Macroprudential Regulation: A Risk Management Approach

Systemic Risk in the European Financial Sector

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Two DNB working papers on systemic risk

1. **Risk Measurement** Dimitrov/van Wijnbergen, 2023a: *Quantifying Systemic Risk in the Presence of Unlisted Banks*
    - attributing systemic risk across banks using credit-based Marginal Expected Shortfall (MES) estimated from CDS prices
2. **Risk Measurement** Dimitrov/van Wijnbergen, 2023b: *Macroprudential Regulation: A Risk Management Approach*s
    - calibrating the size of the macroprudential capital buffers

Excursion on CDS prices

- CDS: insurance derivative contract (OTC) on default of an underlying
- Typically traded on standardized T&Cs (maturities, the definition of a credit event, etc.)
- Linked directly to default risks of the company
  - Since 2014 ISDA definition of a credit event also *includes restructuring* and *government intervention*.
- The CDS market is more liquid and has *fewer trading frictions than the bond market*
- An *edge over credit rating agencies*
- Some evidence CDS prices may lead the equity markets in price discovery
  - Insiders active on the CDS market, *Acharya & Johnson [2005]*
- Alternatives exist:
  - Equity based; What about non-listed banks (e.g. the Rabo...)?
  - Balance-sheet based (Z-Scores ?); How predictive are they really?

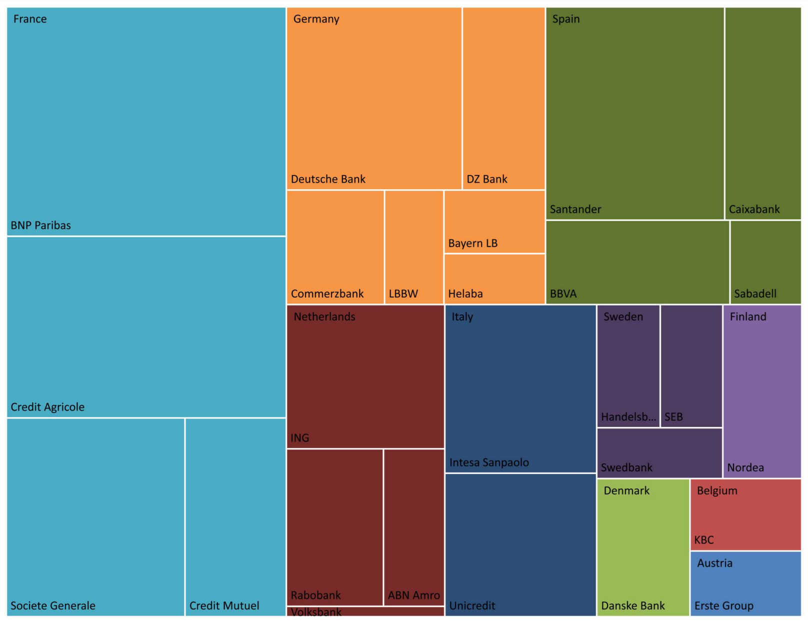
A Model of Bank Distress: Overview

- Imply the risk of the simultaneous defaults of multiple banks using CDS data
  - Level of the CDS price speaks about the market view on the credit-worthiness of the institution
  - Co-movements in default probabilities (single-name CDS prices) speak about the tendency of banks to be exposed to the same risk drivers
- Use a structural credit model (Merton's Disntance-to-Default) to relate capital ratios to Probability of Default (PD)
  - carve out current implied variance of bank's assets
  - quantify the relationship between PD and bank's capitalization
- Develop two approaches to determine the macro capital buffers of individual banks
  - Equalize Expected Systemic Costs between an SII and a non-SII
  - Minimize systemic risk

Empirical Application

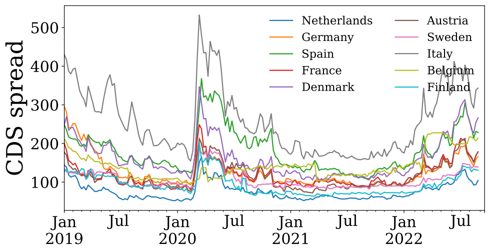
- Universe of 27 large European banks (O-SII and G-SII).
- Evaluation date: Aug, 29, 2022
- Correlation time window: 3 years
- Dataset:
    - Single-name CDS spreads on banks' subordinate debt;
    - Balance sheet liability sizes
    - CET1 capitalization ratios

Relative Liability Size



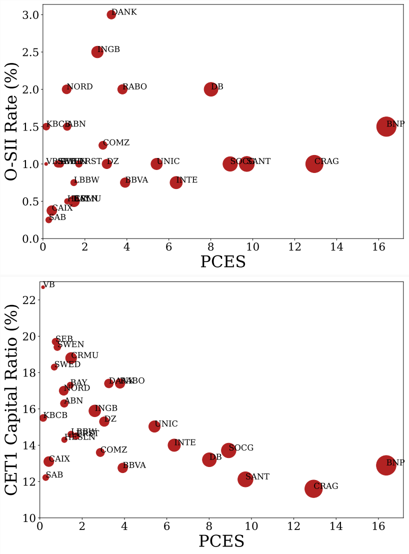
CDS Prices

Figure 1: Median CDS Rates per Country (bps)



Systemic Risk Shares vs. O-SII Rates

Figure 3: Share of Systemic Risk vs. Capitalization



Macroprudential Policy

- Now, apply to capital requirements (main innovation of Dimitrov/van Wijnbergen, 2023b)
- Total required capitalization

$$k_i = k_{i,micro} + k_{i,macro}$$

- Macroprudential regulation: determine the optimal $k_{i,macro}$ based on bank's systemic relevance for given $k_{i,micro}$

Optimal Macro Buffers: Approaches

1. Equal Expected Impact approach
    - define a probabilistic systemic cost of default (SCD) function
    - equalize SCDs between a SII and a reference non-SII
2. Risk minimization approach
    - Minimize systemic risk by allocating a capital buffer "budget" (average)
3. Determine the size of the socially optimal budget through cost-benefit analysis of higher buffers

1. EEI Approach

1. Define:

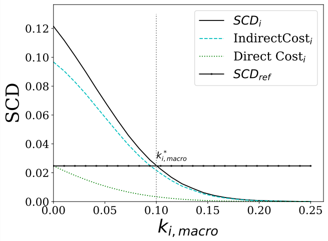
   Systemic Cost of Default =

   Direct Effect: Expected Loss in Distress for bank i +

   Indirect Effect: Expected Net Loss of *other banks* in distress conditional on bank i's distress

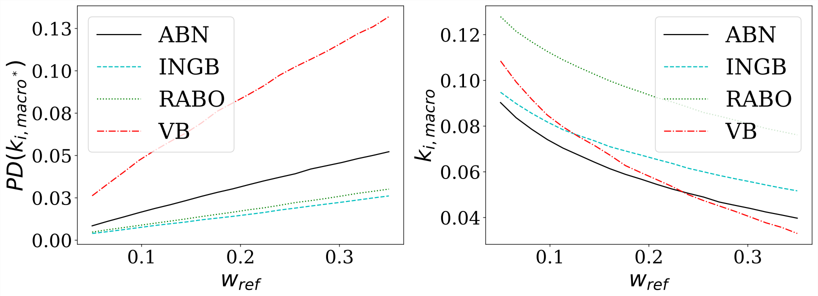
2. Construct a benchmark non-systemic institution (no indirect cost associated with it)

3. Set macro buffers to equalize the reference SCD to that of the systemic institution subject to macro add-on



1. EEI: Empirical Application to the Dutch Sub-sample

Figure 5: Optimal Macro Buffers



(a) **(b)**

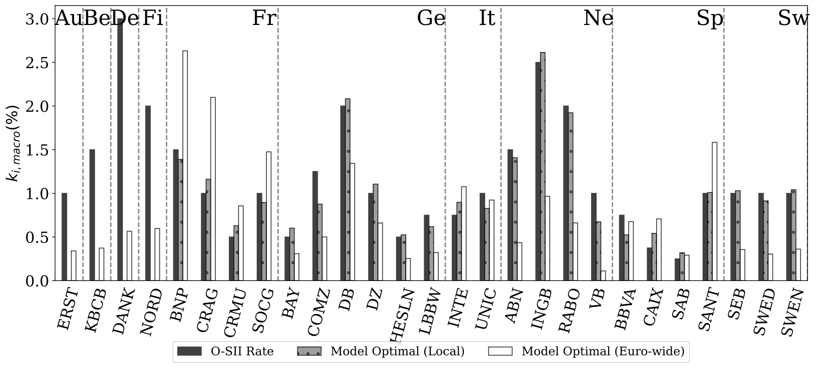
- Rankings are stable but levels depend on choice of w_{ref}
- EEI approach puts
  - high emphasis on distress correlations
  - high emphasis on asset variance
  - lower emphasis on size

2. ES Approach

- The financial system can be seen as a portfolio of long loan positions
- Define Expected Shortfall [Acharya eA, 2017; Huang eA 2012] as the potential default losses beyond a tail threshold ($\bar{L}$)
- Minimize system's potential default losses (Expected Shortfall) by increasing macro capital requirements across banks subject to an average target marco buffer rate

Calibrate to current O-SII buffer average ($\bar{k}$) in the Euro sample

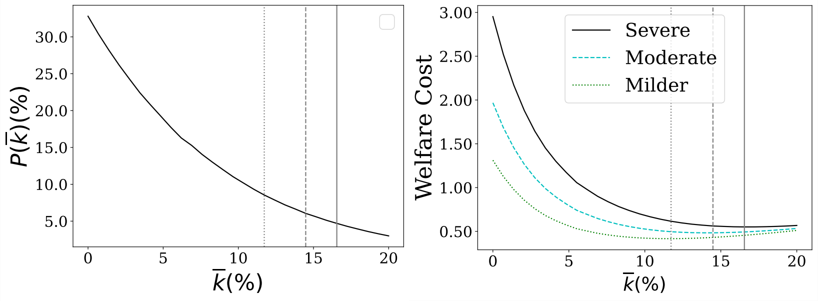
Figure 7: Optimal Macro Buffers at current O-SII average



4.3. How high should $\overline{k}$ be?

- Define an overarching policymaker objective
- Choose $\overline{k}$ to balance
  - the social costs of default given that systemic distress occurs (SCD) with probability $P(\overline{k})$
  - and the social costs of higher buffers (SCB) given that no system-wide distress occurs
- Probability of distress conditional on optimal allocation of capital buffers between banks in line with (13)

Figure 9: Macroprudential Cost Calibration

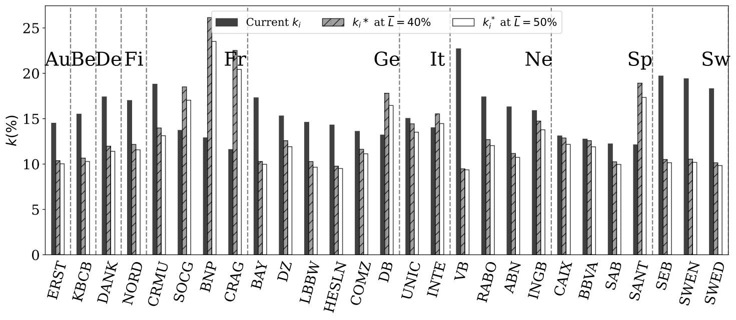


(a) **(b)**

For reasonable calbration $\overline{k}$ between 7.3% and 8.4% depending on the loss-aversion of the regulator.

4.2. ES Approach: Empirical results

Figure 11: Total Optimal Buffers, at current socially Optimal $\overline{k}$



Annex

A Model of Bank Distress

U_i is an (unobserved) credit-worthiness variable s.t.

$$U_i \sim N(0, 1)$$

Default occurs if:

$$\mathbb{1}_i \equiv \begin{cases} 1 & \text{if } U_i \leq X_i \\ 0 & \text{otherwise} \end{cases} \tag{1}$$

with X_i representing a fixed default threshold (quasi-observed)

$$\implies PD_i \equiv \Phi(X_i)$$

with $\Phi(.)$ the standard normal distribution

Excursion on Implying PDs from CDS quotes

- We can't rely on observations of default (defaults of systemic institutions are very rare)
- ... but we quasi-observe banks' default probabilities (PD) through the CDS market, [Duffie, 1999]
- By convention the swap has zero value at contract initiation:

$\implies$ Value of CDS premia payments in survival = Expected value of protection in default

$$\underbrace{CDS_t \int_t^{T_{cds}} e^{-r_\tau \tau} \Gamma_\tau d\tau}_{\text{PV of CDS premia in survival}} = \underbrace{(1 - ERR_t) \int_t^{T_{cds}} e^{-r_\tau \tau} q_\tau d\tau}_{\text{PV of protection payment in default}} \tag{2}$$

- Assume fixed interest rate r_t, default intensity q_t. Solve for q_t
- Set $PD_i = q_t$

Modelling the System: Default Correlations

- *Systemic risk implies*: defaults need to be evaluate in the context of other banks defaulting
- Latent factor model drives default correlations:

$$U_i = \rho_i M + \sqrt{1 - \rho_i \rho_i'} Z_i \tag{3}$$

$M = [m_1, \ldots m_f]'$ is a vector of f common latent factors, and Z_i is the bank-specific factor ($M, Z_i \sim N(0, 1)$), $\rho_i = [\rho_{i,1}, ..., \rho_{i,f}]$ is a vector of factor loadings, such that $\rho_i \rho_i' \leq 1$.

Excursion on Factor Exposures Estimation

Estimate all ρ_i, ρ_j relative to a target correlation matrix

$$\min_{\rho_i,\ldots,\rho_j} \sum_{i=2}^{N} \sum_{j=1}^{N} (a_{ij} - \rho_i \rho_j')^2 \tag{4}$$

with target correlations a_{ij} evaluated from co-movements in banks' PDs [Cf. Tarashev & Zhu, 2006; Andersen eA, 2003]

We need structure to related CDS spread changes over time to asset correlations $a_{ij} \implies$ Merton's firm model

Excursion on the Merton Model

- Assume the Merton firm model (under the r.n. distribution) holds

$$d \ln V_{i,t} = rdt + \sigma_i dW_{i,t} \tag{5}$$

where $V_{i,t}$ is the (unobserved) risk-weighted asset value of bank i; r is the risk-free rate; $dW_{i,t}$ is a Brownian Motion.

- Default occurs if assets fall below value of debt

$$PD_{i,t} = \mathbb{P}(V_{i,t+T} \leq D_i) \tag{6}$$

$$\implies DD_{i,t} = \frac{\ln \frac{V_{i,t}}{D_i} + \left(r - \frac{\sigma_i^2}{2}\right) T}{\sigma_i \sqrt{T}} \tag{7}$$

- Combining (1) and (7) : $PD_{i,t} = \mathbb{P}\left(\underbrace{\frac{W_{i,t+T}}{\sqrt{T}}}_{U_i} \leq \underbrace{-DD_{i,t}}_{X_i}\right)$

The Merton Model and Target Correlations

No need to estimate $V_{i,t}; DD_{i,t}$ but model has important implications

1. Target asset corrs:

$$a_{ij} = \mathbb{Corr}(\Delta\Phi^{-1}(-PD_{i,t}), \Delta\Phi^{-1}(-PD_{i,t}))$$

Three factor model captures the common variation in the the CDS data well.

A Model of the Bank Distress

2. DD is related to bank's capitalization

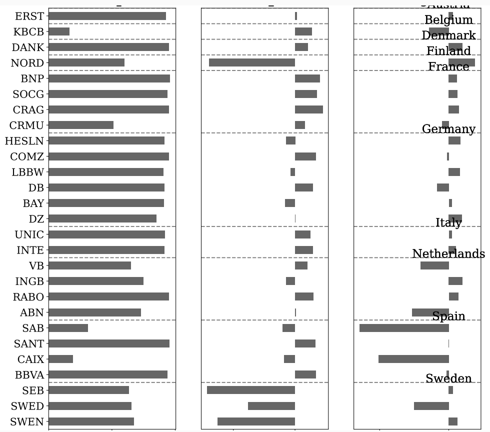
$$DD(k_i; \sigma_i) = \frac{-\ln(1 - k_i) + \left(r - \frac{1}{2}\sigma_i^2\right)}{\sigma_i} \tag{8}$$

with $k_i = E_i / D_i$, corresponding to CET1 capital; σ_i is st.dev. of bank's RWAs, r is the risk-free rate

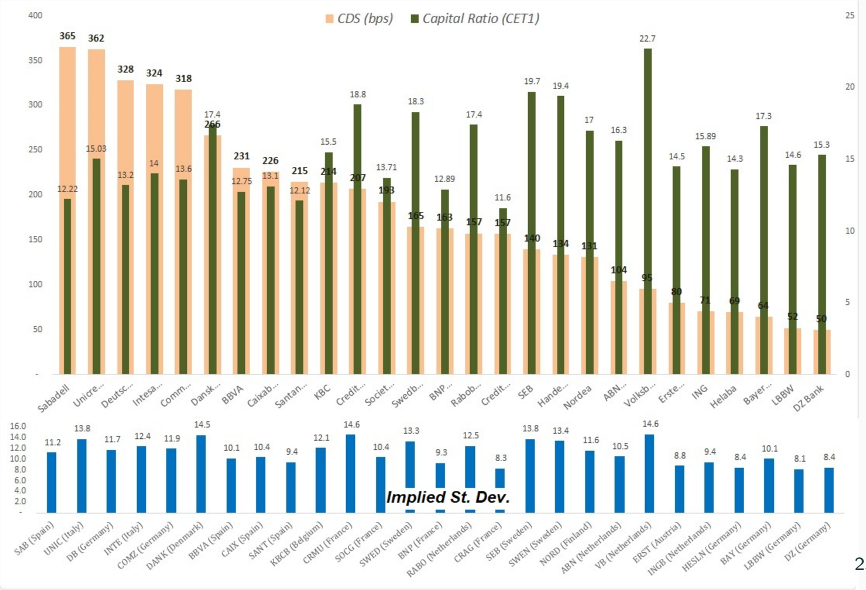
$$\implies PD_i = \Phi\left(-DD(k_i; \sigma_i)\right) \tag{9}$$

- Two purposes of (9):
    1. Given current PD_i and k_i imply σ_i
    2. Given σ_i, vary k_i and observe effect on bank's $PD \implies$ evaluate the effect on the system

Factor Loadings



CDS Spreads, Capitalization and Implied Variance



PDs and Systemic Risk

Define a cost function associated with systemic risk (Systemic Cost of Default, with EL_i as Expected Loss):

$$SCD_i = EL_i + \sum_{j \neq i} (EL_{j|i} - EL_j) PD_i$$

or in relative terms:

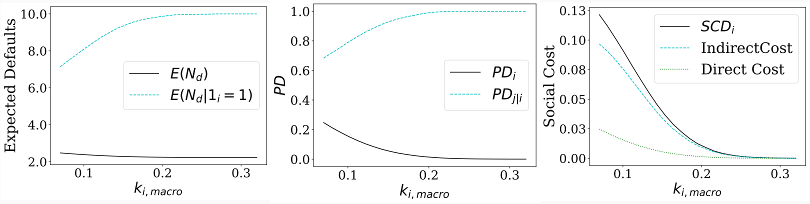
$$SCD_i = \underbrace{w_i LGD_i PD_i}_{\text{Direct Cost (Microprudential)}} + \underbrace{\sum_{j \neq i} w_j LGD_j \left(PD_{j|i} - PD_j \right) PD_i}_{\text{Indirect Cost (Macroprudential)}} \quad (10)$$

w_i relative liability size (EAD for the regulator); PD_i default probab.; $PD_{j|i}$ conditional default of j given i defaults; LGD_i Loss Given Default (assume 100%); SCD_i is relative to the total size of the banking system (total liabilities)

Quantitative Example

Assume a financial system of ten homogeneous banks. Increase the capitalization of bank i.

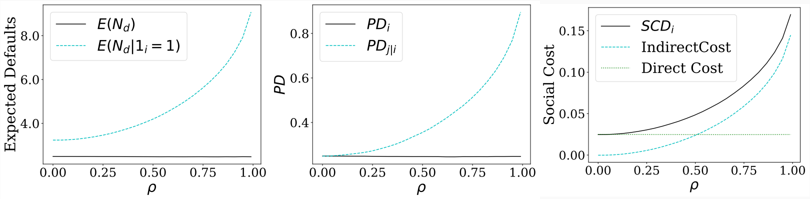
Figure 14: Capital Requirements



(a) Number of Defaults **(b)** Default Probabilities **(c)** Systemic Cost

Assume a financial system of ten homogeneous banks ($\rho_i = \rho$)

Figure 16: Asset Correlation



(a) Number of defaults **(b)** Default Probabilities **(c)** Systemic Cost

4.2. Expected Shortfall Approach

Second approach:

- The financial system can be seen as a portfolio of long loan positions
- *Idea:* Evaluate and manage through capital buffers the credit risk of this portfolio
- Formally, define credit losses as

$$
\begin{aligned}
L_i &= \mathbb{1}_i LGD_i \\
L_{sys} &= \sum_{i=1}^{N} w_i L_i
\end{aligned}
\tag{11}
$$

- Define Expected Shortfall [Acharya eA, 2017; Huang eA 2012]

$$
ES_{sys} = \mathbb{E}\left(L_{sys} | L_{sys} > \overline{L}\right) \tag{12}
$$

- Minimize system's potential default losses (Expected Shortfall) by increasing macro capital requirements s.t. a target

The policymaker problem:

$$\min_{k_{\mathbf{1},macro},\ldots,k_{N,macro}} ES_{sys}(k_{micro}; k_{1,macro}, \ldots, k_{N,macro})$$
$$s.t. \sum_i w_i k_{i,macro} = \overline{k} \tag{13}$$

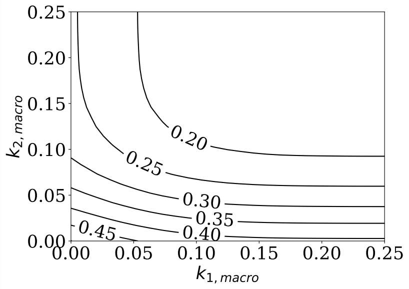


Figure 18: Expected Shortfall, Example

How high should $\overline{k}$ be?

Formally, we can write a disutility function:

$$\min_{\overline{k}} \left\{ P(\overline{k}) SCD(\overline{k}) + (1 - P(\overline{k})) SCB(\overline{k}) \right\}$$

where

$$P(\overline{k}) = \mathbb{P}(L_{sys} > \overline{L}), P < 0$$

$$SCD(\overline{k}) = \lambda \mathbb{E}(L_{sys} | L_{sys} > \overline{L}), SCD' < 0$$

$$SCB(\overline{k}) = \eta \left(\overline{k} - \overline{k}_0 \right)$$

with λ as macro multiplicator for financial losses and η as the sensitivity of aggregate output to capital buffers, which can be decomposed into

$$\eta = -\frac{dY/d\overline{k}}{Y} = -\left(\frac{dY}{dC} \frac{C}{Y} \right) \left(\frac{dC}{d\overline{k}} \frac{1}{C} \right) \tag{14}$$

4.3. Calibrating $\overline{k}$

- λ: Reinhart/Rogoff, 2009: Banking crises produce 9% GDP decline on average. Assumed $LGD = 100\%$. Assuming banking crisis occurs if 1/2 of the sector is in distress $\implies \lambda = \frac{9\%}{.5 \cdot 100\%} = .18$
- $(dY/dC)(C/Y)$: Brauskaite eA, 2022: 1% reduction in loan supply results in .6% decline in GDP growth
- $(dC)(d\overline{k})(1/C)$: Favara eA, 2021: 1% incremental increase in macro capital, leads to 3-4% decline in lending of the targeted banks