c_t + \beta^q_{f,\Delta} fci_t \; + \; \epsilon^q_\Delta$
- $fci_{t+1} = \beta^q_{y1,f} y_{t+1} + \beta^q_{f,\Delta} \Delta c_{t+1} + \beta^q_{f,c} c_{t+1} + \Omega_t \; + \; \epsilon^q_f$
- Instrumentation via granular instruments (Gabaix and Koijen 2020)
  - Instrument average Δ capital and capital with **bank's granular PTNI/RWA and Tier1 Capital/RWA** data respectively
  - Instrument FCI with **bank's granular EDF** (expected default frequency), **granular CAPM costs** (banks' funding costs) and **US monetary policy shocks** from Cieslak and Schrimpf (JIE 2019)

Granular Instruments (Gabaix and Koijen 2020)

1. **Panel regression** with time and fixed effects at the granular level: $c_{i,t} = \alpha_i + \lambda_t + \epsilon_{i,t}$

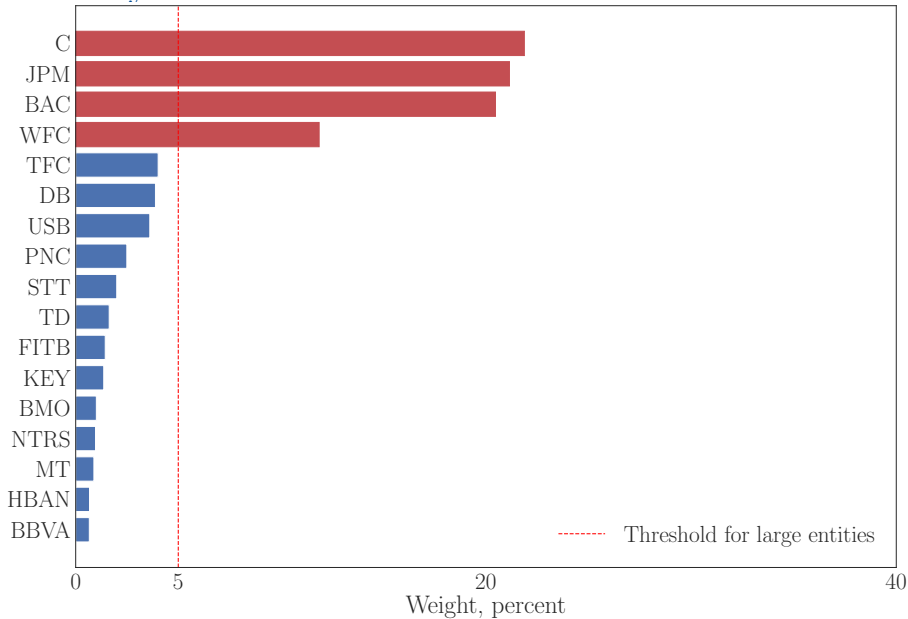
2. **Principal component analysis** with K components on the panel residuals: $\epsilon_{i,t} = \sum_{k \in K} \Lambda_k + \nu_{i,t}$

3. The granular instrument is the **average of largest banks' idiosyncratic shocks** $\nu_{i,t}$: $I_t = \sum_{l \in L} w_{l,t} \nu_{l,t}$ where $w_{l,t}$ is the share of bank l assets into the banking system total assets

- The cross-sectional and time orthogonalization of shocks via panel and PCA → **exclusion restriction** with ϵ^q

- The averaging of the largest idiosyncratic shocks → **relevance condition**: the idiosyncratic shocks of largest banks are likely to impact the endogeneous variable.

Market Share by Banks and Selection Threshold



Macrofinancial Feedback Loop

- The direct effect is defined as the real or financial impact from GDP or from FCI to the banks (standard stress-tests)
- The feedback loop represents the second-round impact of **shocked banks' capital** on the economy and the financial sector (deleveraging, increase in risk premium, etc.)
- In other words, how banks are amplifying the economic/financial crisis at different points of the distribution of GDP and FCI?
- We estimate a **counterfactual distribution** for GDP, FCI and banks' capital, where the feedback loop is neutralized, using a restricted version of our dynamic density model

Restricted Model

We consider the model where we shut down the impact of capital on GDP and FCI:

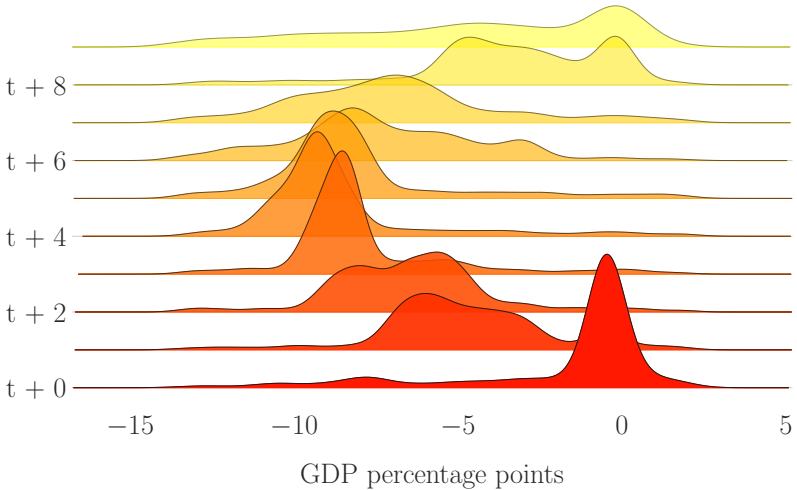
$$y_{t+1} = \beta^q_{y,y} y_t + \beta^q_{\Delta c,y} \overline{\Delta c}_{t0} + \beta^q_{c,y} \overline{c}_{t0} + \beta^q_{f,y} fci_t \ + \ \epsilon^q_y$$

$$\Delta c_{t+1} = \beta^q_{y1,\Delta} y_{t+1} + \beta^q_{y,\Delta} y_t + \beta^q_{\Delta,\Delta} \Delta c_t + \beta^q_{c,\Delta} c_t + \beta^q_{f,\Delta} fci_t \ + \ \epsilon^q_\Delta$$

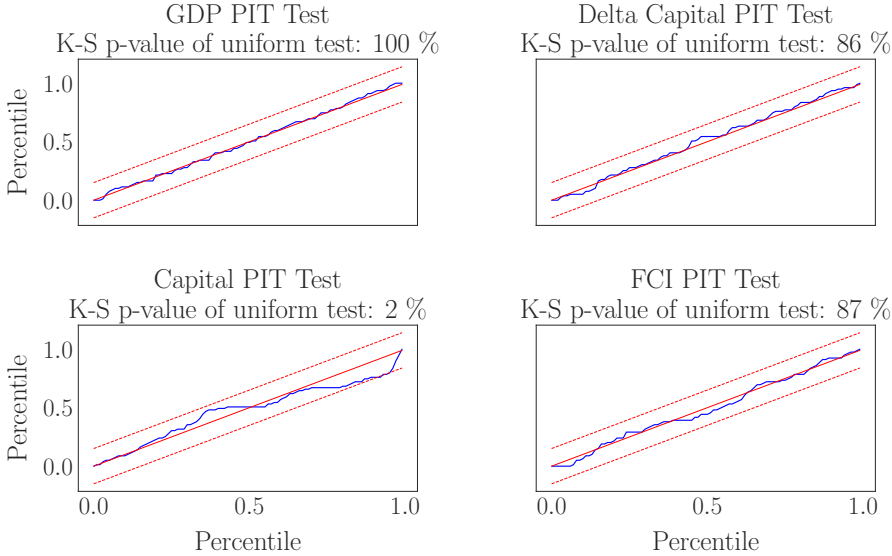
$$fci_{t+1} = \beta^q_{y1,f} y_{t+1} + \beta^q_{\Delta c,f} \overline{\Delta c}_{t0} + \beta^q_{c,f} \overline{c}_{t0} + \beta^q_{y,f} y_t + \beta^q_{f,f} fci_t \ + \ \epsilon^q_f$$

- To avoid inducing intercept-driven shocks, we keep both banks' capital/RWA and PTNI/RWA constant at their initial level
- The macrofinancial feedback is therefore shutdown in the restricted model

Multi-Modality and Skewness



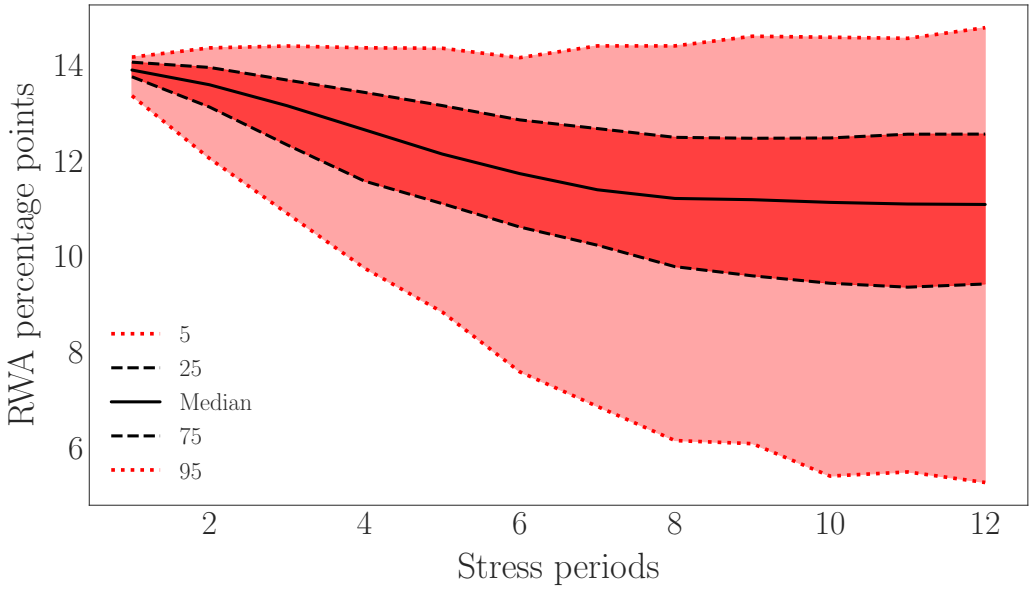
Probability Integral Transform Tests



Our Empirical Model and CCAR Results

- Our simple framework replicates the aggregate path of bank capital (Tier 1 Capital/RWA) over a 3-year horizon under the CCAR severely adverse scenario
- About 3 p.p. of median decline in capital ratio from start to minimum, **close to the 2.7 p.p. decline in CCAR** on average, between 2013 and 2020 (excluding the global market shock)

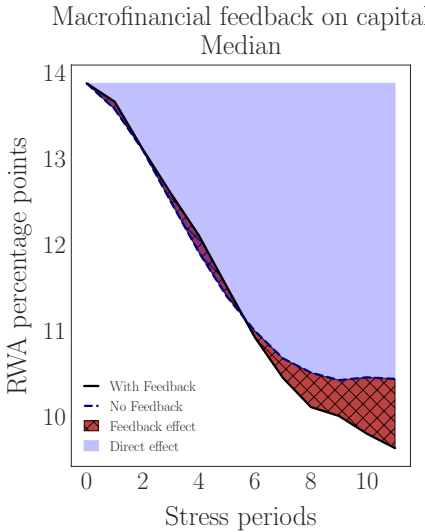
Capital Fan Chart under CCAR: Median Peak to Trough around 3 p.p.

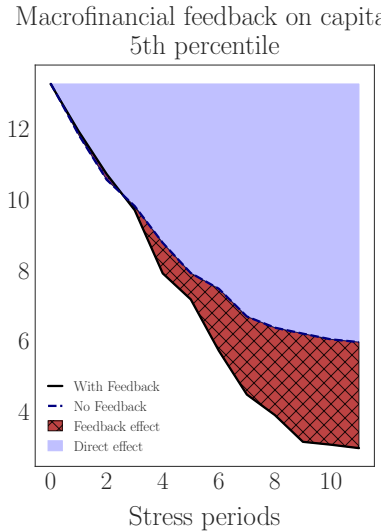


Macrofinancial Feedback and Capital Surcharge

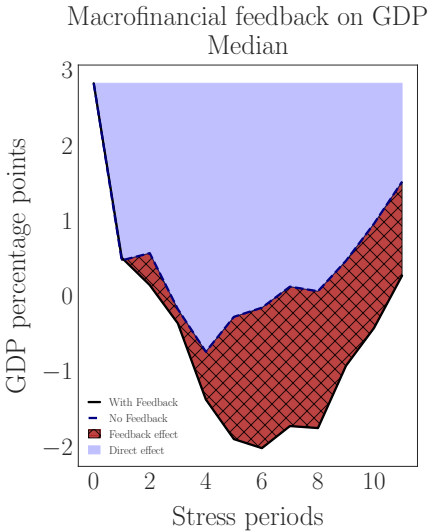
- Macrofinancial feedback: difference in projected GDP growth and FCI between unrestricted and restricted models
  - In the context of stress testing with CCAR shocks, it reflects how banks amplify a crisis (drop in GDP and tight financial conditions)
- It also impacts banks' own level of capital, through the lower GDP generated from their own feedback
- Causality captured via Granular Instrumental Variables
- Capital surcharge is defined as the additional capital needed to offset banks' macrofinancial feedback:
  - In 2019, **A capital surcharge of 1.5 p.p. for the median (3.4 p.p. for the 5th percentile)** will be needed to offset a macrofinancial feedback impact on GDP of around 2 p.p. for the median (7.5 p.p. at 5%)

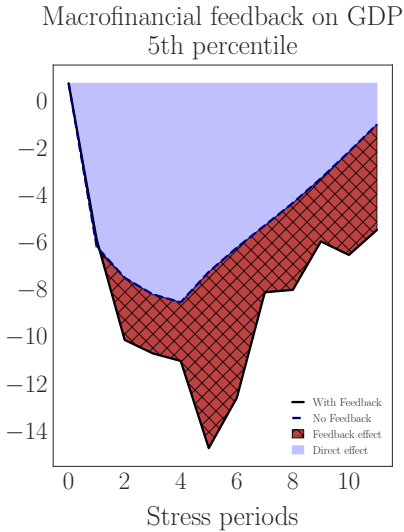
Feedback Loop on Capital Path from 2019 Q4





Feedback Loop on GDP Path from 2019 Q4



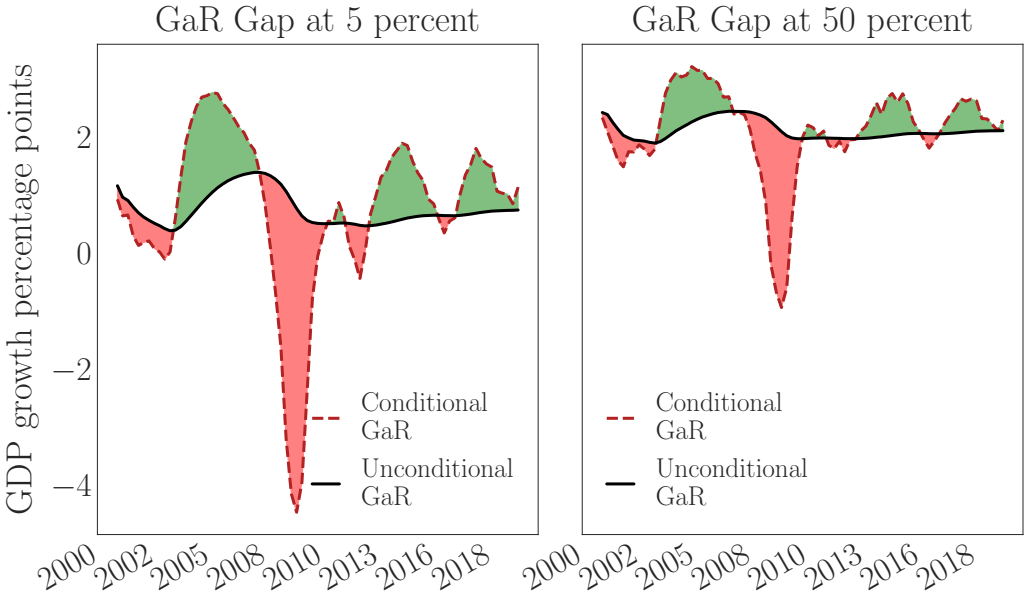


Growth-at-Risk Gap as Vulnerabilities Metric

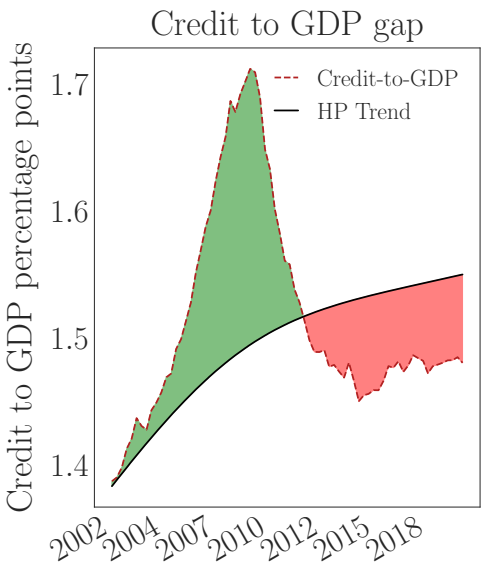
- Growth-at-Risk is derived from our parsimonious model
- GaR estimates downside risks to GDP:
  - It is a forward-looking, time-varying metric that depends on the state of the economy (conditional distribution)
  - Natural anchor: unconditional Growth at Risk, updated with historic sample and incorporating structural changes
- Difference between conditional and unconditional GaR: **cyclical versus structural vulnerabilities**.
- To mitigate parametric noise at finite distance, we approximate the unconditional distribution by the quantile projection at sample mean on expanding sample

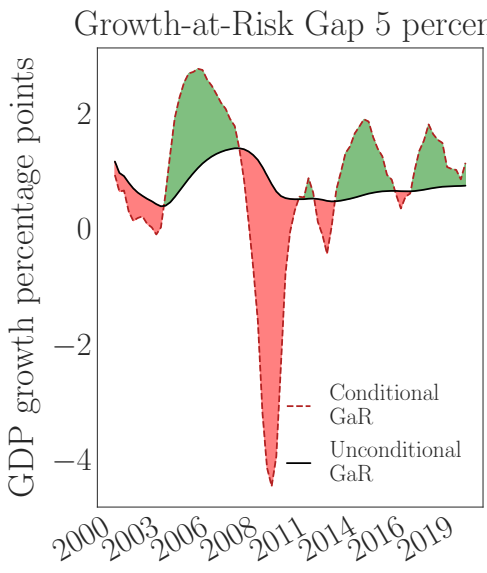
$$\text{Gap}(\tau) \;=\; Q(y_{t+1}|y_t, fci_t, \Delta c_t, \tau) - Q(y_{t+1}|\overline{y_t}^m, \overline{fci_t}^m, \overline{\Delta c_t}^m, \tau)$$

Counter-cyclical Growth-at-Risk Gap Metric



Credit to GDP Gap vs. Growth-at-Risk Gap Metric





Growth-at-Risk Gap vs Credit-to-GDP gap

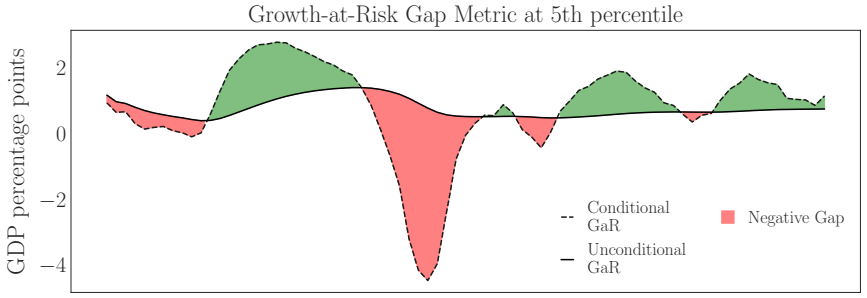
- Our GaR Gap measure improves upon alternative measures of financial vulnerabilities, such as the Credit-to-GDP Gap:
  - Credit-to-GDP gap measures one potential source of vulnerabilities (e.g., excessive credit relative to GDP), whereas the **GaR Gap summarizes different vulnerabilities into one consistent metric**
  - Credit-to-GDP gap reacts slowly to the cycle: empirical evidence suggests it is a poor counter-cyclical indicator
  - Credit-to-GDP gap is not risk-based, does not capture amplification in the tails
  - HP filter suffers from many statistical shortcomings (end-point problem, choice of lambda, over-persistent trend, etc.), which makes it difficult for policy use

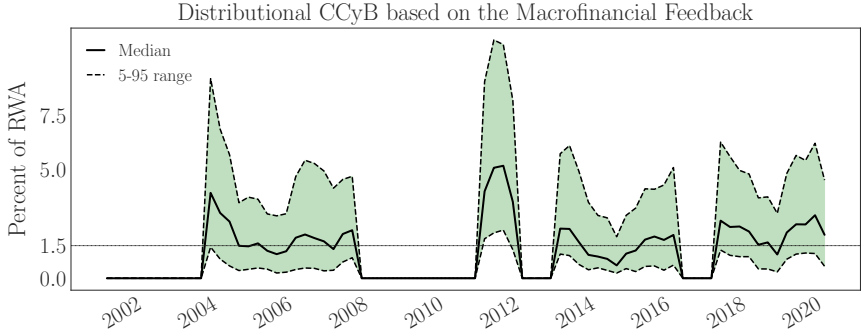
From Macrofinancial Vulnerabilities to the CCyB

- Conceptually, vulnerabilities include the macrofinancial feedback (banks' amplification of shocks), recursively estimated with instrumented quantile regressions:
  - Macrofinancial feedback is larger in the tails
- This provides a **counter-cyclical, state-dependent and risk-based capital surcharge**
- The capital surcharge is defined as the additional bank capital needed to offset the macrofinancial feedback across the business cycle, at a given risk level

Definition and Policy Uses of the Risk-Based CCyB

- Capital needed to offset the macrofinancial feedback
- It depends on the state of the economy, as well as the level of capital of the banking sector
- It is only actived when the GaR Gap is positive
- It does not offset all vulnerabilities, only the amplified effect from banks.
- **Menu of policy options**: the CCyB depends on the **risk-preference of policymakers**:
  - How much risk the policymaker would like to hedge against will determine how much extra capital is needed
  - Very strong non-linear relationship: needs much more capital to hedge the left tail than to hedge the median


Growth-at-Risk Gap Metric at 5th percentile
GDP percentage points
2
0
−2
−4
Conditional GaR
Unconditional GaR
Negative Gap


Distributional CCyB based on the Macrofinancial Feedback
Percent of RWA
Median
5-95 range
7.5
5.0
1.5
0.0
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020

Main Takeaways

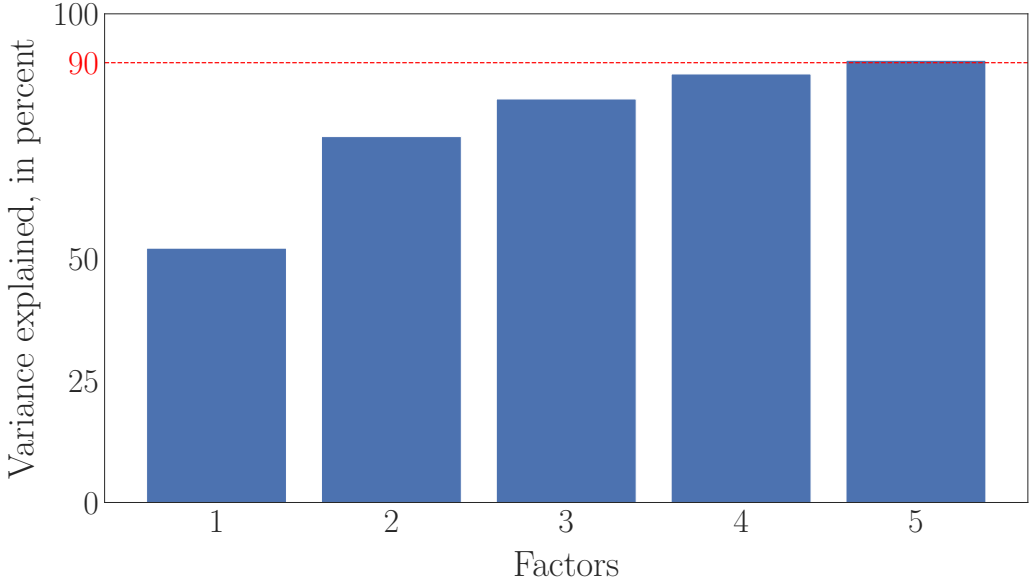
- We propose a parsimonious, stylized 3-variable macrofinancial model with **rich policy implications and realistic results**
- Using the 2020 CCAR scenario, our proposed vulnerabilities metric (GaR Gap) informs the setting of a countercyclical capital buffer that offsets the macrofinancial feedback through the business cycle:
  - Capital surcharge on the median in the **pre-GFC should have been on average at 1.9 p.p.** (near the upper bound of Basel III CCyB), and 4.6 p.p. for the 5th percentile
  - Capital surcharge on the median in the **post-crisis should be between 1.4 p.p. and 3.2 p.p. (around 2.1 p.p. on average)**, and about 5.1 p.p. on average for the 5th percentile

Expanding the Current Stress Testing Framework

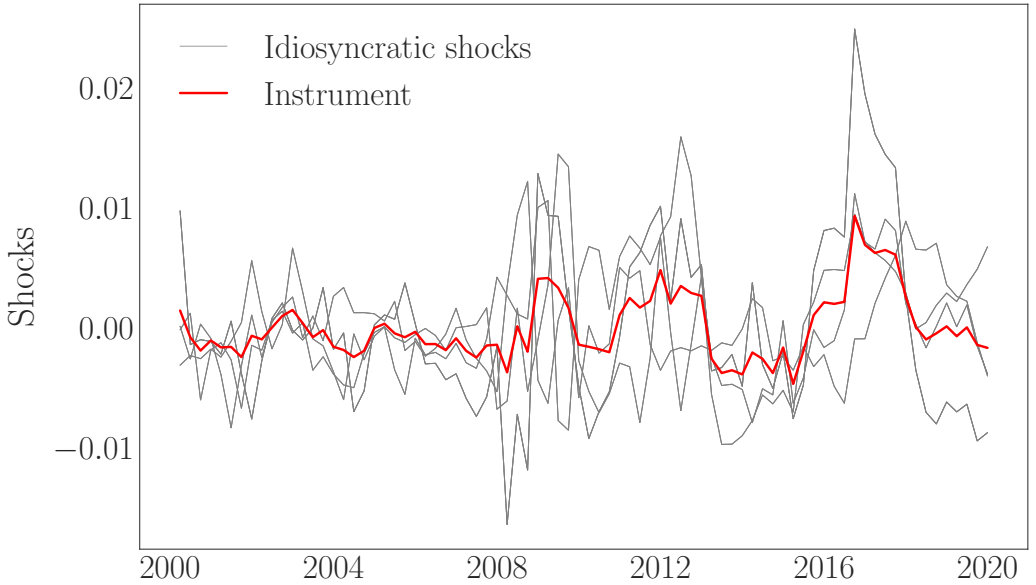
- Traditional stress tests overlook macrofinancial feedback effects
- Our methodology can easily augment the current stress testing machinery to include the calculation of the **macrofinancial feedback** and **the capital surcharge**:
  - Quick implementation using simple auxiliary equations relative to models currently estimated
- Our framework provides simple guidelines that use stress tests to inform the setting of the **countercyclical capital buffer**
- It is applicable to any stress testing approach (e.g., macro scenarios of different severity, different planning horizons) and thus can be easily adopted by supervisors

Appendix Slides

Variance explained by the PCA factors



Δ Capital idiosyncratic shocks and weighted average



Quantile Regressions and Signs Restrictions

- Estimation of the recursive system line by line, via quantile regressions
- 2-steps approach for the instrumented variable (estimated the fitted values via OLS)
- To make sure that the system is stable, impose inequality constraints on the quantile coefficients, for all quantiles:
  - Impact of GDP on Δ capital is positive: when GDP goes down, banks' losses increase and capital goes down
  - Impact of financial conditions on capital is negative: when FCI tighten, banks' have more difficulties to raise capital
  - Impact of capital on financial conditions is negative: lower average banks' capital tighten financial conditions
- Note that most of the inequality constraints are true in the unconstrained model

Density Path Scenario from Supervisory Stress Tests