Interbank Tiering and Money Center Banks

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Outline

● **Part I: Interbank tiering**
  - Define tiering in networks → core-periphery model
  - Procedure to fit model to real-world networks
  - Identifies core ⊂ intermediaries

● **Part II: Empirical application**
  - Bundesbank data: interbank exposures (n>1800)
  - Testing for structure: clear & persistent tiering
  - Not random: bank features predict network position
  - Link banking theory and network formation.
From intermediation to tiering

- An **interbank intermediary** is a bank acting both as lender and borrower in the interbank market.
  - Redistribution
  - Insurance and diversification
  - Maturity transformation.

- **Interbank tiering** arises when some banks intermediate between other banks that do not transact among themselves.
  - Structural property of system (not of a single bank)
  - Network concept: two tiers based on bilateral relations
  - Founded on economic concept: intermediation
  - Special intermediaries that hold together the interbank market.
Illustration of tiering

- Reds lend to each other
- Whites do not lend to each other
- Reds lend to Whites
- Reds borrow from Whites

- Red=core: special intermed.
- Hold together IB market
- It’s a network concept.
Distance: aggregating structural inconsistencies

Tiering is a matter of degree:
→ measure distance between perfectly tiered structure and actual network
→ Fitting = find core as the optimal (distance-minimizing) partition.
Network model of tiering

- A network exhibiting tiering should have this block-model form:

\[
M = \begin{pmatrix}
CC & CP \\
PC & PP
\end{pmatrix} = \begin{pmatrix}
1 & RR \\
CR & 0
\end{pmatrix}
\]

- Special kind of core-periphery model: emphasis on relation *between* core and periphery
- Tight on core, lax on periphery, makes sense for interbank market.
Fitting models to networks by minimizing distance

- Devise procedure for fitting networks and judging the fit
- Regression est $\beta$, here optimal sets (# & id) mins structural distance
- $M$ predicts how $N$ should look like under perfect tiering
- Aggregate errors in each block (size endogenous)

\[
E = \begin{pmatrix}
    c(c-1) - \sum_{i \in C} \sum_{j \in C} N_{ij} \\
    (n-c) \sum_{j \in C} \max \left\{ 0, 1 - \sum_{i \notin C} N_{ij} \right\} \\
    (n-c) \sum_{i \in C} \max \left\{ 0, 1 - \sum_{i \notin C} N_{ij} \right\} \\
    \sum_{i \notin C} \sum_{j \notin C} N_{ij}
\end{pmatrix}
\]

Distance = total error score:

\[
e = \frac{E_{11} + E_{22} + (E_{12} + E_{21})}{\sum_i \sum_j N_{ij}}.
\]
Solution: optimal core

\[ C^* = \arg \min C' e(C) \]
\[ = \{ C \in \Gamma | e(C) \leq e(c) \ \forall c \in \Gamma \} \]

- Intermediaries are nec and suf for identifying core-periphery
- Core banks are (strict) subset of all intermediaries
- Property of model carries over to statistical fit.
Empirical part: The German interbank market

- Constructing the network
  - *Gross und Millionenkreditstatistik*
  - All large (>€ 1.5m) or concentrated (>10% K) exposures
  - Bilateral exposures between 2000+ banks, qtrly 1999Q1+
  - Consolidated by Konzern, excluding IO, excluding XB

- Basic network statistics
  - Large n=1800 banks*, sparse: dens=0.41% → structure
  - *Furball* vs model-based fitting
  - Large-scale problem in combinatorial optimization → *Algorithm*

* 40 Kreditbanken, 400 Sparkassen, 1150 Kreditgenossenschaften, 200 special purpose banks
Results I

- #Core = 2.7% of #intermediaries
- Error score: 2406 (12.2% links, 0.0074% cells), o/w 1723 in periphery
- Dense core (60%), sparse periphery
- No errors in off-diagonal blocks: proper core banks.
Results II: Structure is highly persistent over time

- Measurable in transition matrix
- Identified a *structural* feature: can’t just be liquidity shocks.
Results III: Structure seems robust

- Structure unchanged when raising censoring threshold
- Still observed in segment least shaped by legal factors.
Results IV: Significance?

- Test against random networks (not hierarchical in nature)
- German score much closer to zero than any realization
- Reject $H_0$ that observed tiering may result from random process.
Interbank tiering and money center banks

- If tiering arises by purposeful economic choice, expect different banks to build different patterns of linkages!
- Differentiate by bank-specific features: balance sheets for 1800 banks
- Test: do bank variables predict core membership?

\[ \text{prob}(b_i = 1) = \Phi(x_i'\beta). \]
Predicting network position

- Larger banks more likely to be in the core; periphery banks small
- In line with MCBs, FFM studies, reserve pyramiding
- Connectedness also helps (outliers: „too connected to fail“?)
- Systemic importance proxied by interbank intermediation
- Core can be identified even without network data
- Each variable contributes a facet to explaining network position.
Concluding thoughts

- Interbank network doesn’t look like banking theory imagines:
  - Persistent – something more structural than liquidity shocks
  - Sparse and hierarchical – key role of intermediation!
  - Predictability – bank features drive network position.

- This bridge suggests:
  - promising avenue for understanding network formation
  - Asymmetric structures require specialization or heterogeneity in banking models.

Thank you.
Extra slide: Implementation algorithm

- Fitting M to N is a large-scale problem in combinatorial optimization
- Vast number of partitions (size of core is endogenous)
- NP-hard problem (exponential time): impossible for 2000 nodes
- Devised two algorithms (runs in polynomial time $n^2$ and $n^1$)
  - Switch nodes in/out of core until error score minimized
  - Greedy algorithm (steepest descent) with random initial partition
  - Simulated annealing (more randomness) to avoid local minima.
  - To assure consistent results: backtest in Pajek, validate on constructed networks, repeat applications.
  - Details in Appendix B.
Extra slide: German Banking System June 2003
(rendered in Pajek, Kamada-Kawai algorithm)

How do you discern the structure?
Current approach: calculate 100 unrelated network measures
Our approach: block-modelling based on economic concept