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Calibrating the Magnitude of the CCyB using Market-Based Stress Tests

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Introduction

This paper

- Is the range of 0 to 250 bps sufficient for the CCyB to be effective?

- Novel method to calibrate the magnitude of the cap on the CCyB using reversed market-based stress tests.

- Two-fold contribution:
  1. Enhancements to market-based stress tests
     - Estimate the **point-in-time prudent level of capital**
     - Explicit link with risk tolerance of the macroprudential authority
     - Facilitates constructing a time series
  2. Estimate range for the CCyB
     - Depends on historical relationships between indicators of macrofinancial conditions and the amount of capital above the prudent level.

Introduction

- **Main objective of the counter-cyclical capital buffer (CCyB):**
  - "[T]he aim is to ensure that the banking sector in aggregate has the capital on hand to help maintain the flow of credit in the economy without its solvency being questioned, when the broader financial system experiences stress after a period of excess credit growth." (BCBS, 2010)

- **Magnitude of the CCyB:**
  - International members of the BCBS have agreed to a level of the CCyB of up to 250 bps of RWAs.
  - Somewhat arbitrary cap of 250 bps of RWAs has been a point of debate.
  - Some jurisdictions indicate that they may set the CCyB at a higher level, if necessary (BCBS, 2018).
  - Mandatory international reciprocity is limited to 250 bps of RWAs.

Introduction

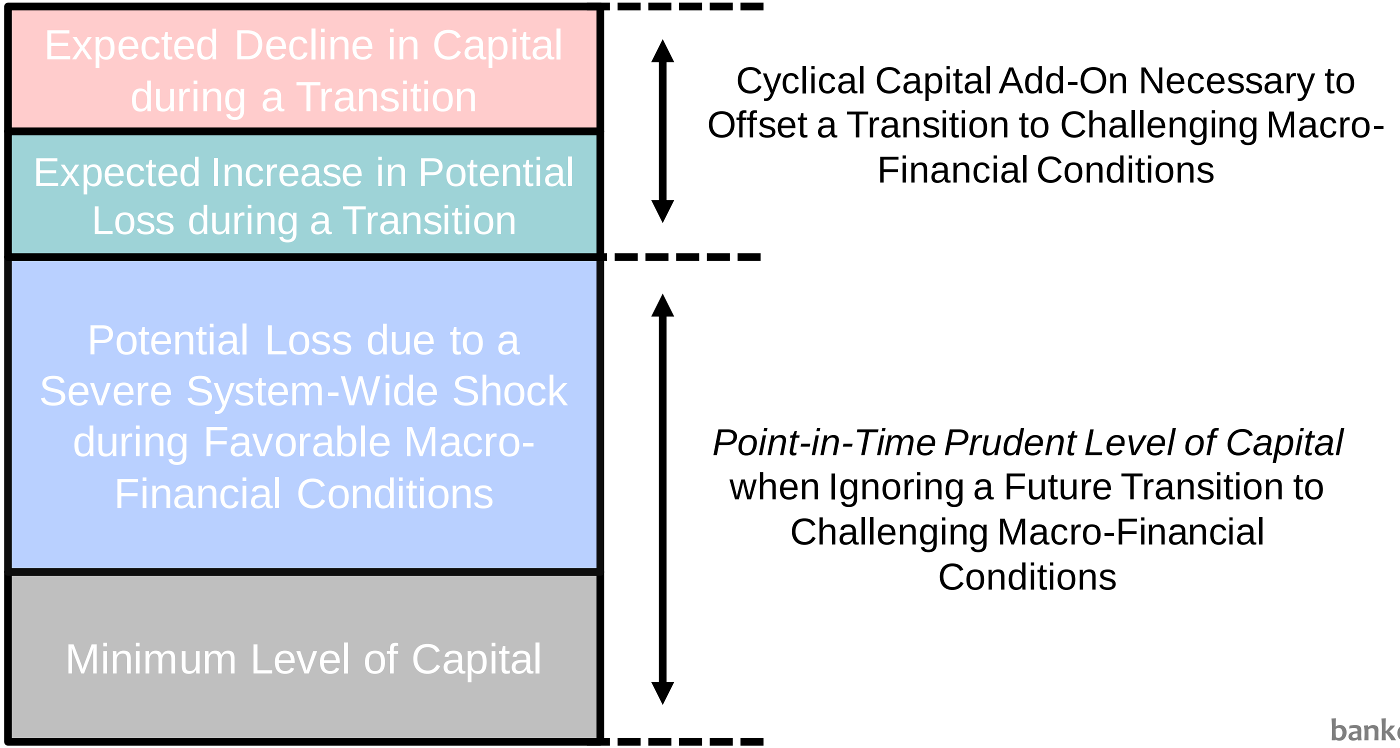
Broadly speaking, there are four tools that help to calibrate the CCyB:

1. Early Warning Models of Banking Crisis
   - Behn et al. (2013), Anundsen et al. (2016), Tolo et al. (2018).
2. General Equilibrium with an Explicit Role for Bank Capital
   - Angelini et al. (2014), Clerc et al. (2015), Rubio and Carrasco-Gallego (2017).
3. Regulatory Stress Tests
   - Bennani et al. (2017), Anderson (2018).
4. Market-based Stress Tests
   - This presentation.

These tools are largely complementary.

Introduction

"…to help maintain the flow of credit in the economy without its solvency being questioned, when the broader financial system experiences stress after a period of excess credit growth"



Market-based stress tests

Idea in a nutshell

- Use return dynamics in stock markets to estimate the performance of an institution in a hypothetical system-wide stress scenario.

Caveats

- Market-prices can be noisy and there is estimation uncertainty.
- Market-prices may incorporate policy reactions.
- Regulatory stress tests can also incorporate confidential information.
- Market perceptions could be "wrong."

Benefits

- Even if the market is "wrong," their perceptions may still lead to funding and market liquidity issues.
- Market-based stress tests can be operated at an automatic basis at a low cost.
- Market data is easily-accessible and available in real-time.
- Forward looking view; incorporates the impact on future profits and losses.
- Can act as a soundness check for regulatory stress tests.

Market-based stress tests

- **Use return dynamics in stock markets to estimate the performance of an institution in a hypothetical system-wide stress scenario.**
  - Method of calculating expected "capital shortfalls" in terms of market capitalization ("SRISK") popularized by Acharya et al. (2012) and Brownlees and Engle (2017).
  - Acharya et al. (2014) use this methodology to reverse-engineer a "prudential level of capital" that is associated with a zero "capital shortfall" in expectation.

- **Two enhancements to derive *point-in-time prudent level of capital***
  - Explicitly account for the leverage effect in stock returns when calculating the prudential level of capital (volatility of stock returns is higher when capital ratios are low).
  - The prudent level of capital is defined as the level that contains the probability of breaching some minimum in the event of a severe system-wide shock within a certain permissible failure probability.
  - Approach results in a simple formula for the prudential level of capital that relies on a long-run version of the *exposure CoVaR* measure of Adrian and Brunnermeier (2016)

Point-in-time Prudent Level of Capital

- Consider a state of the world where the return of bank i with initial capital $k_{i,t}$ equals $R_{i,[t;t+h]}$

- What would be the *Capital Shortfall* (assuming a fixed $D_{i,t}$)?

$$\begin{aligned}\text{Capital Shortfall}_{i,t+130} &:= kA_{i,t+130} - MV_{i,t+130}, \\ &= kD_{i,t} + (k-1)MV_{i,t}\left(1 + R_{i,[t;t+h]}\right).\end{aligned}$$

- **Reverse**: At what level of the initial capital ratio $k_{i,t}^{A}$ would the capital shortfall be zero?

$$k_{i,t}^{A} = \frac{k}{1 - (1-k)\hat{R}_{i,[t;t+h]}\left(k_{i,t}^{A}\right)},$$

  - $\hat{R}_{i,[t;t+h]}\left(k_{i,t}^{A}\right)$ is the counterfactual return on equity if the capital ratio were $k_{i,t}^{A}$ instead of $k_{i,t}$.

- The hypothetical return is approximated (correction for the leverage effect*) as

$$\hat{R}_{i,[t;t+h]}\left(k_{i,t}^{A}\right) = R_{f,[t;t+h]} + \frac{k_{i,t}}{k_{i,t}^{A}}\left(R_{i,[t;t+h]} - R_{f,[t;t+h]}\right).$$

(*) Assuming the risk of bank assets is independent of financing structure and using the assumption of the fixed value of $D_{i,t}$.

Point-in-time Prudent Level of Capital

- The **point-in-time prudent capital ratio** $k^*_{i,t}$ that contains the probability of breaching some minimum k in the event of a severe system-wide shock that occurs with probability q within a certain permissible failure probability p is

$$k^*_{i,t} = \frac{k + (1-k)k_{i,t}\left(LRCoVaR^q_{i,t}(p) + R_{f,[t;t+h]}\right)}{1-(1-k)R_{f,[t;t+h]}}.$$

- The $LRCoVaR^q_{i,t}(p)$ reflects the concept of a “long-run exposure CoVaR”, which is implicitly defined as

$$\Pr\left[R_{i,[t;t+h]} < -LRCoVaR^q_{i,t}(p) | R_{s,[t;t+h]} < -LRVaR_{s,t}(q)\right] = p,$$

and where

$$\Pr\left[R_{s,[t;t+h]} < -LRVaR_{s,t}(q)\right] = q.$$

- The $LRCoVaR^q_{i,t}(p)$ can be estimated from the joint distribution of $\left(R_{i,[t;t+h]}, R_{s,[t;t+h]}\right)$, which is simulated after modeling $\left(R_{i,[t-1;t]}, R_{s,[t-1;t]}\right)$ with a GJR-GARCH DCC model.

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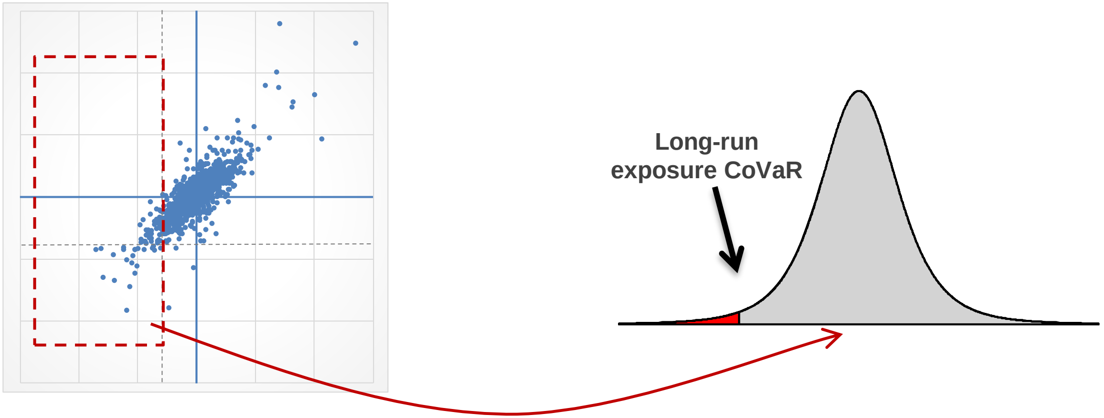
Point-in-time Prudent Level of Capital

Goal: Estimate the long-run Value-at-Risk of bank *i* conditional on an system-wide stress scenario

<u>Steps</u>

1) Collect historical stock prices and some accounting data of banks.
2) Construct two return series: (a) for bank *i* and (b) for an index containing all other banks in the system.
3) Estimate a bivariate model allowing for time-varying correlation and volatility (DCC GJR-GARCH).
4) Simulate a lot of potential future outcomes for the two series over a period of six months.
5) Select simulations with the five percent worst outcomes for the banking system.
6) Use those to estimate the maximum loss that is not exceeded with a confidence level of 95 per cent.



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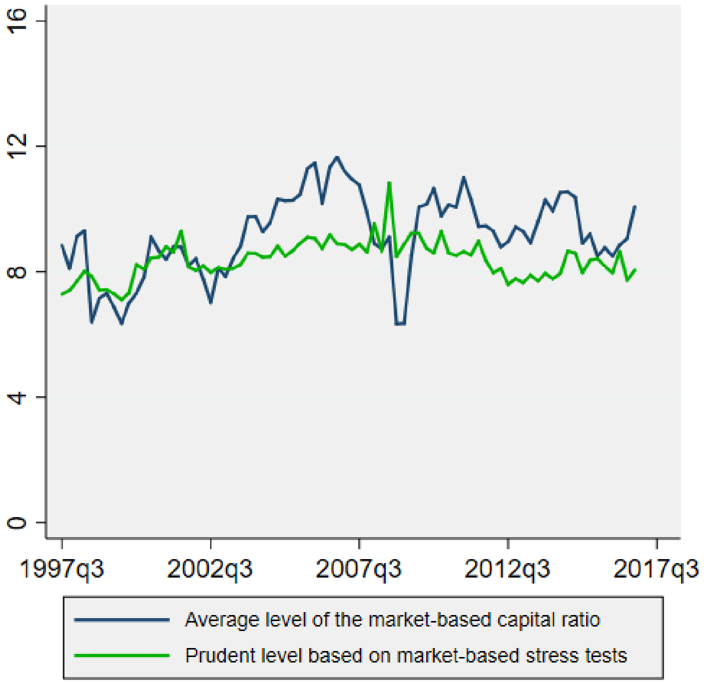
Point-in-time Prudent Level of Capital

Suppose: goal of macroprudential regulator is 95 per cent confidence in banks staying above a minimum ratio of 4.5 per cent of total assets in the 5 percent worst system-wide events over the next six months.

Figure: Average for Canadian banks (value-weighted, in per cent of total assets)



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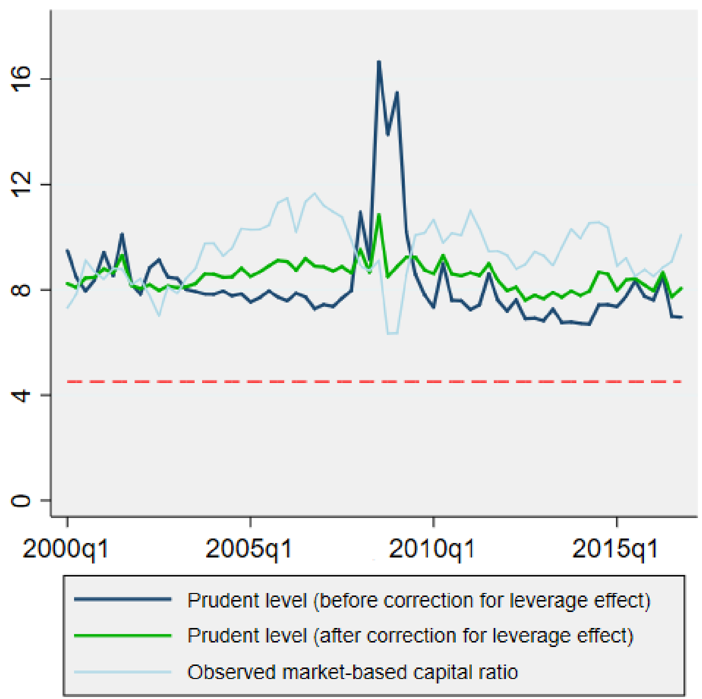
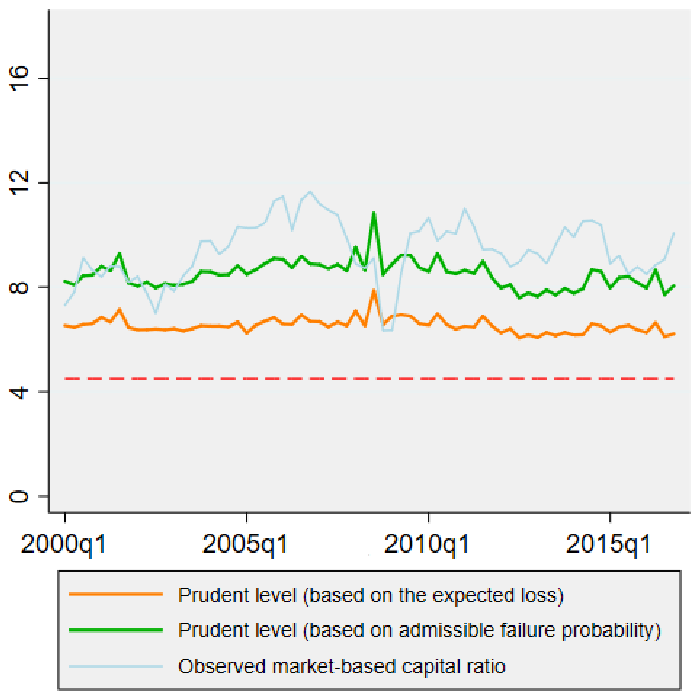
Prudent Level of Capital: Enhancements

Correction for leverage effect



Using the admissible failure probability



Estimate magnitude of CCyB

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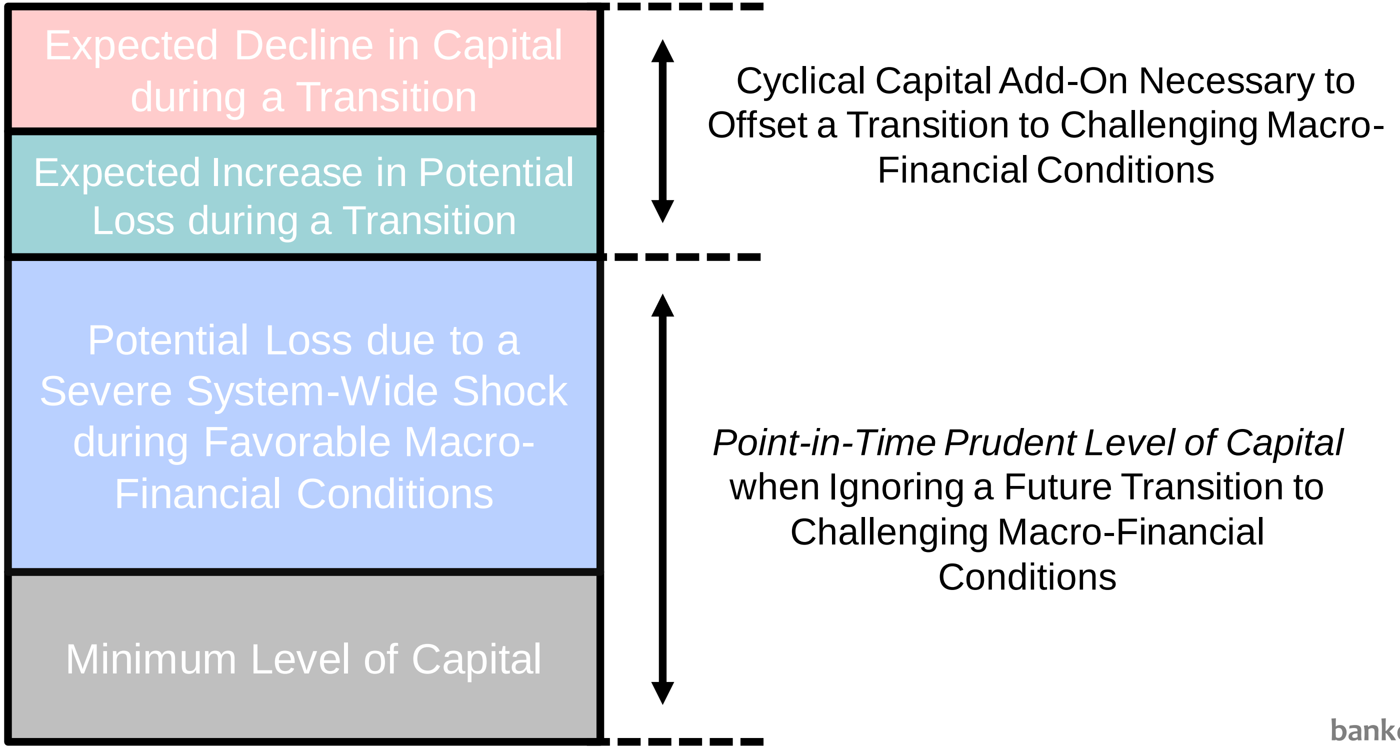

Estimate magnitude of CCyB

Magnitude of the CCyB

At what level would the CCyB be large enough to offset

(a) the potential decrease in *actual capital,* and

(b) the potential increase in the *point-in-time prudent level of capital*.

Equivalent to saying that CCyB needs to be able to offset decline in the *capital buffer*, defined as the difference between actual capital and the point-in-time prudent level of capital.

The necessary range of the CCyB to offset the decline translates into a **prediction exercise:** *What is the expected decline in the capital buffer associated with a peak-to-trough decline in the relevant indicator of macro-financial conditions?*

Estimate magnitude of CCyB

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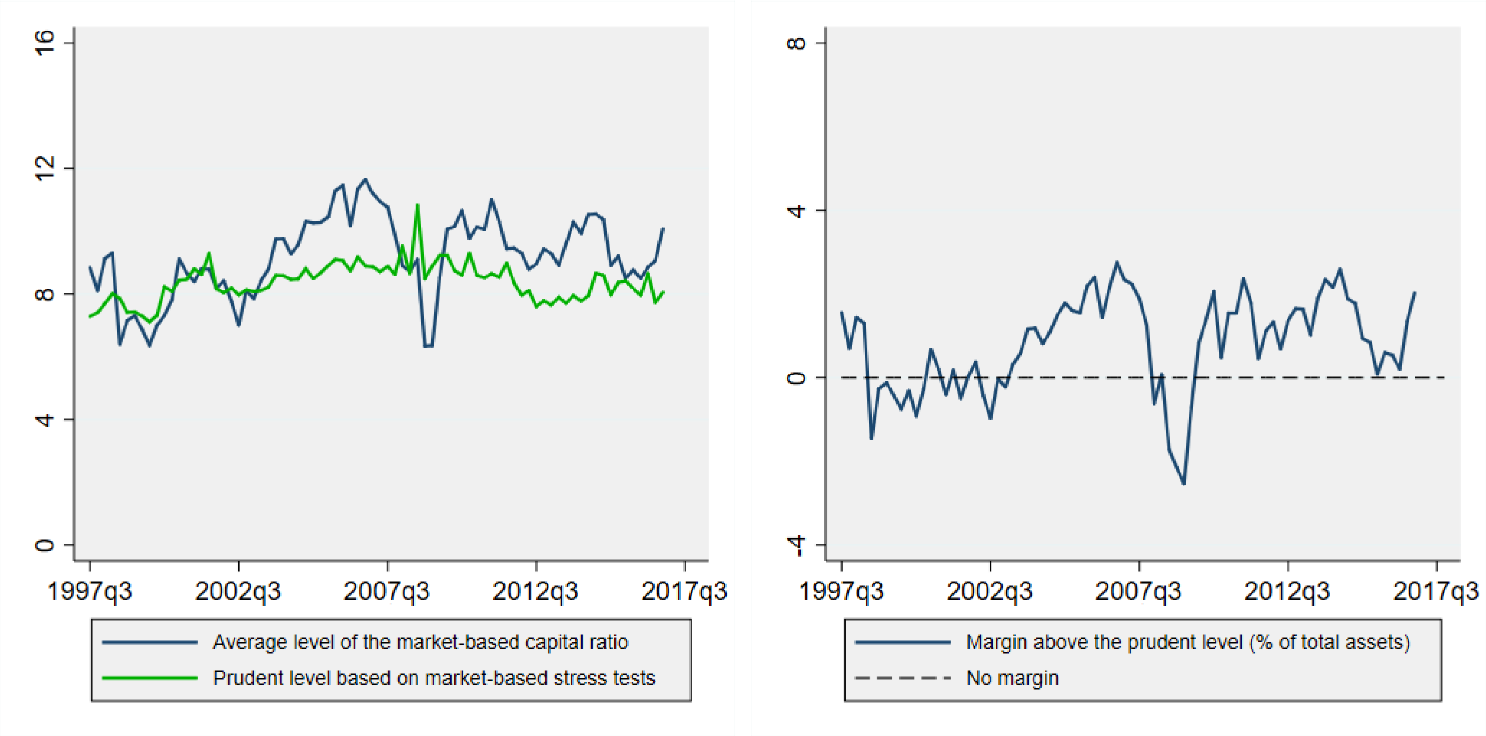

Methodology: Model

A. Calculate the capital buffer $B_{i,t}$:

(1) $B_{i,t} = k_{i,t} - k^*_{i,t}$,

where $k_{i,t}$ is the actual level of capital and $k^*_{i,t}$ is the estimated point-in-time prudent level of capital.

B. Estimate the sensitivity of $B_{i,t}$ with different indicators of macro-financial conditions $I_{c,t}$:

(2) $B_{i,t} = \beta I_{c,t} + \delta \mathbf{X}_{i,t} + \gamma \mathbf{Z}_{c,t} + \alpha_i + \alpha_t + \varepsilon_{i,t}$,

where $\mathbf{X}_{i,t}$ are bank-specific and $\mathbf{Z}_{c,t}$ are country-specific control variables.

C. Estimate the expected decline in capital buffer:

(3) $c^* = \hat{\beta}$ x ($\mathbf{E}[I_{c,t}$ | favorable financial conditions] - $\mathbf{E}[I_{c,t}$ | challenging financial conditions]).

Methodology: Data

Almost 7,500 quarterly observations for large banks in six advanced economies (1990Q1-2016Q4).

- **Calibration prudential capital ratio**
  - Minimum capital ratio of 4.5%, a confidence level of 95 per cent for each bank in the 5% worst system-wide events over the next 6 months.
  - On average: prudential capital ratio of 9.2% versus a market-based capital ratio of 10.0%.
- **Macro-financial conditions**
  - Annual growth in credit-to-GDP, bank-credit-to-GDP and residential real estate prices;
  - *Values* for annual growth and 12-years backward looking *rolling-window percentiles.*
- **Macro-economic control variables**
  - Real economic growth rate, unemployment rate, inflation rate, stock market return, short-term interest rate and the slope of the yield curve.
- **Bank-specific control variables**
  - Non-interest-income share, loans-to-assets ratio, liquid-assets-to-total-assets ratio, equity-to-assets ratio, deposit-funding-gap, asset-share, Herfindahl-index.

Results: Correlations with the Buffer

Timing of Indicator	Growth in Credit-to-GDP (y-o-y)	Growth in Bank-Credit-to-GDP (y-o-y)	House Price Growth (y-o-y)
Panel (a): Value of the macro-financial indicator			
Lead of 12 quarters	-0.095	-0.163	0.165
Lead of 8 quarters	0.010	0.016	0.304
Lead of 4 quarters	0.146	0.165	0.463
Coincident	0.327	0.314	0.472
Lag of 4 quarters	0.449	0.427	0.258
Lag of 8 quarters	0.503	0.433	0.103
Lag of 12 quarters	0.408	0.284	0.052
Panel (b): Rolling-window percentile of the macro-financial indicator			
Lead of 12 quarters	-0.026	-0.105	0.142
Lead of 8 quarters	0.065	0.073	0.274
Lead of 4 quarters	0.177	0.223	0.366
Coincident	0.403	0.350	0.342
Lag of 4 quarters	0.485	0.423	0.222
Lag of 8 quarters	0.373	0.358	0.130
Lag of 12 quarters	0.275	0.184	0.068

Results: Contemporaneous conditions

Dependent Variable: Capital buffers of global banks based on market-based stress tests

	(1)	(2)	(3)	(4)	(5)	(6)
	Value	Percentile	Value	Percentile	Value	Percentile
Growth in Credit-to-GDP$_{i,t}$ (y-o-y)	0.202***	0.021***				
	(0.034)	(0.003)				
Growth in Bank-Credit-to-GDP$_{i,t}$ (y-o-y)			0.078*	0.008**		
			(0.041)	(0.003)		
House Price Growth$_{i,t}$ (y-o-y)					0.103***	0.013***
					(0.016)	(0.003)
Implied cyclical capital add-on	1.4%	1.7%	0.6%	0.6%	1.6%	1.0%
(95% confidence interval)	(0.9% - 1.8%)	(1.1% - 2.2%)	(0.0% - 1.3%)	(0.1% - 1.1%)	(1.1% - 2.1%)	(0.6% - 1.5%)
Observations	7,377	6,431	7,471	6,593	5,649	5,649
Banks	88	88	88	88	61	61
Bank-specific controls	Yes	Yes	Yes	Yes	Yes	Yes
Macro-economic controls	Yes	Yes	Yes	Yes	Yes	Yes
Bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Cluster at time level	Yes	Yes	Yes	Yes	Yes	Yes
Cluster at bank level	Yes	Yes	Yes	Yes	Yes	Yes
R-squared (within)	0.543	0.515	0.536	0.494	0.532	0.523

Conclusions

Novel methodology

- Enhancements to (reverse) market-based stress tests
- New method to calibrate the magnitude of the CCyB based on market-based stress tests.

Take aways

- Selection of the indicators: In our international sample, the credit-to-GDP-ratio and house price growth perform relatively well.
- Magnitude of the buffer: Estimates suggest that the releasing the CCyB may have to offset a change in capital and risk that surmounts to around 1.6 to 1.7 per cent of total assets.
- Economic significance: With an average risk-weight of, e.g., 50 per cent, this implies an add-on of 320 to 340 bps (somewhat more than the internationally agreed maximum reciprocatory level of 250 bps).
- Risk tolerance: Estimates aim at achieving that banks do not breach the minimum capital ratio with a 95 per cent level of confidence after a six-month system-wide shock that occurs on average every 10 years.

THANK YOU