DEUTSCHE BUNDESBANK EUROSYSTEM

Centrality-based Capital Allocations*

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*** Alter, A., B. Craig and P. Raupach (2015), Centrality-based capital allocations, *International Journal of Central Banking* 11(3), 329-377.**

Intro
Classic vs. systemic view on bank default risk

- Classic micro-prudential regulation of bank capital:
  - Consider all risks (and their interaction) on single-bank level.
  - Motto: Require the bank to hold enough capital to limit its default probability: $\text{Prob}(\text{losses} > \text{bank capital}) \leq 0.1\% \Leftrightarrow$

    $\text{Bank capital} \geq \text{Quantile}_{99.9\%}(\text{losses})$ (Value-at-Risk)
- Not THAT easy to implement. However, even if it was perfect:
  - External effects of bank defaults (the ultimate reason for bank regulation...) can be very different across banks.
  - Aspects:
    - Size of losses
    - Size of effects to the real economy
    - Which counterparties are affected (banks? insurances? or just “normal” depositors?)
    - Would their default have (particularly strong) effects? ← Our focus
    - Does the bank provide other critical services to the financial system?

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Approaches to a systemic bank regulation: The „gold standard“

- Task: make regulatory (= required minimum) capital dependent on a bank’s place/role in the financial system

- Steps:
  - Set up a comprehensive model of how risks to banks evolve and translate through the system to the ultimate risk takers
  - Choose a risk measure for the whole system (e.g. *average total losses* or *average of extreme losses* (the 1% worst ones…)

  - “Gold standard”: Minimize that measure over all possible capital allocation principles. All parameters of the risk model (including all bank-individual parameters) could be relevant

    Virtually impossible.
  - Instead: Choose plausible, more or less ad-hoc allocations

Approaches to a systemic bank regulation: More realistic approaches

- Even though ad-hoc to some degree, various reasonable capital allocation principles have been proposed, e.g.:
  - Determine by how much the system's risk measure changes through a bank's entry into the system (≈ "risk contribution" a.k.a. "Euler allocation", e.g. *Marginal Expected Shortfall*)
  - Determine by how much the system's risk measure changes through a bank's distress (e.g. *Delta-CoVaR*)
  - Current regulatory approach: Aggregate indicators of broad concepts of systemic importance (e.g. size, interconnectedness) and map them into (few) categories of systemic importance.

Our approach

Preceding steps as before:

- Set up a comprehensive risk engine that includes:
  - correlated losses from lending to the real economy
  - Propagation of losses through interbank lending
- Choose a risk measure for the whole system: expected total bankruptcy costs.
- Acknowledge that…
  - the value-at-risk-based capital allocation properly measures lending risks from the real economy;
  - some bank-specific centrality measures of the interbank lending network might capture aspects of who is important in loss propagation through the interbank network.
- Aggregate the two measures in a simple way:
  - Required capital = reduced VaR-based capital + network based capital
- Primary question: **Are network measures useful in this context at all?**

Related work

- **Elsinger, Lehar, Rheinberger, Summer (2006)**
  - combine common exposures with interbank network
  - fully fledged systemic risk analysis of the Austrian banking system
  - market and credit risk

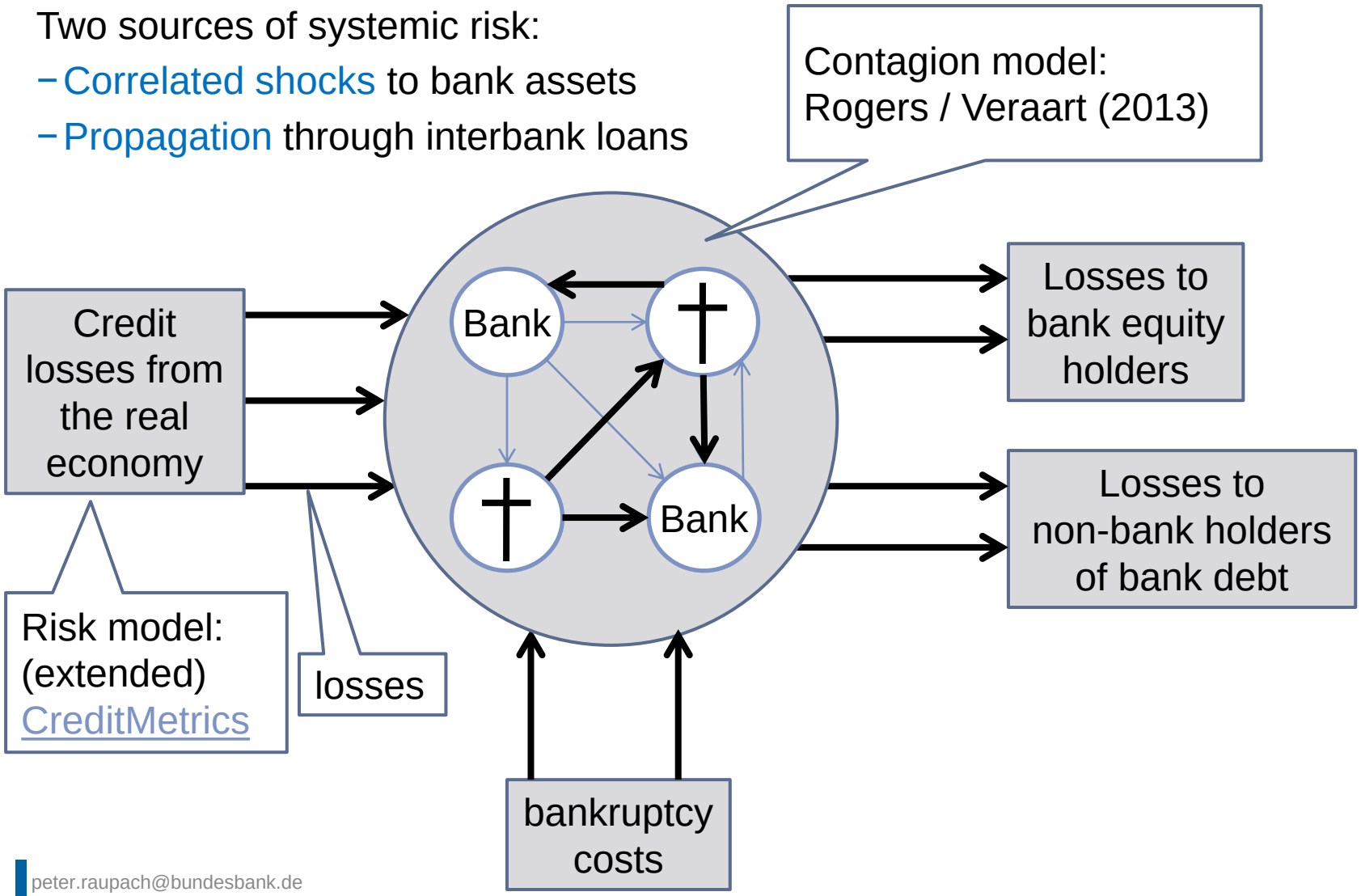
- **Gauthier, Lehar, Souissi (2012)**
  - introduce liquidity risk (through fire sales)
  - test return-based systemic risk measures
  - ambitious model with complicated feedback effects;
    fitted to 6 Canadian banks
  - not tractable for a large banking system as the German one (1700 banks)

The risk engine

The risk engine

Two sources of systemic risk:

- Correlated shocks to bank assets
- Propagation through interbank loans



Risk engine, block 1: Losses from lending to the real economy

Two sources of systemic risk:

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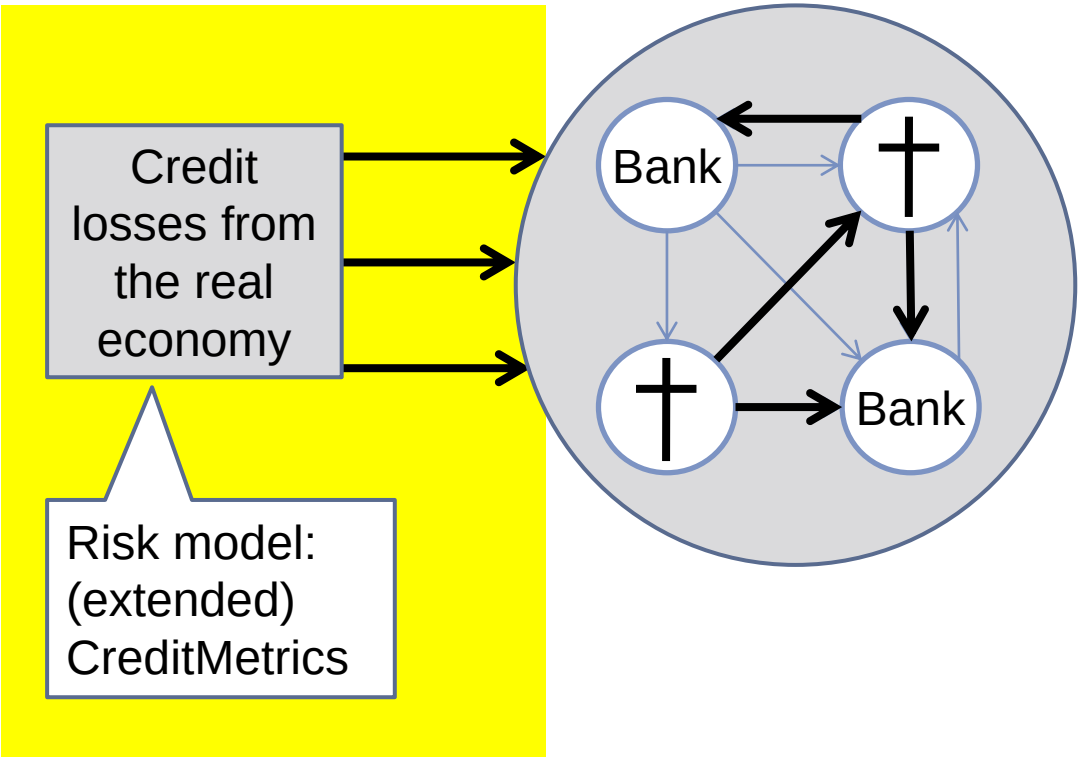
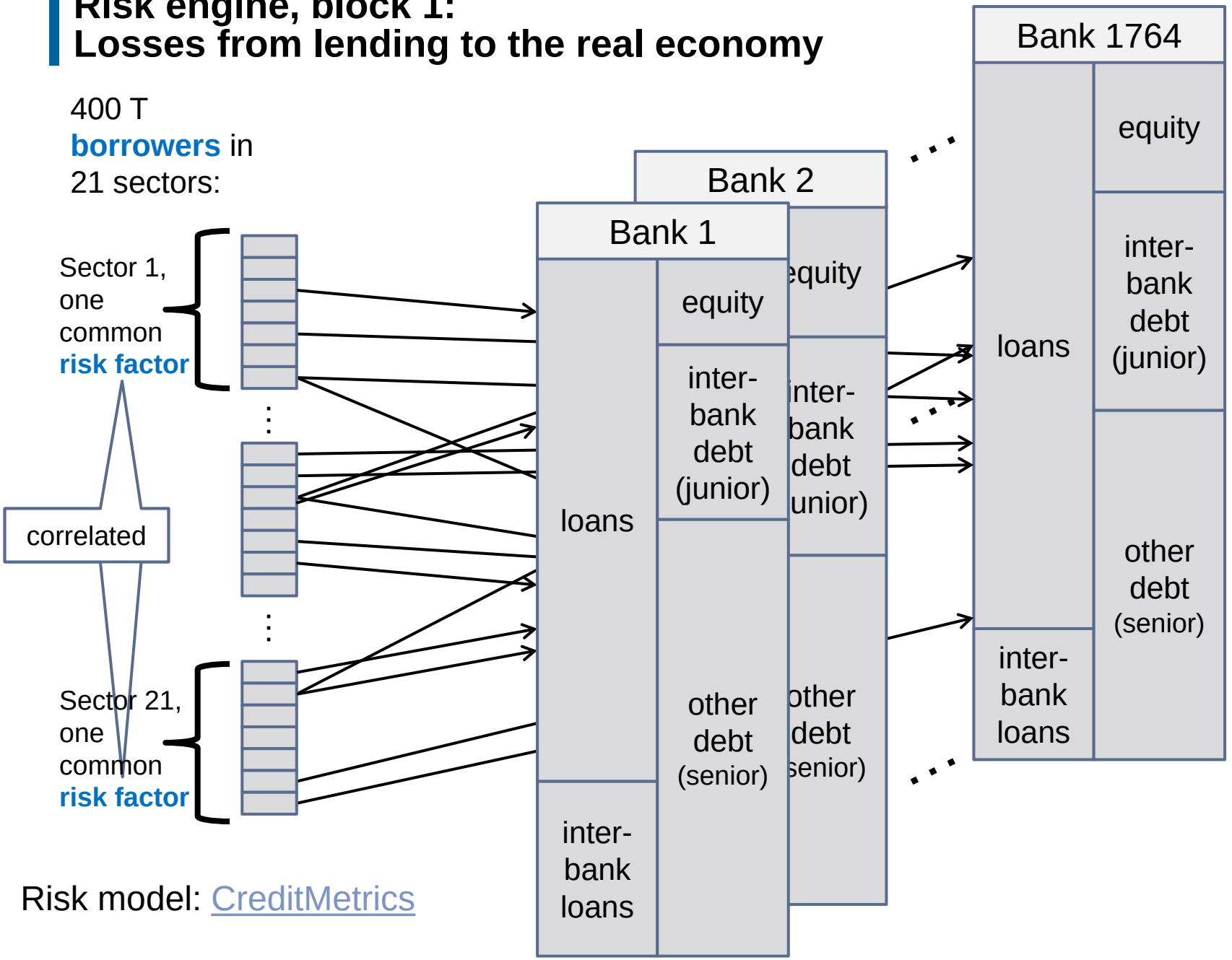


Risk engine, block 1: Losses from lending to the real economy



Risk model: CreditMetrics

Risk engine, block 2: Contagion model

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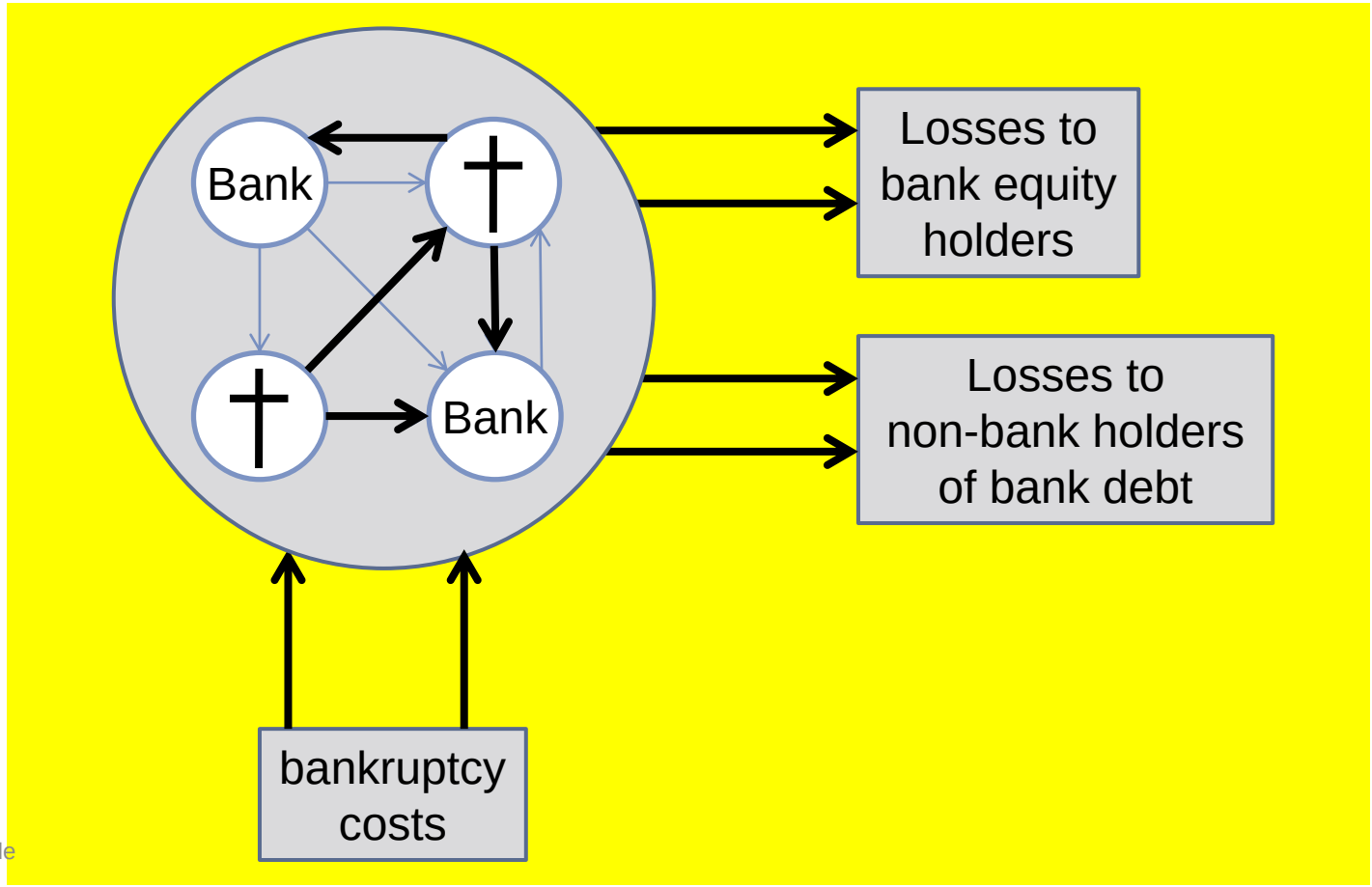


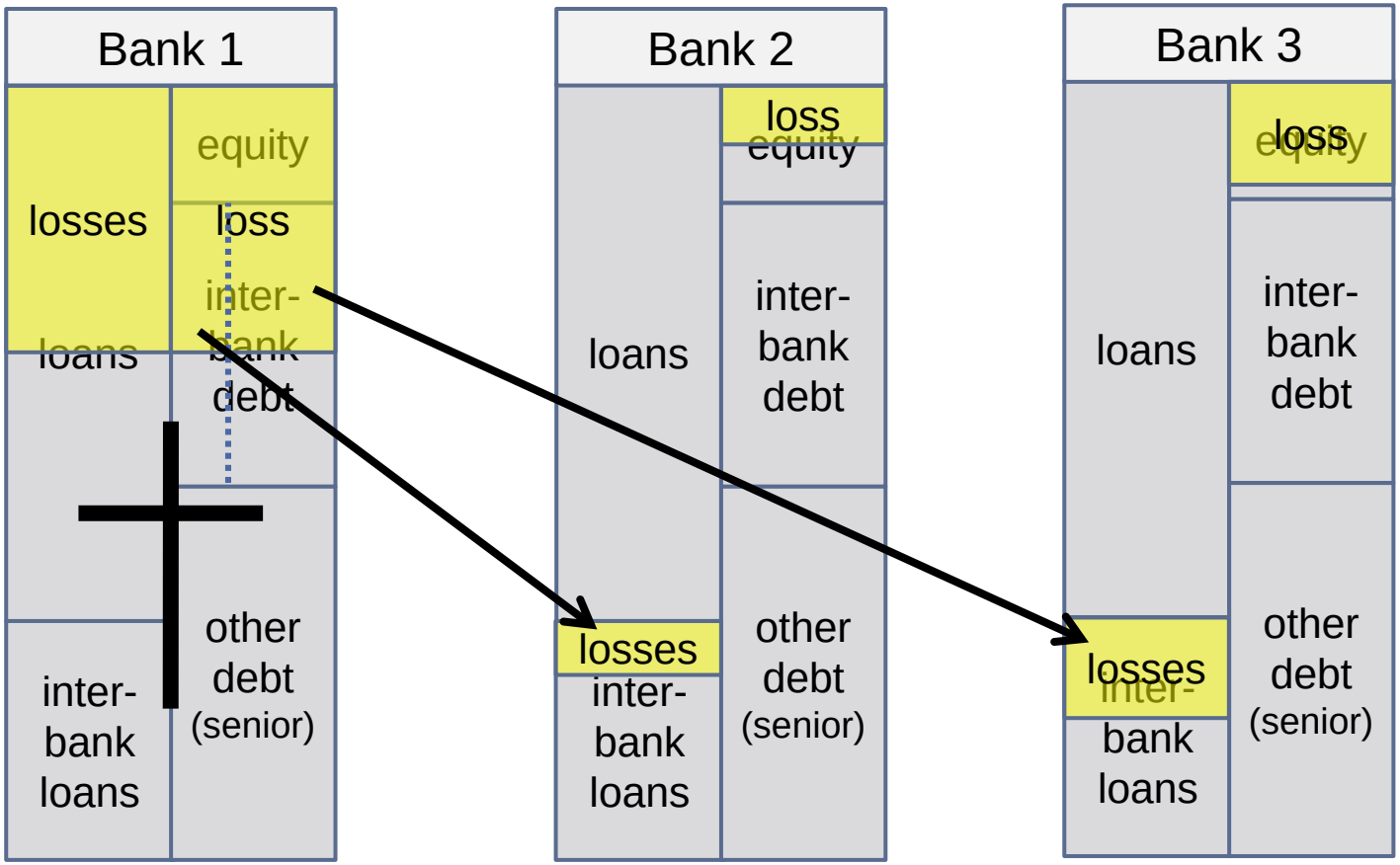
Risk engine, block 2: Contagion model

- Rogers / Veraart (2013), Failure and Rescue in an Interbank Network. *Management Science* 59 (4), 882-98.
  - Extends Eisenberg / Noe (2001) by bankruptcy costs
  - Simple algorithm converges to the minimum fixed point of losses.

- Main features:
  - Interbank liabilities are junior to non-bank liabilities (e.g. deposits).
  - In case of bank default:
    - Proportional loss sharing among interbank lenders;
    - Bankruptcy costs as a proportion of total assets. The proportion rises with aggregate bankruptcies in the system (proxy for “downturn LGDs” and fire sales)

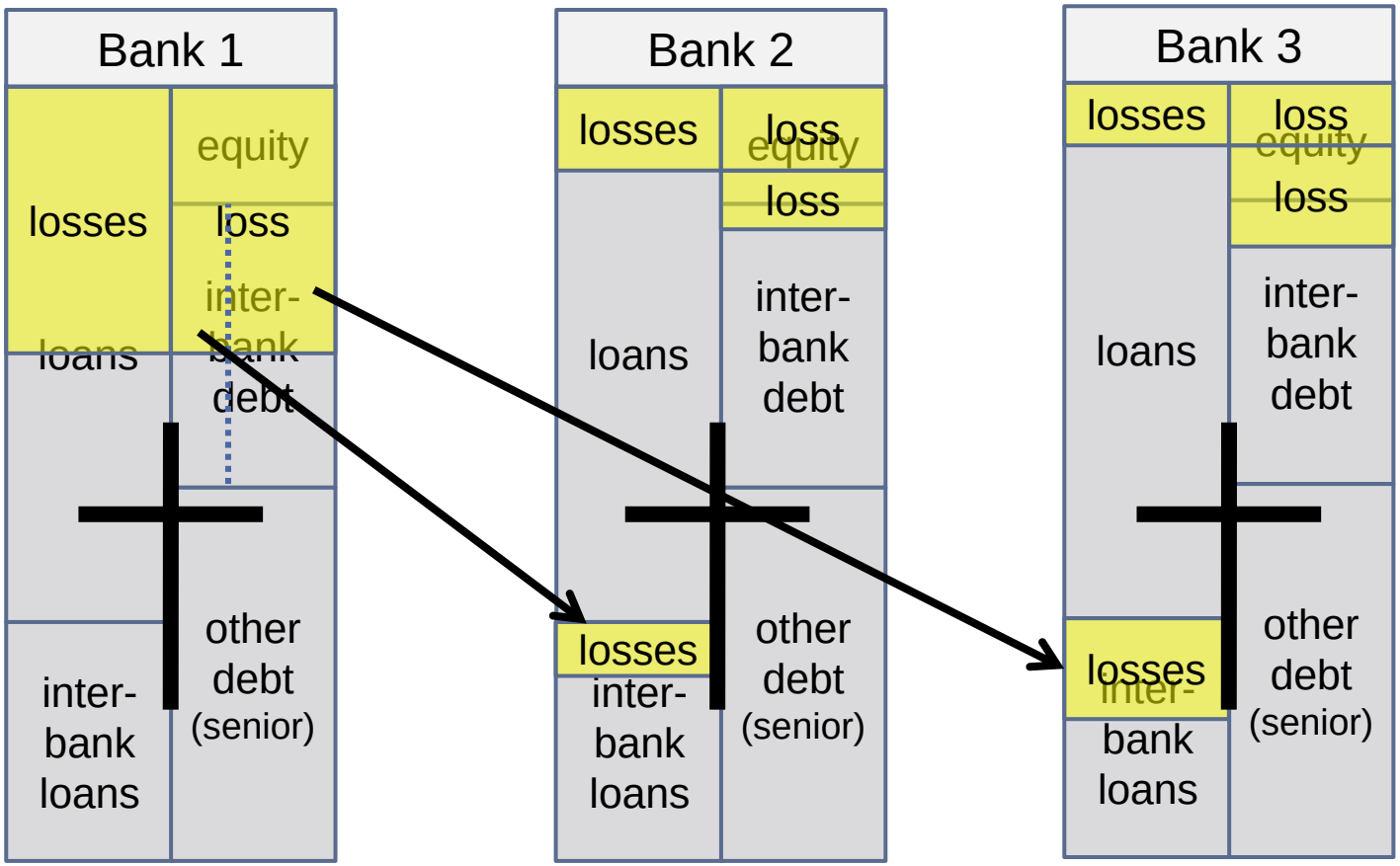
Why is it important for contagion that block 1 generates correlated losses from the real economy?

- Regime 1: **NO** correlation between losses from real-economy loans
- Scenario: Extreme losses for bank 1, bank 2 and 3 “as usual”



Why is it important for contagion that block 1 generates correlated losses from the real economy?

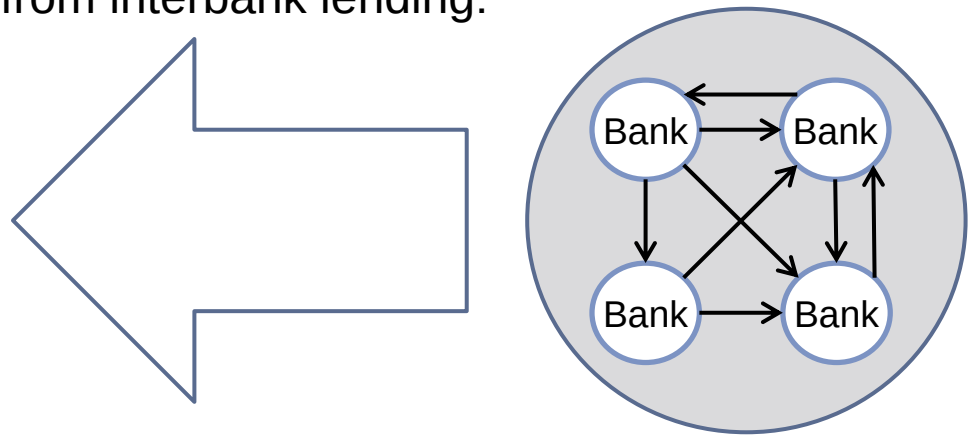
- Regime 2: correlation between losses from real-economy loans
- Scenario: Extreme losses for bank 1, bank 2 and 3 have “similar problems”:



Network centrality measures

Network centrality measures

- For each bank, calculate from interbank lending:
  - Eigenvector centrality
  - Closeness
  - Clustering coeff.
  - Opsahl centrality
  - Betweenness
  - …
  - …



- Each measure describes an aspect of a bank's place in the network

- Rather simple (➔ operable!), yet looking beyond the relationships directly visible to a bank (= arrows from/to a certain node)

Network centrality measures – Examples

- **Out degree**: number of banks a bank borrows from
  - "A bank is *central* if it borrows from many banks
- "**Opsahl centrality**" (Opsahl, Agneessen, Skvoretz, 2010)

$$OC_i = (\text{out degree}_i)^{1/2} * (\text{interbank liabilities}_i)^{1/2}$$

  - "A bank is *central* if it borrows much from many banks

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Network centrality measures – Examples

- **Eigenvector centrality** (similar: Google matrix)
  - "A bank is *central* if it borrows from many "central" ☺ banks."
- **Weighted eigenvector centrality**
  - "A bank is *central* if it borrows much from many "central" banks."
- **Closeness**: There is a *path* (of length *N*) from bank **A** to bank **B** if:

  A [borrows from a bank which]$^{N-1}$ borrows from **B**

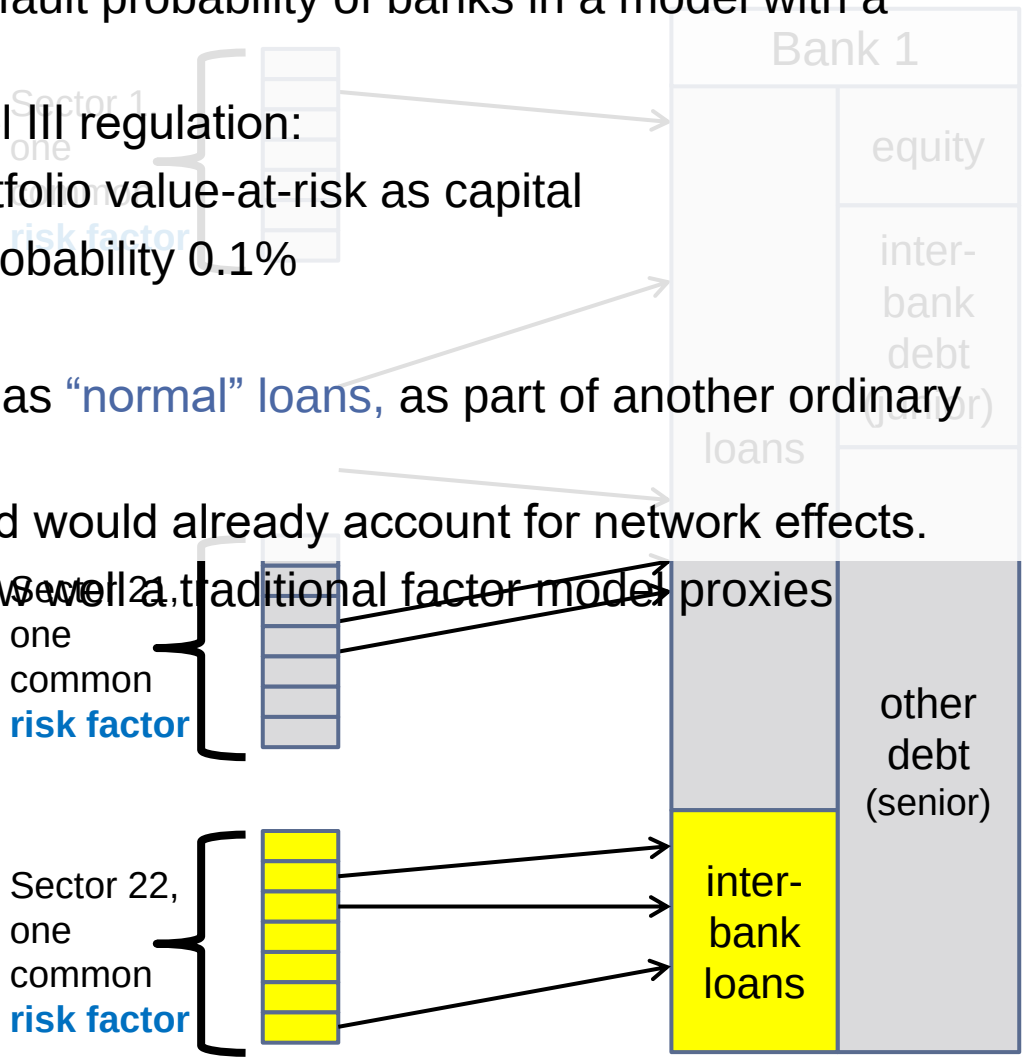
  - "A bank is *central* if it has many of short paths to other banks."

  $\mathrm{distance}(A, B)$: length of shortest path between A and B, otherwise ∞

  $$\mathrm{Closeness}(A) = \sum_{\text{other banks } B} \exp\{-\mathrm{distance}(A, B)\}$$

The benchmark capital allocation

- Basel III targets at a 0.1% default probability of banks in a model with a single systematic factor
- We suppose a “perfect” Basel III regulation:
  - Banks hold their 99.9% portfolio value-at-risk as capital
  - Banks would default with probability 0.1%
- However…
  - Interbank loans are treated as “normal” loans, as part of another ordinary sector of the real economy.
  - Otherwise, our “Basel” world would already account for network effects.
  - By-product: validation of how well a traditional factor model proxies defaults of interbank loans.



Capital (re)allocation – Putting the benchmark and network measures together

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- Give each bank *i* an (imaginary!) proportional relief of their benchmark capital (99.9% portfolio VaR under the benchmark model)

  Redistribute this relief proportionally to a network centrality measure C_i

$$K_{i,\text{centr}} = \text{VaR}_{i,99.9\%}(1 - \beta + a\beta C_i)$$

- Tune a such that the total required capital in the system remains constant.
- Optimization over β and the choice of a centrality measure.

  Target: expected bankruptcy costs

  - Why this? These are frictions in the system.

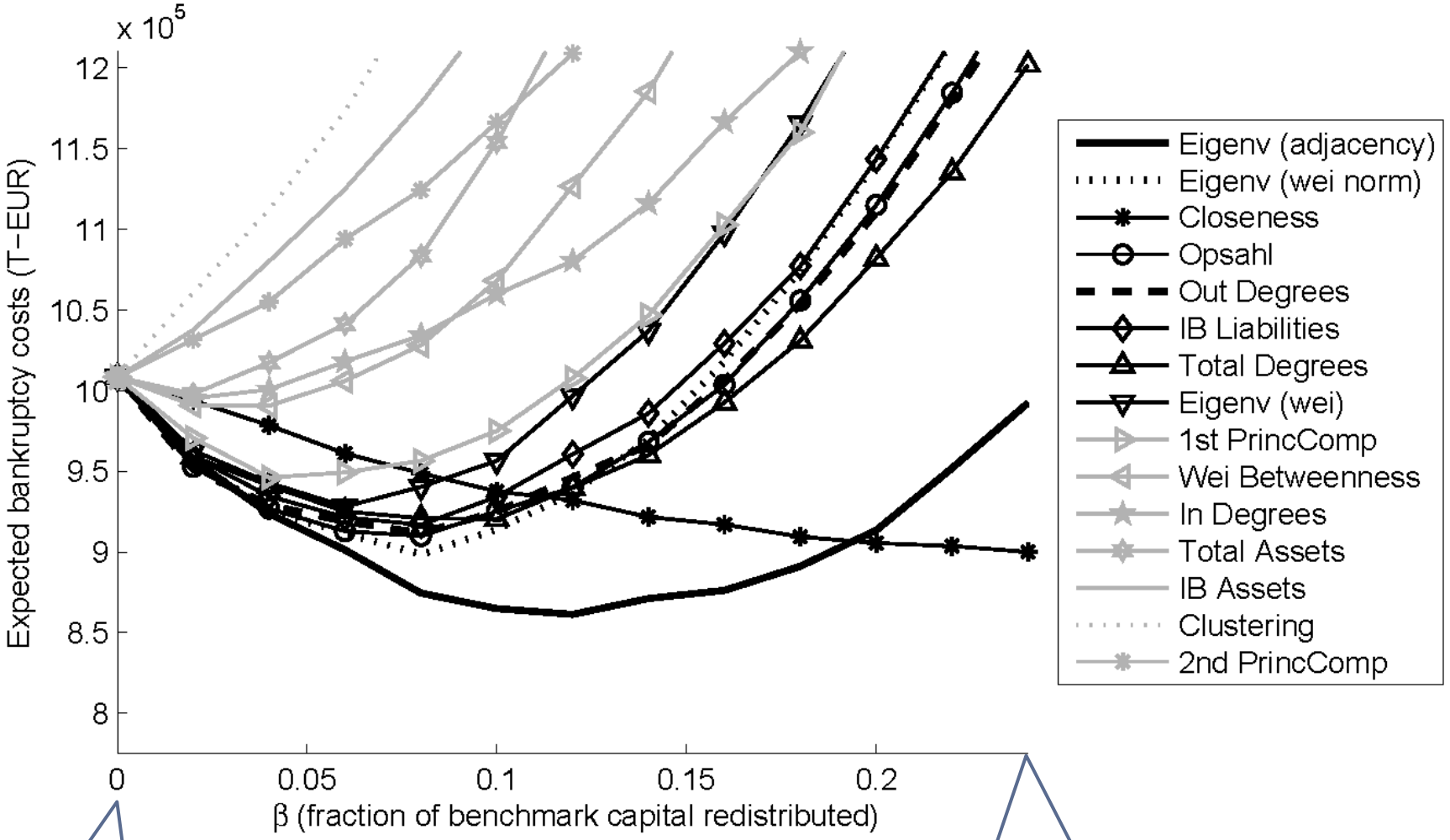
We perform this exercise with real lending data from Germany

- German credit register: bilateral info on all loans in excess of EUR 1.5 mn
  - Loan volume
  - Borrower's identity
  - Sector (Industry)
  - Probability of default
- Snapshot Q1 2011
  - 1,764 banks, mostly S&L banks and cooperative banks
  - total assets: EUR 7.7 tn
  - 400 T bank-borrower pairs

- Borrower statistics: domestic lending (covers loans neglected by credit register), by…
  - Bank
  - Sector

Results

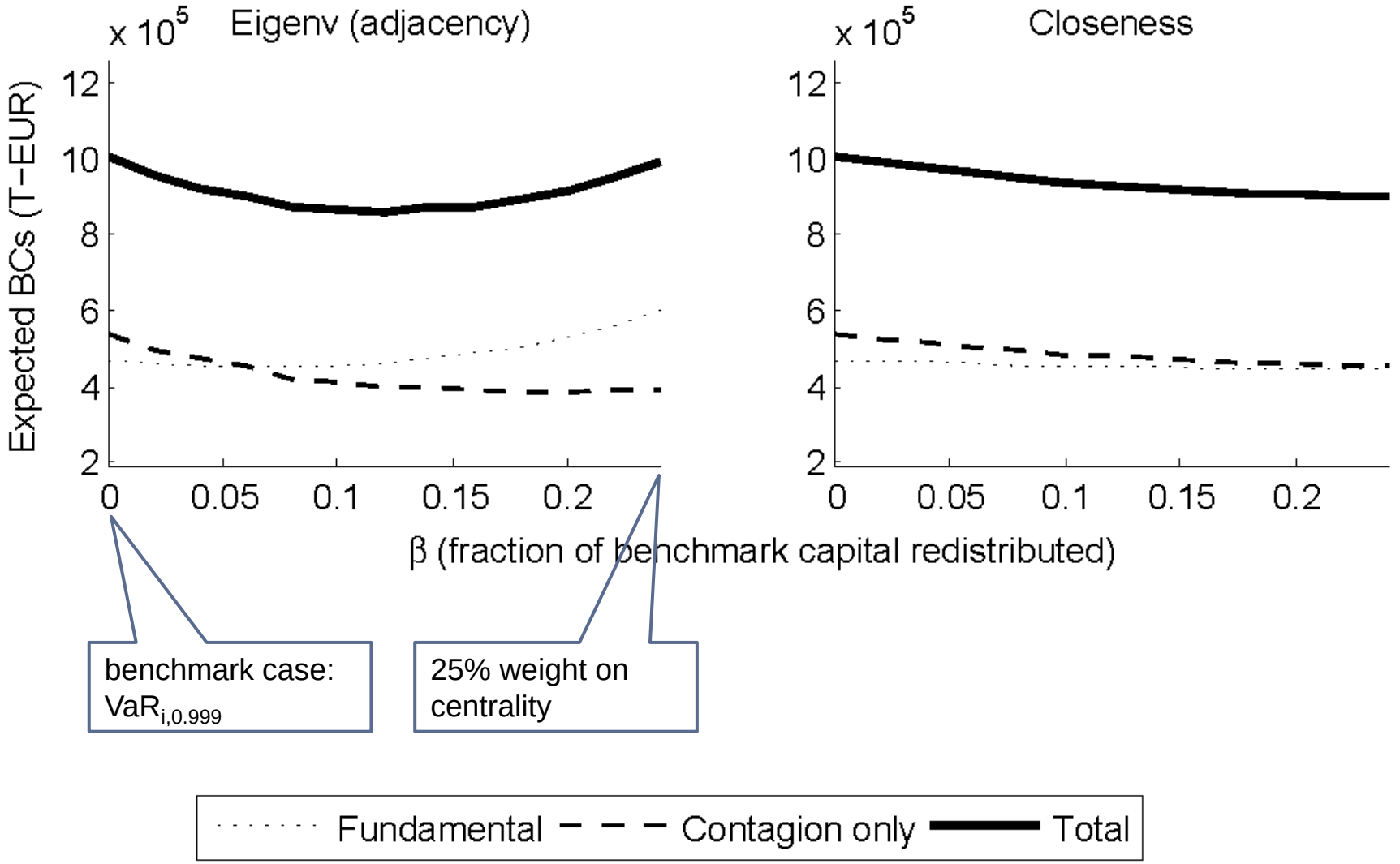
Capital (Re-) Allocation, Optimization Results
Expected Bankruptcy Costs



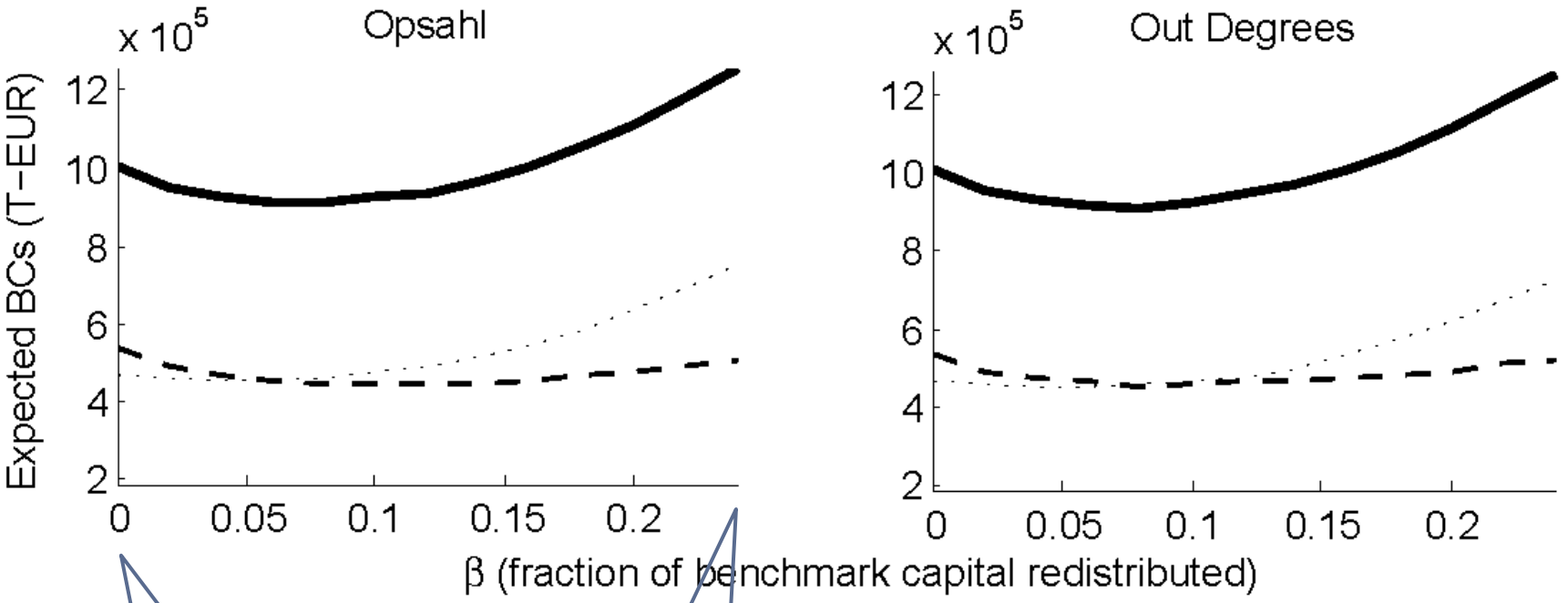
benchmark case:
$VaR_{i,0.999}$

maximum weight on centrality:
$0.75\ VaR_{i,99.9\%} + 0.25\ a \times C_i$

Components of expected bankruptcy costs – Before and after contagion



Components of expected bankruptcy costs: Before and after contagion

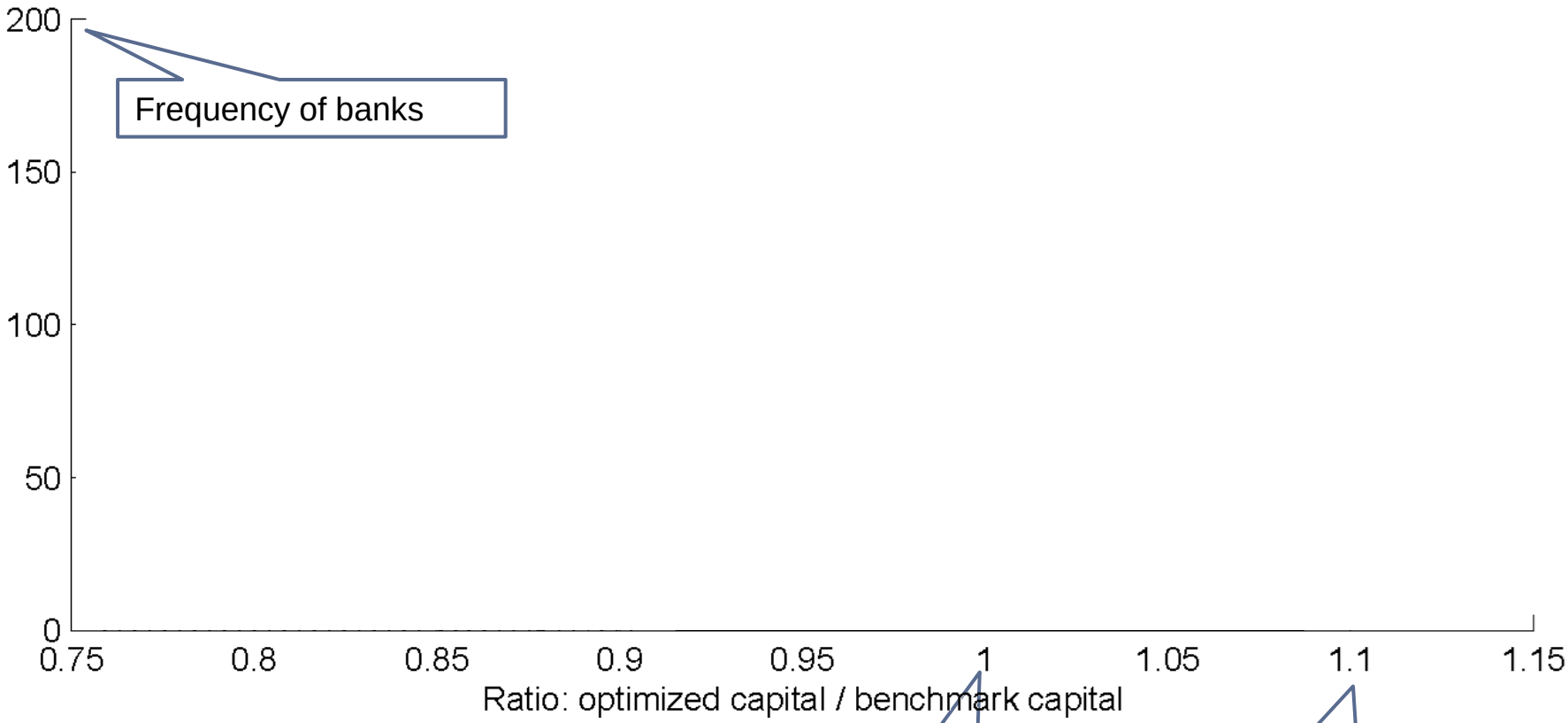


benchmark case: $VaR_{i,0.999}$

25% weight on centrality

Fundamental — Contagion only — Total

Who has to hold more capital, who less?



(Link: effect on PDs)

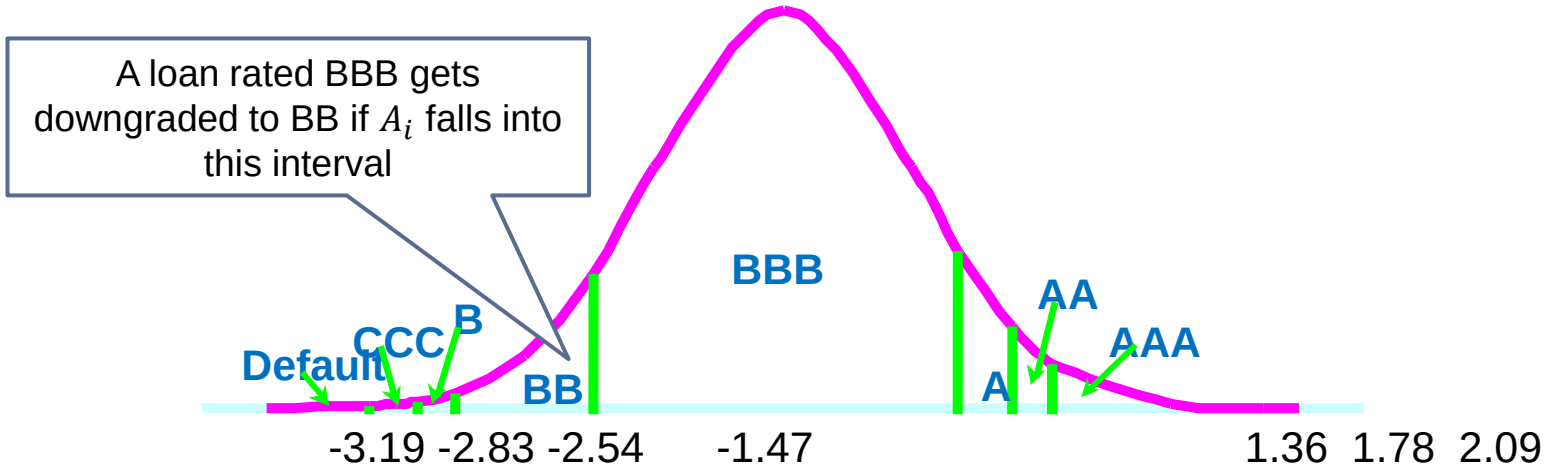
Conclusion

- We utilize network measures to search for capital allocations that account for systemic aspects
  - Operable, owing to the simplicity of the measures and the absence of estimation errors; tractable for large banking systems.
- Thorough risk modeling:
  - Precise lending data
  - Correlated shocks from the real economy. This is essential!
  - Fixed point in the interbank market involves bankruptcy costs
- Network measures can help improving system stability w/o additional capital, with moderate benefits
- The centrality measure most intuitive for interbank lending (eigenvector) performs best

Simulating Credit Portfolio Returns: The Basic Mechanics of CreditMetrics (1)

(back)

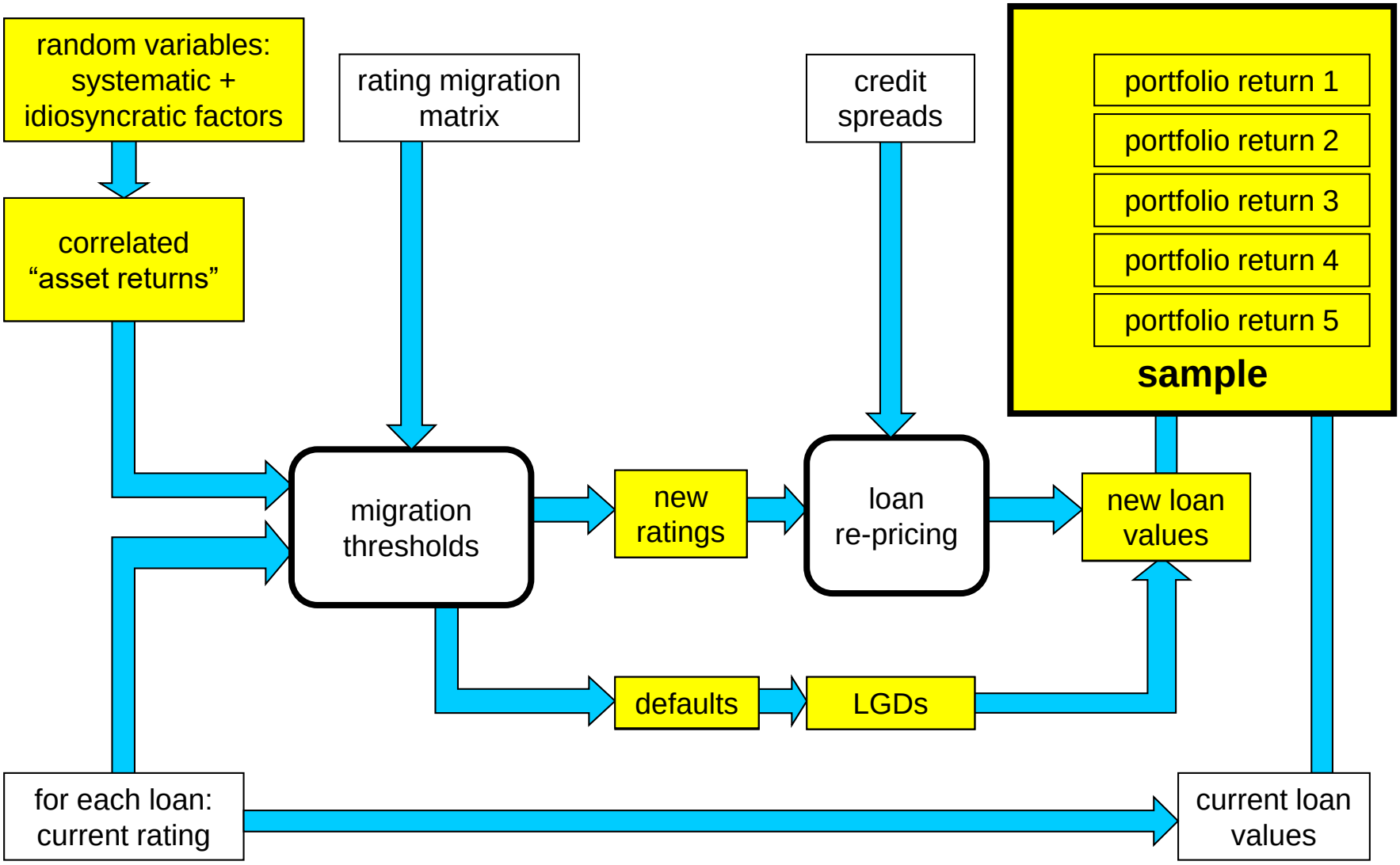
- CreditMetrics simulates rating migrations for all loans in a portfolio
- Migrations are derived from (very stylized, $N(0,1)$-distributed) random "asset returns" A_i using a threshold mechanism:



- These "asset returns" are correlated, e.g. via one (or more) common factor(s): $A_i = \sqrt{\rho}Y + \sqrt{1-\rho}Z_i$

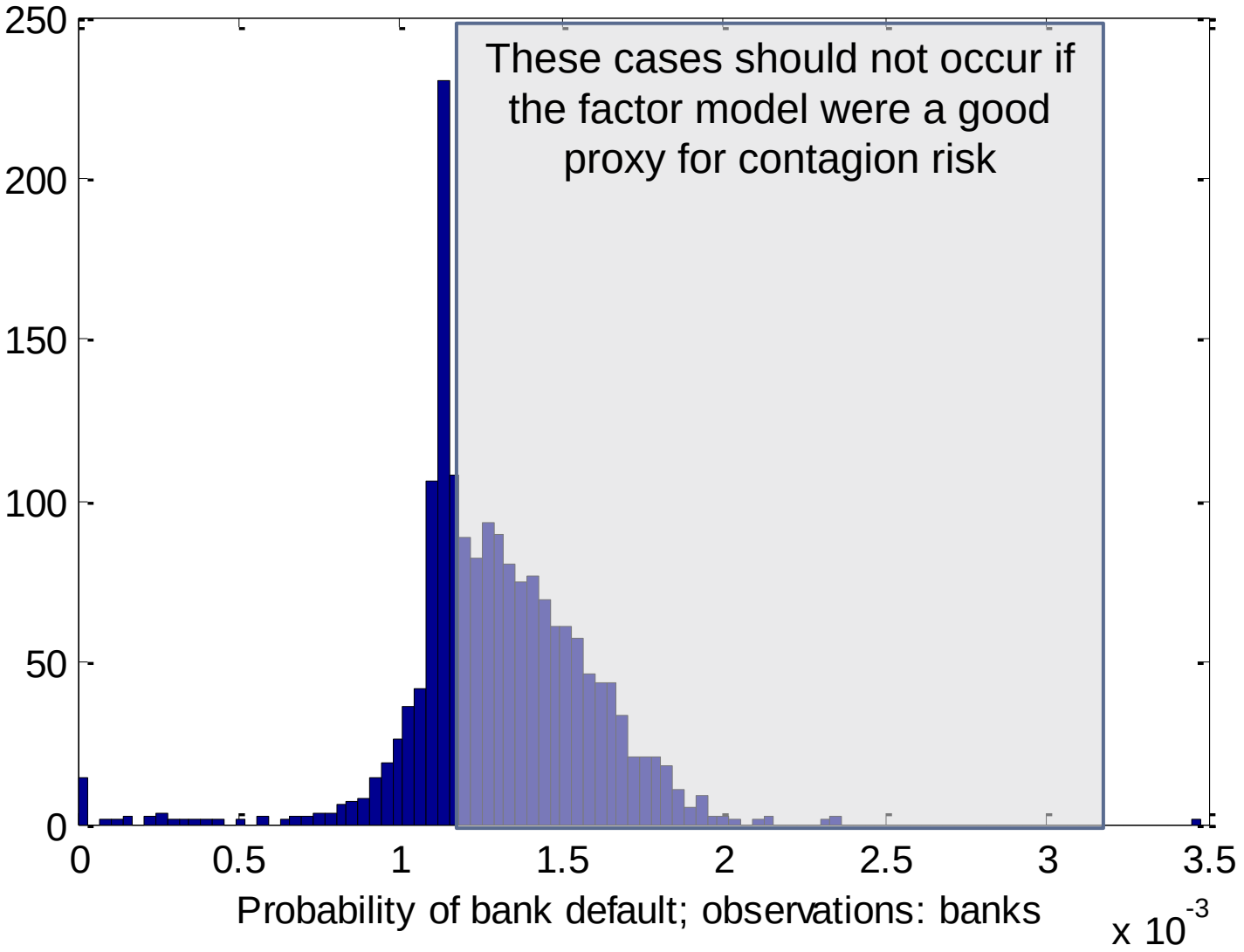
Simulating Credit Portfolio Returns: The Basic Mechanics of CreditMetrics (2)

(back)



The Benchmark capital allocation
By-product: Validation of factor model for interbank loans

(back)



Who has to hold more capital, who less?

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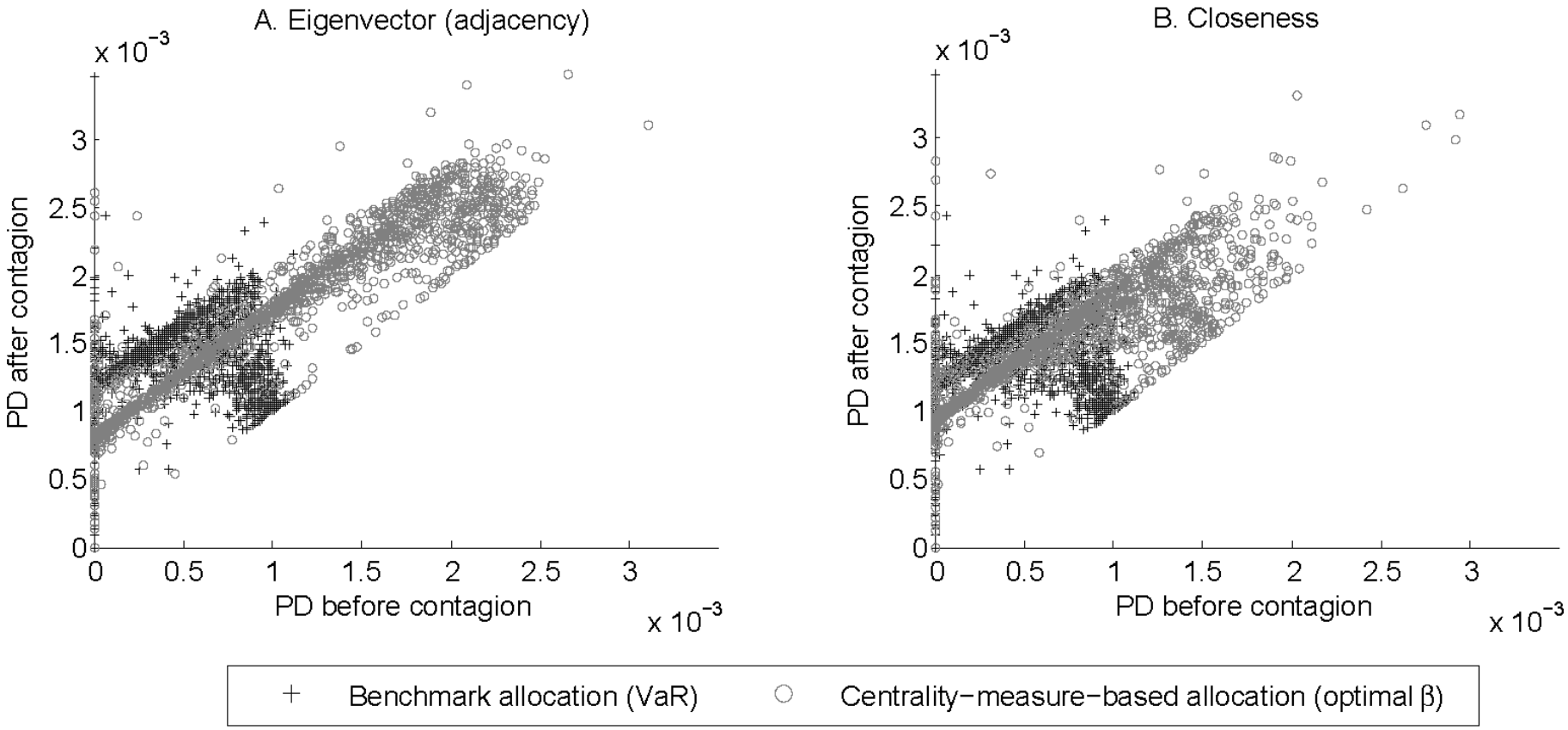

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