# Systemic Risk and Vulnerabilities of Bank Networks

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Mexico City, September 27, 2017

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# Outline

- Microprudential vs macroprudential regulation
- Description of EBA data
- Shock propagation model
- Results for various scenarios
- Discussion of phase space
- Conclusion

# Micro vs. Macro

**The macro- and microprudential perspectives compared**

| | **Macroprudential** | **Microprudential** |
|---|---|---|
| Proximate objective | limit financial system-wide distress | limit distress of individual institutions |
| Ultimate objective | avoid output (GDP) costs | consumer (investor/depositor) protection |
| Characterisation of risk | Seen as dependent on collective behaviour ("endogenous") | Seen as independent of individual agents' behaviour ("exogenous") |
| Correlations and common exposures across institutions | important | irrelevant |
| Calibration of prudential controls | in terms of system-wide risk; top-down | in terms of risks of individual institutions; bottom-up |

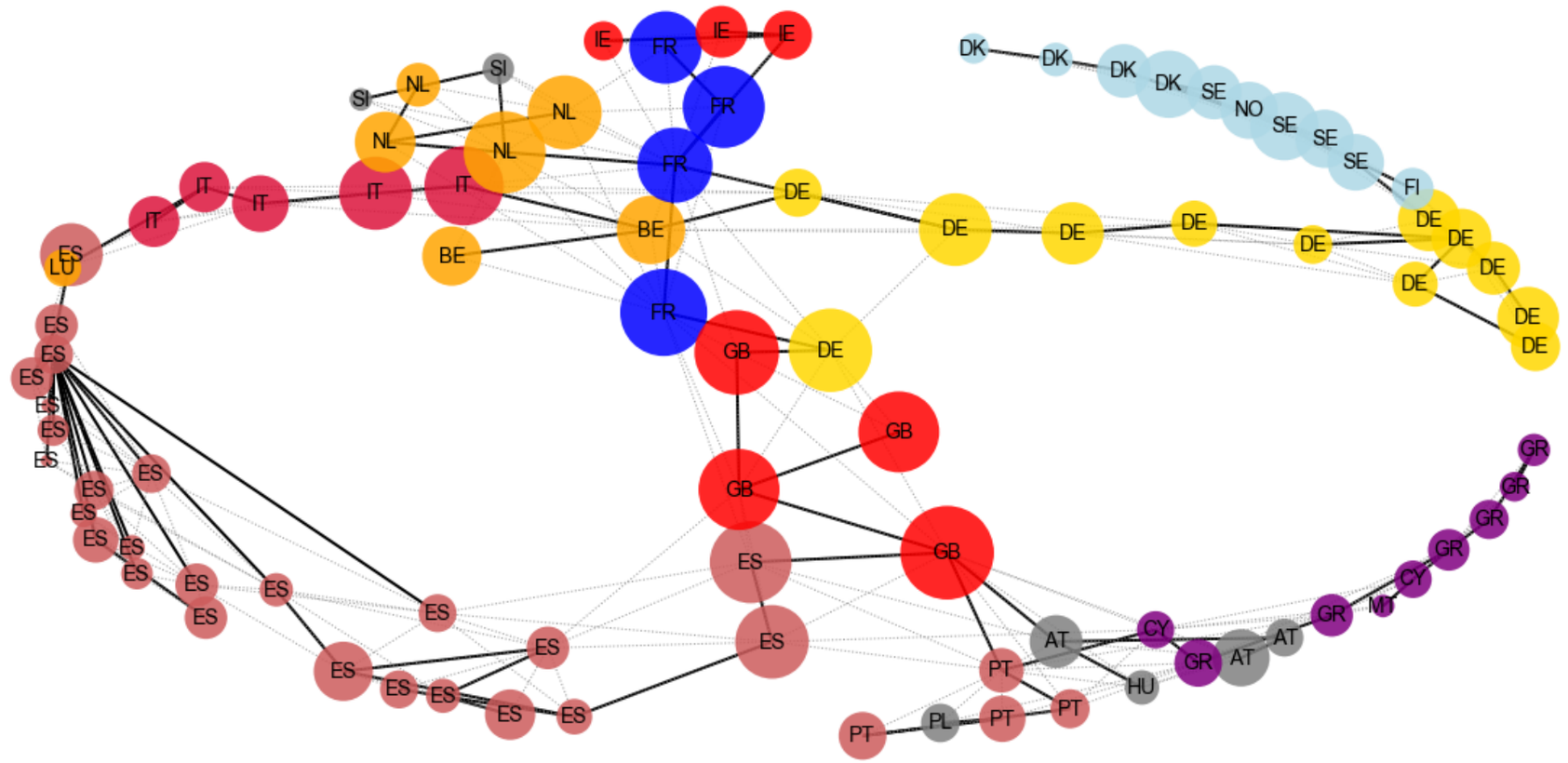
BIS Working Papers, No 128
"Towards a macroprudential framework for financial supervision and regulation?"
Claudio Borio (2003)

# EBA data

- 90 banks
- initial capitalizations of banks from 2011
- 33 sovereign debts
- 7 asset classes (sov. debt, financial institutions, corporations, retail residential, retail SME, retail revolving, commercial real estate)

- Assumption: sovereign debt is a proxy for where a bank does its business.

# Regional Bias in Banks' Portfolios




**Network of European Banks**

Nodes are banks in the EBA dataset.

Link weights are given by the similarity of portfolio in sovereign debts.

Planar Maximally Filtered Graph to capture most meaningful information.

Size of nodes corresponds to log of total asset exposure



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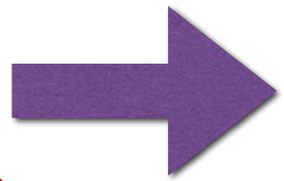
# Bank Assets

- Tier 1 Capital $C$
- Risk Weighted Assets $w_a A_a$



Tier 1 Capital Ratio $R$

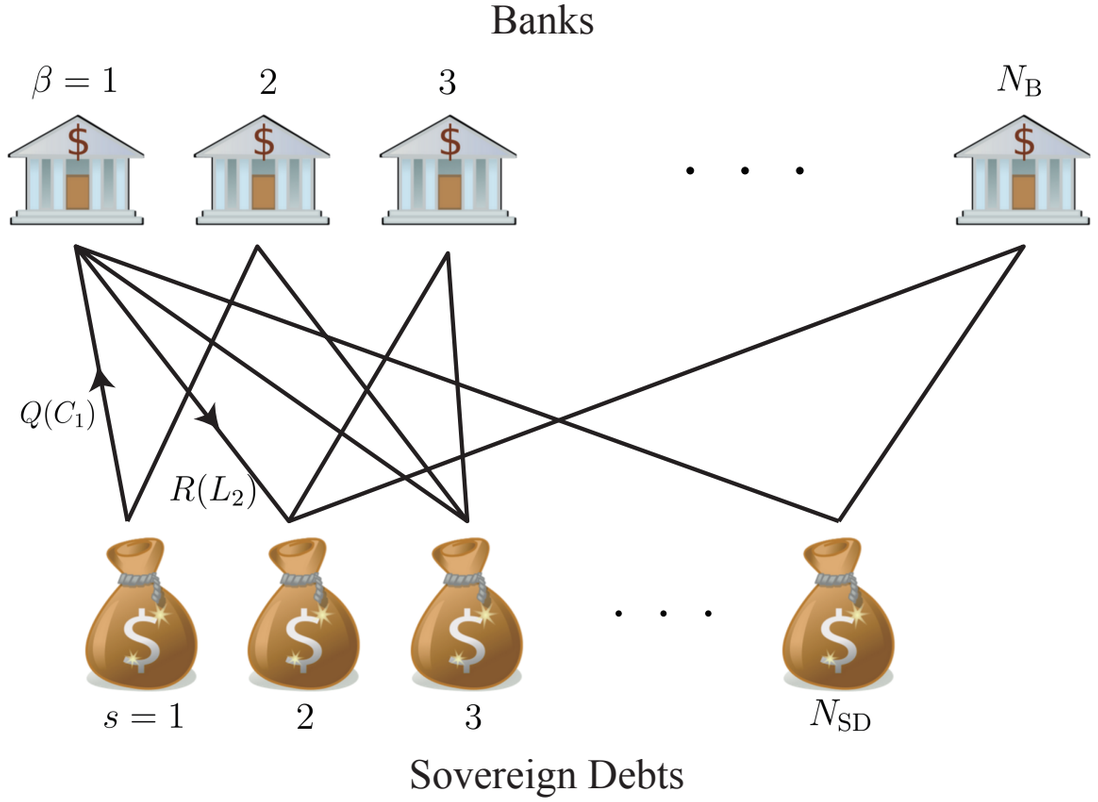
| $a$ | Item | | $w_a$ range | $A_a$ | $w_a$ | $w_a A_a$ |
|---|---|---|---|---|---|---|
| 1 | Sovereign Debt | | [0.002, 0.1] | 27,267 | 0.002 | 55 |
| 2 | Financial institutions | | [0.5, 1.0] | 25,044 | 0.5 | 12522 |
| 3 | Corporate | | [0.5, 1.3] | 61,237 | 0.5 | 42866 |
| 4 | Retail: | Residential Mortgages | [0.5, 0.8] | 36,663 | 0.5 | 14665 |
| 5 | | Revolving | [0.8, 1.2] | 23,153 | 0.8 | 18522 |
| 6 | | SME | [1.0, 1.3] | 3,467 | 1.0 | 3467 |
| 7 | Commercial real estate | | [1, 2] | 22,228 | 1.0 | 22228 |
| | | | **Total RWA** $W$, according to Eq. (2) | | | 114325 |

# Risk weights

- Risk weighted assets describe the exposure of a bank to its assets and their risk
- The more accurate bank assesses risk, the more loans it can give out with the same amount of capital
- Internal rating-based approaches common to assess counterparty credit risk

# Model

- We propose shock propagation model on a bipartite network between assets, like sovereign debts, on one side and banks on the other side



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# Model

- At t=0, the risk weight of a sovereign debt (SD) is increased to reflect a readjustment of risk perception
- At t=1, all banks who own the SD see an increase in their risk weighted assets and thus a decrease in their Tier 1 Capital Ratio
- At t=2, decrease in tier 1 capital ratio of some banks creates credit pressure, amplifying the risk weights of SD:

$$r_s(t=2) = r_s(t=1) \,/\, \textit{credit pressure}$$

- Continue back and forth

# Credit pressure

**$r_s(t+1) = r_s(t)$ / *credit pressure***

$$\Omega_s(t+1) = 1 - Q(D_s)\left(1 - \frac{\sum_{\beta=1}^{N_B} S_{\beta,s}\, P\left(\frac{R_\beta(t)}{R_\beta(t-1)}\right)}{\sum_{\beta=1}^{N_B} S_{\beta,s}}\right)$$

How strongly is a shock to a bank propagated back to the asset *s*?

— asset specific parameter $Q(D_s)$;

— how much of this asset is held by the affected banks;

— how the banks react to a reduction in their Tier 1 Capital Ratio *R*.

# Inherent riskiness of asset

Credit pressure depends on $\Omega_s$

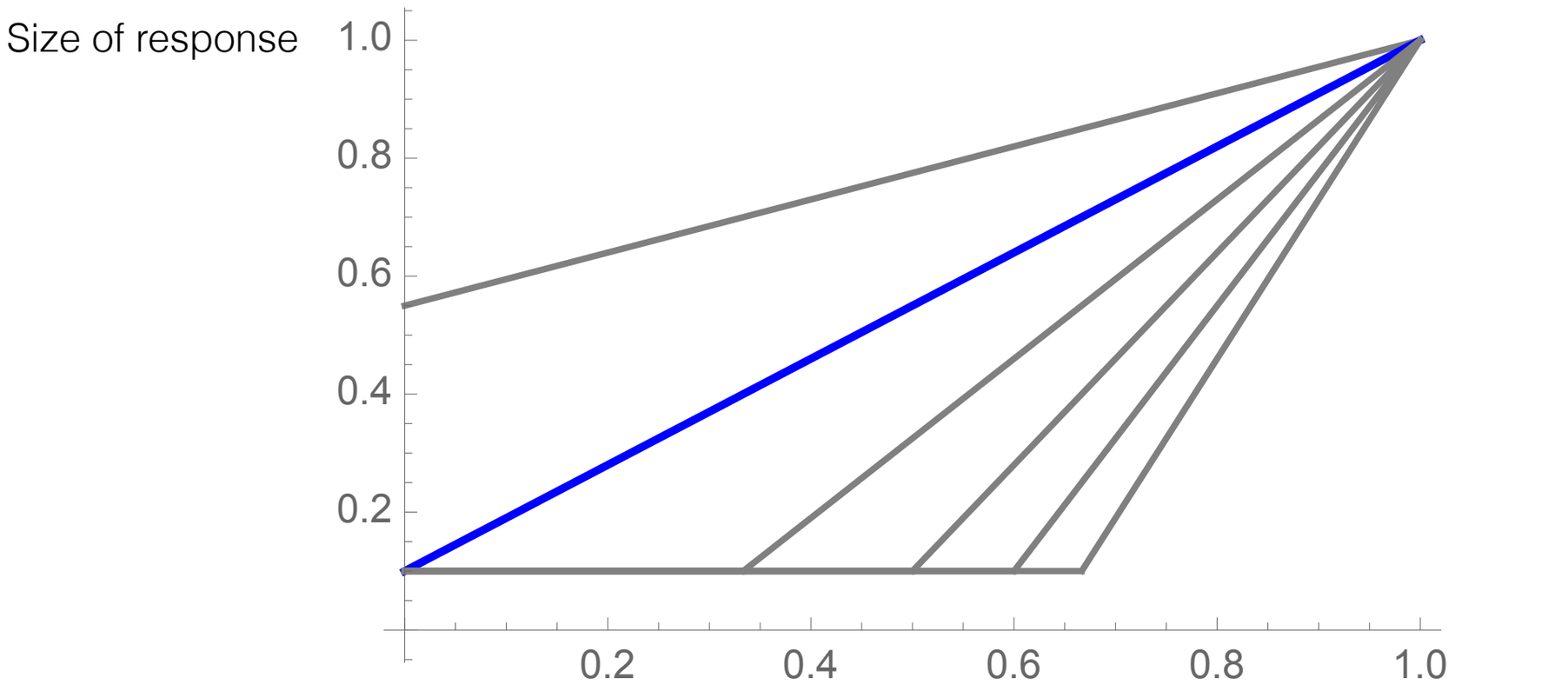
- Use CDS spread as a parameter for riskiness of sovereign debt

$$Q(D_s) = 1 - 2^{-D_s/100}$$

| | | | |
|---|---|---|---|
| AT | — | 20 | — 0.129 |
| CY | — | 130 | — 0.594 |
| DE | — | 5 | — 0.034 |
| GR | — | 1400 | — 0.999 |
| PT | — | 400 | — 0.938 |

# Bank Response to Shock

- P(x) — bank response function
- How strongly does a bank respond to a loss?

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# What happens to sovereign debts?

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While exposure is significant in absolute terms, the risk weights for sovereign debt are magnitudes lower than for other asset classes!

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# Spillover to other asset classes

$$\Omega_s(t+1) = 1 - Q(D_s)\left(1 - \frac{\sum_{\beta=1}^{N_B} S_{\beta,s}\, P\left(\frac{R_\beta(t)}{R_\beta(t-1)}\right)}{\sum_{\beta=1}^{N_B} S_{\beta,s}}\right)$$

**Sovereign Debt**

Response to change in
Tier 1 Capital Ratio

CDS spread

## Other Asset Classes

$$\Omega_a(t+1) = 1 - Q_a\left(1 - \frac{\sum_{\beta=1}^{N_B} A_{\beta,a}\, P\left(\frac{R_\beta(t)}{R_\beta(t-1)}\right)}{\sum_{\beta=1}^{N_B} A_{\beta,a}}\right)$$

Asset spread

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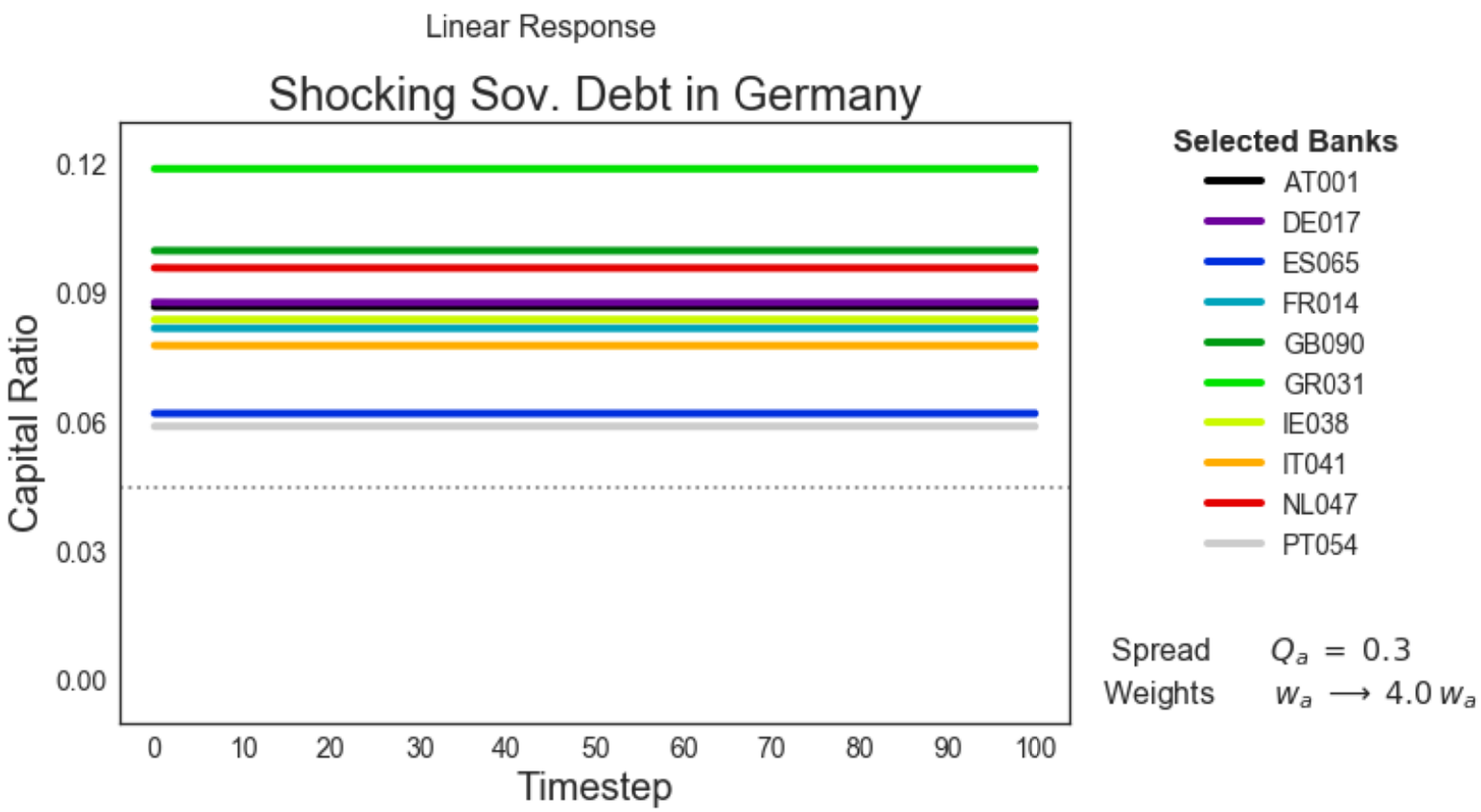
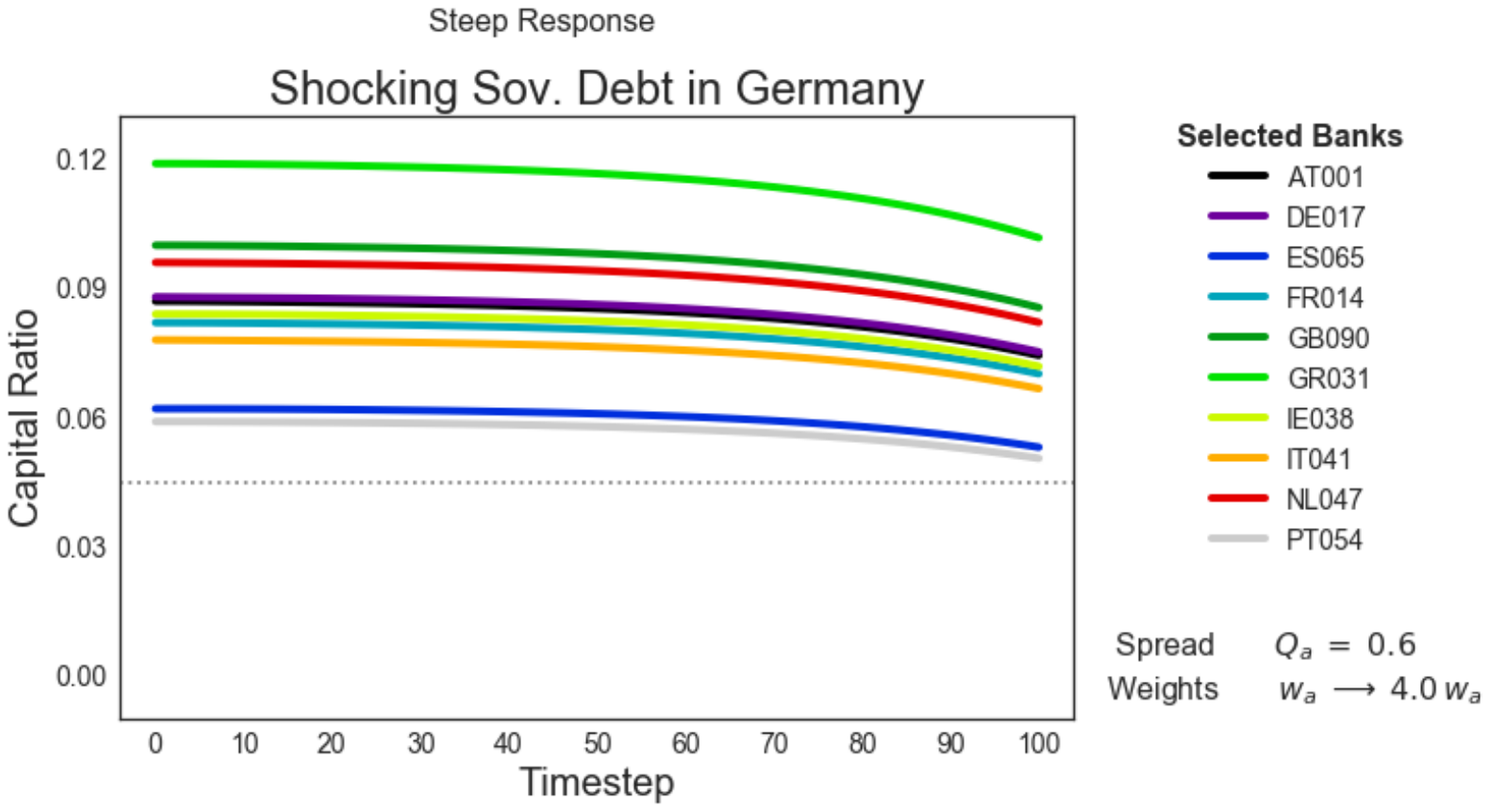
# Shock Scenarios

- Increase in risk weights by sector and / or by country
- Reduce bank capital
- Vary spreading parameter
- Consider different bank response functions

Where does the Tier 1 Capital Ratio end up?

# Exploring Different Scenarios

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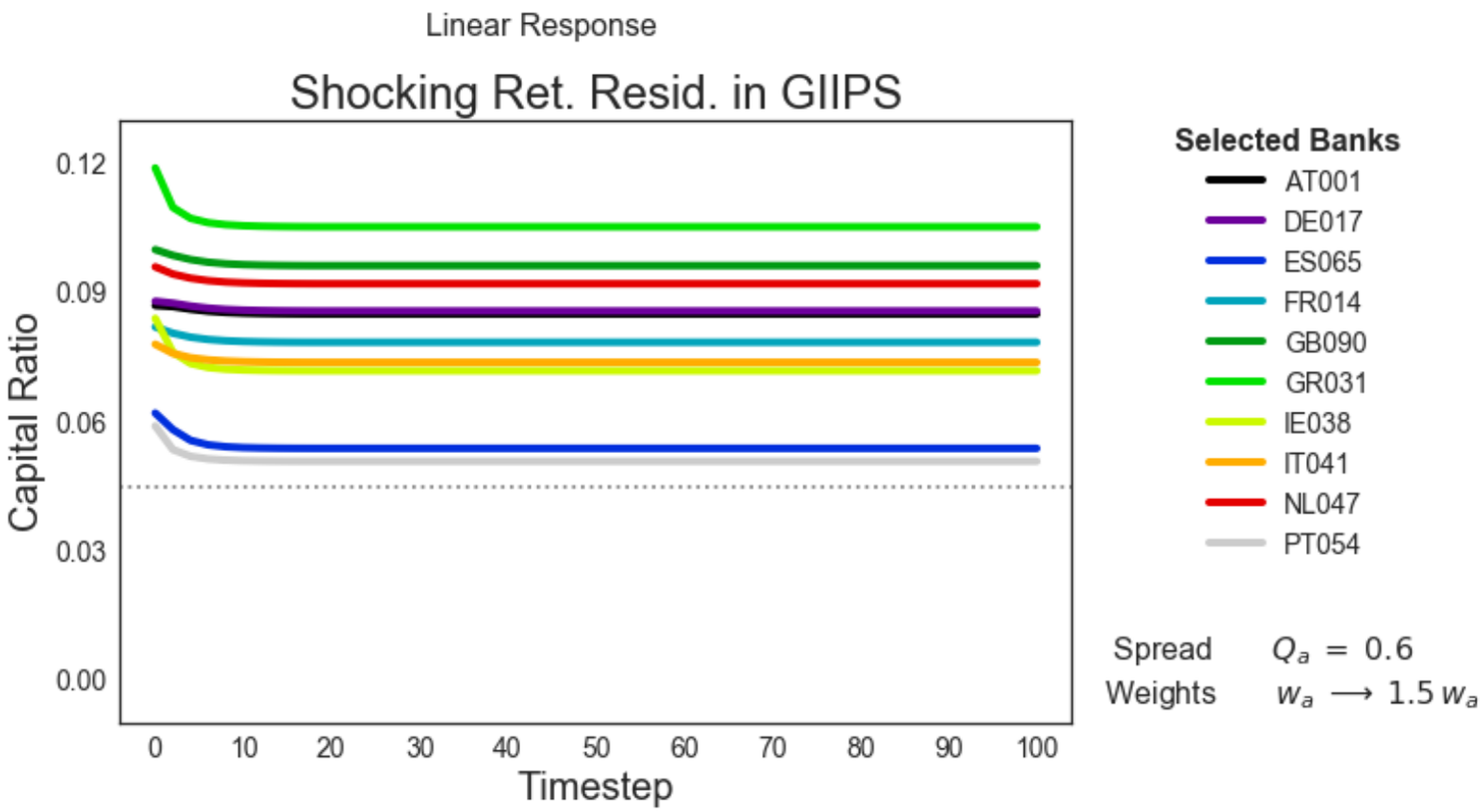
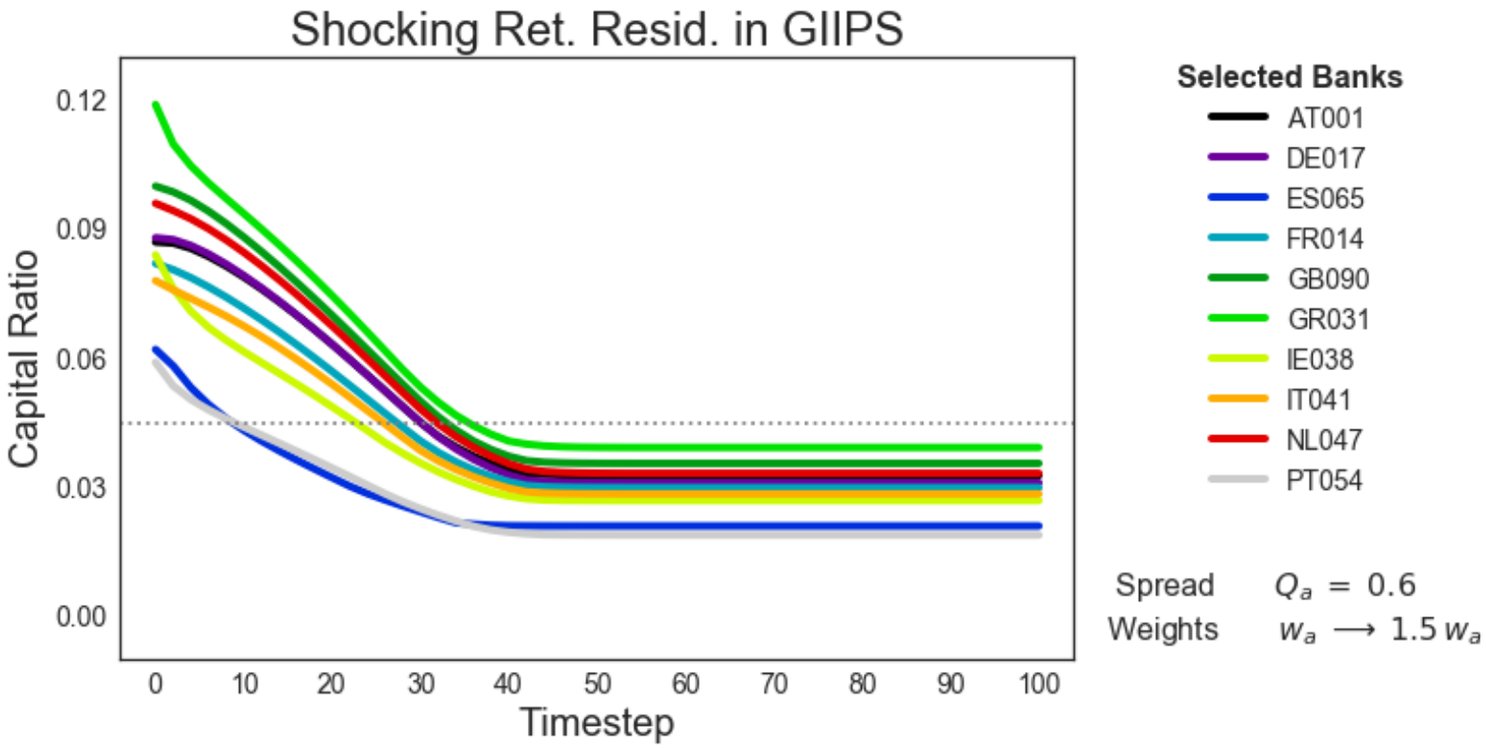
# Exploring Different Scenarios

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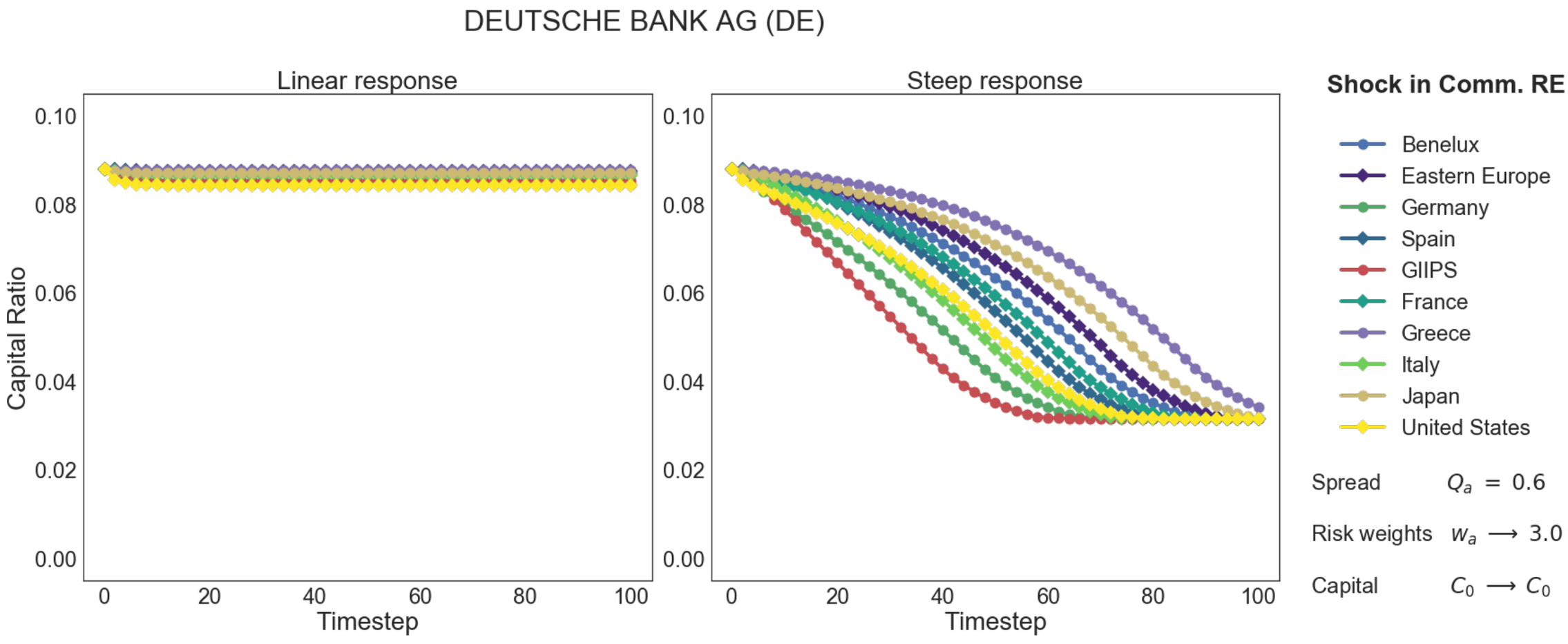
# One Bank's Tale

**Deutsche Bank, given a shock in Commercial Real Estate**

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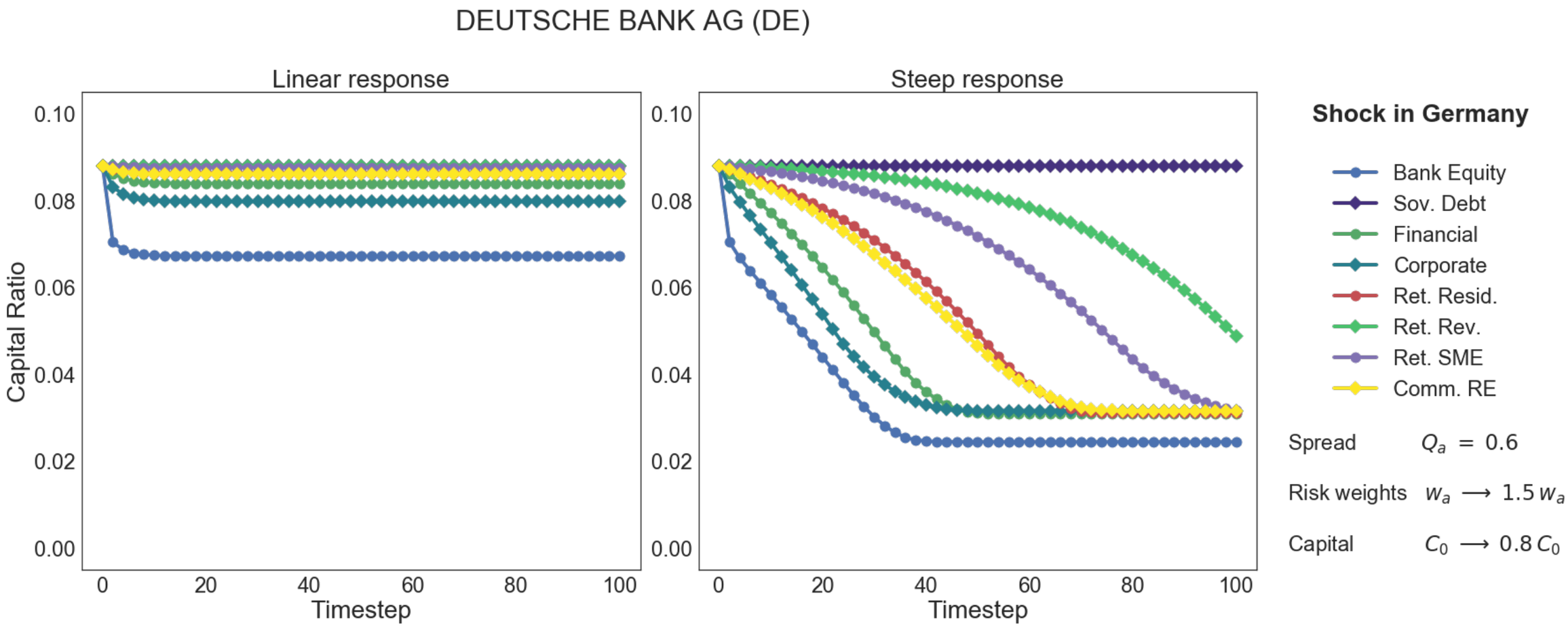
# One Bank's Tale

**Deutsche Bank, given a shock in Germany**

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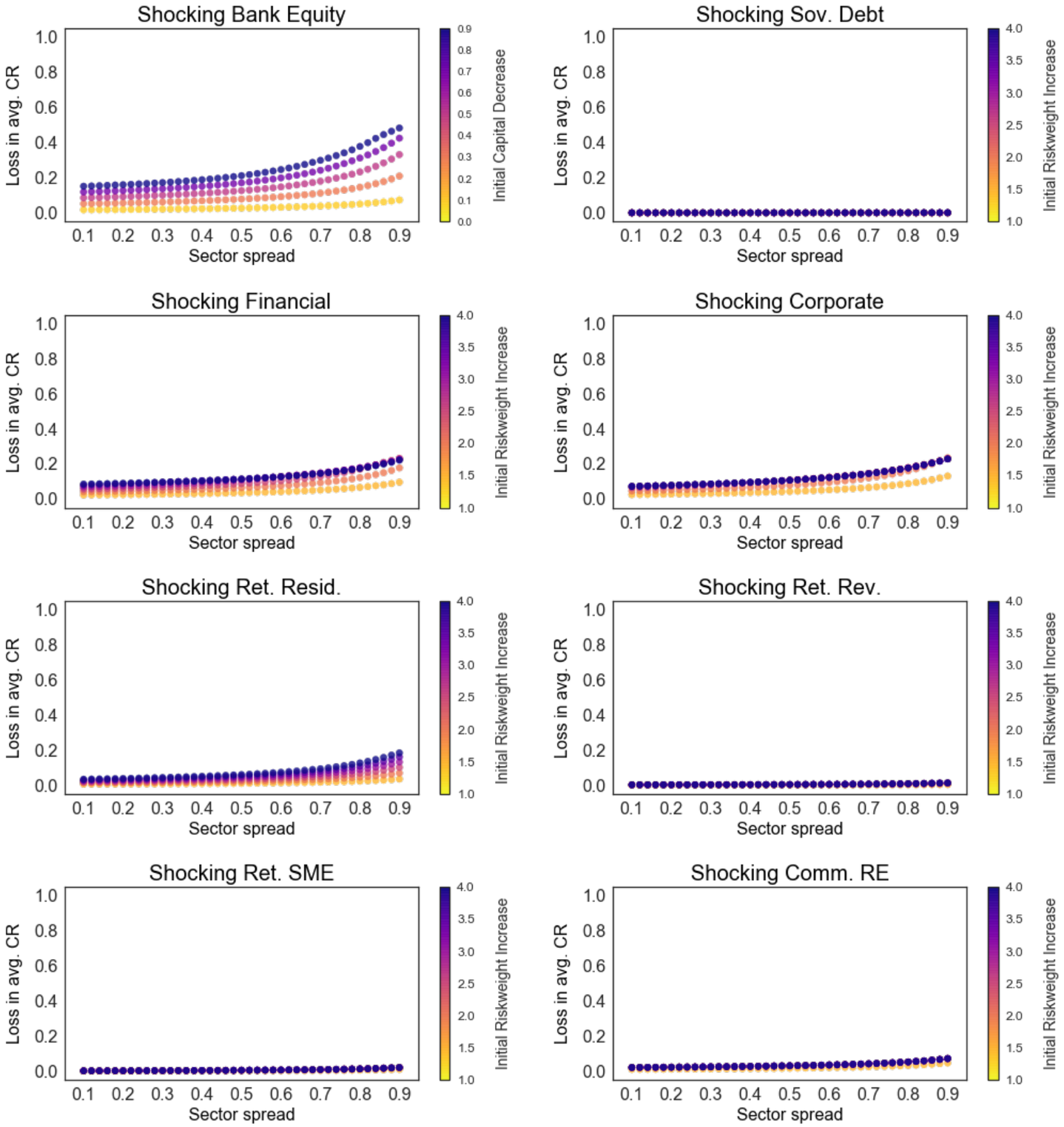
# Phase diagrams

- Study the outcome for banks after a fixed number of time steps for different parameters in different scenarios
  - initial shock size
  - spreading parameter
  - bank response function

# Beginning crisis in Germany
# (Linear response)

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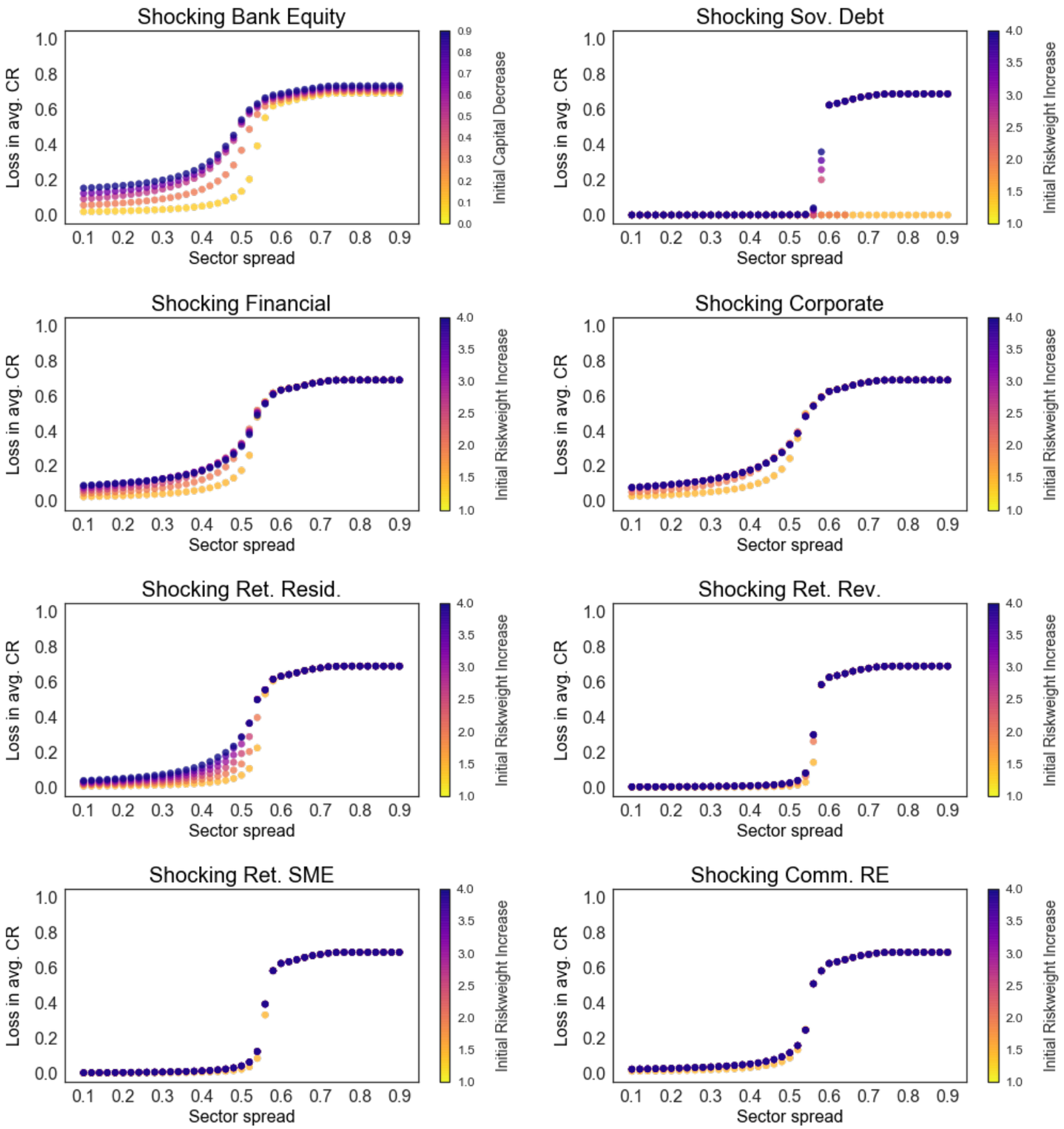
# Beginning crisis in Germany
# (Steep response)

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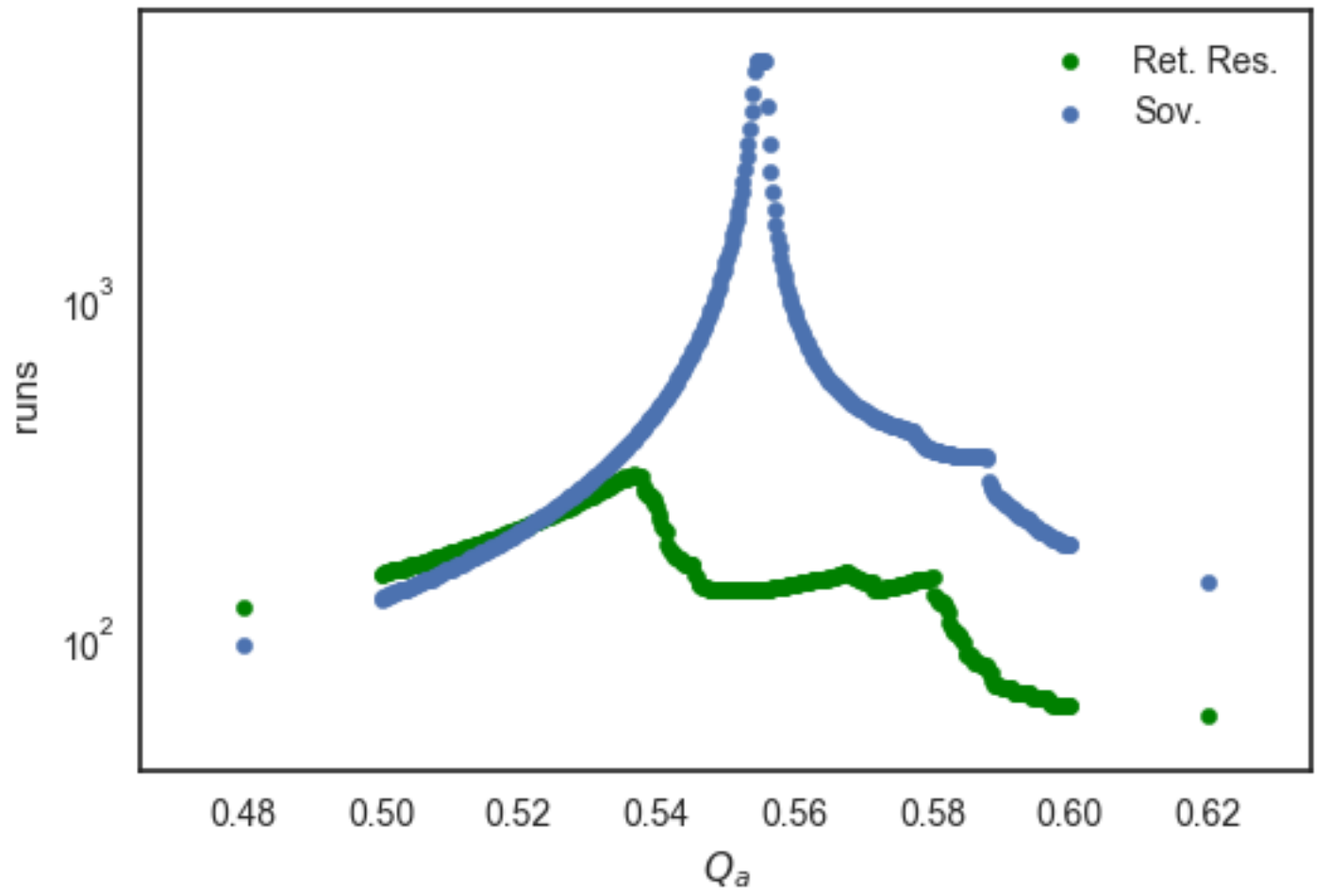
# Simulation run time

- As system nears critical point, the time to reach the final configuration diverges
- Especially pronounced for sovereign debt: very sharp transition
- Non-monotonic decline of relaxation time after first transition; indicates further spread in network.

Shock in Germany



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# Conclusion

- Significant overlap in portfolios, especially through regional bias
- Outcome depends on spreading parameter: measure of contagion!
- Common exposures are more dangerous if the response to a shock is more risk-averse.

  ==> macroprudential approach is essential!