BANK FOR INTERNATIONAL SETTLEMENTS

Filling in the Blanks: Interbank Linkages and Systemic Risk

Kartik Anand, Bank of Canada

Ben Craig, Federal Reserve Bank of Cleveland & Deutsche Bundesbank

Goetz von Peter, Bank for International Settlements

Workshop on *Interlinkages and Systemic Risk* – Ancona July 2013

Motivation & Outline

- Interbank contagion is central, but bilateral linkages often unknown
- Standard: estimate counterparty exposures by **maximum entropy**
- Yet spreading exposures as evenly as possible can be misleading:
  - Conceals “true” structure of linkages in network analysis
  - Diversification assumption causes bias in systemic stress tests

- This short paper proposes opposite benchmark: **minimum density**
- Produces a highly concentrated sparse network that
  - retains some of the original network structure
  - helps provide robustness bounds on systemic stress tests.

Density
33%

Density
62%

?

Density
21%

Part I: Minimum Density – problem statement

- Premise: network linkages are costly and based on relationships
- Efficiency: minimally connected network s.t. satisfying marginals

$$\min_X c \sum_{i=1}^{N} \sum_{j=1}^{N} \mathbf{1}_{[X_{ij}>0]} \quad \text{s.t.}$$

$$\sum_{j=1}^{N} X_{ij} = A_i \quad \forall i = 1,2,..N$$

$$\sum_{i=1}^{N} X_{ij} = L_j \quad \forall j = 1,2,..N$$

$$X_{ij} \geq 0 \quad \forall i,j$$

- Analogous to transport network design problems: NP-hard
- Exhaustive search impossible (1800 banks…) ⇒ devise algorithm.

Algorithm guided by two main ideas

- Robust choice under uncertainty ⊔ multinomial logit function

$$\max_{p \in \Delta} \left[\mathbf{v}'\mathbf{p} - \delta v(\mathbf{p}, \mathbf{q}) \right] \quad \Rightarrow \quad p_i^* = \frac{q_i \, \mathrm{e}^{v_i/\delta}}{\sum_{j \in \mu} q_i \, \mathrm{e}^{v_j/\delta}}$$

- Economic incentives ⊔ disassortative interbank relationships

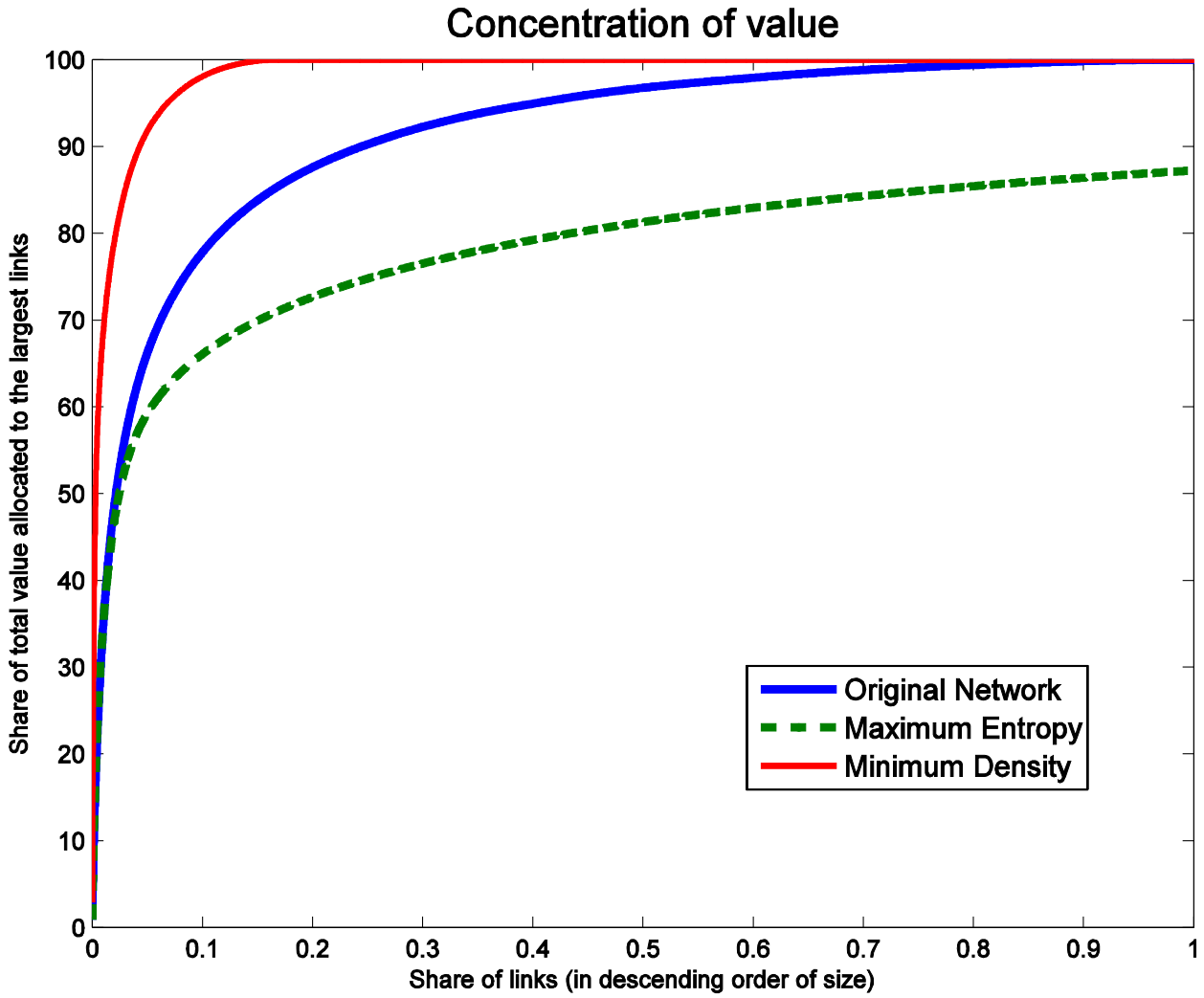
$$Q_{ij} \propto \max\left\{ \frac{AD_i}{LD_j}, \frac{LD_j}{AD_i} \right\} \quad \forall i,j \in \mu.$$

- i ⊔ j if big lender to small borrower, or small lender to big borrower
- Algorithm identifies probable links and puts maximum load until V
- Allow for partial loading and for full space of possible

Part II: Comparison with the German Interbank Market

- The observed ("true") interbank network
  - All large (≥€ 1.5m) or concentrated (>10% K) exposures
  - Consolidated by Konzern, excluding IO, excluding XB
- Basic network characteristics
  - Large (n=1802), sparse (density=0.6%)
  - But most banks active on both sides
- Maximum Entropy (ME) conceals structure (density 93%)
- Minimum Density (MD) solution is efficient (density 0.1%), because banks with small positions drop out of set μ.
- ME and MD differ in trading off the number vs size of links.

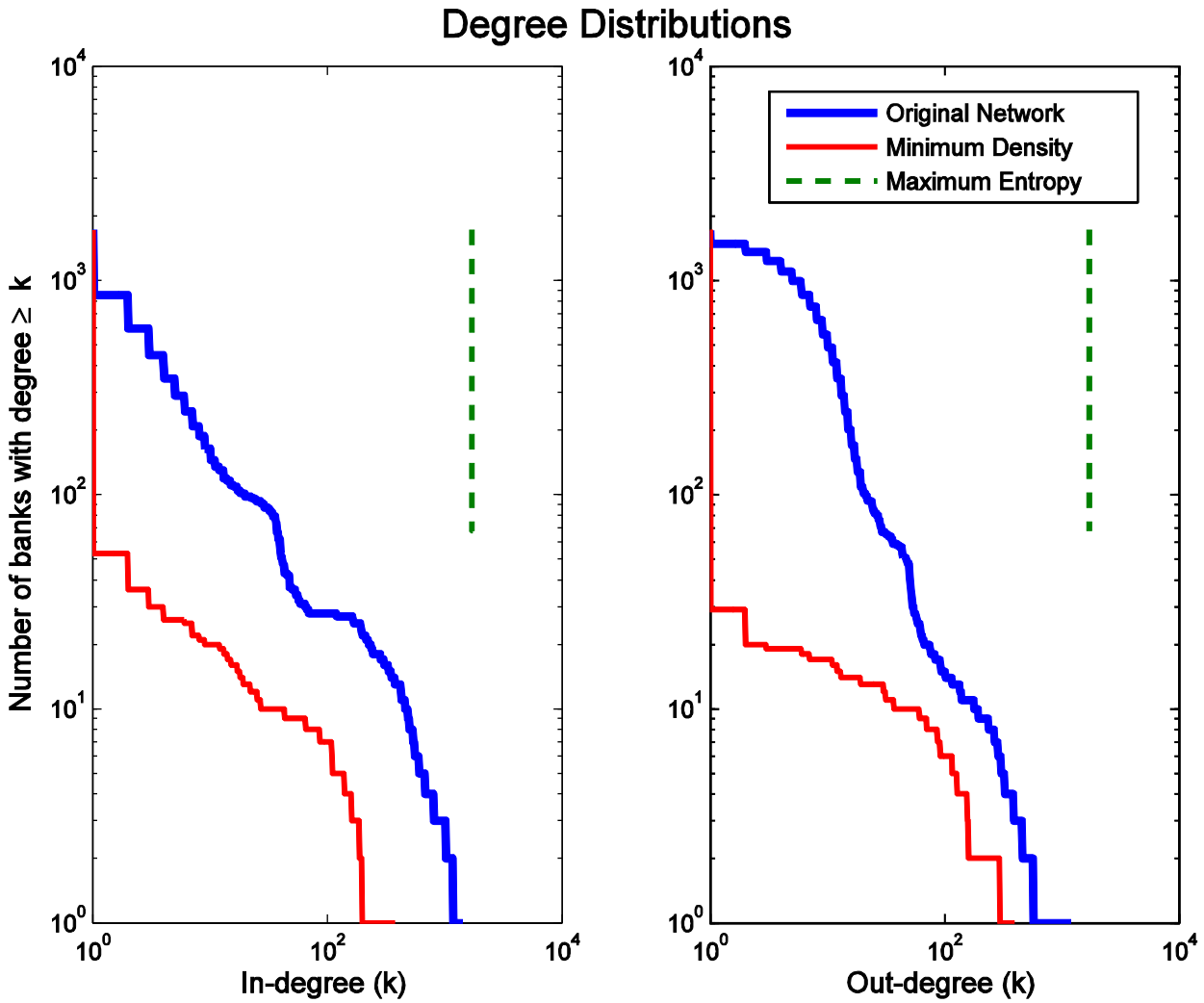
Trade-off between number and size of links



ME fails to preserve structure – MD does somewhat better

Network Characteristic	E Max Entropy	X True Network	Z Min Density
Density, in %	92.8	0.6	0.1
Degree (average)	1649	11.0	1.9
Degree (median)	1710	6	1
Assortativity	0.00	-0.52	-0.66
Dependence on lender, %	12.2	87.0	99.3
Dependence on borrower, %	7.2	43.6	99.2
Clustering local avg, %	99.9	46.6	0.05
Core size, % banks	92.6	2.5	0.8
Error score, % links	21.8	12.2	12.5

Degree distribution: MD retains some features

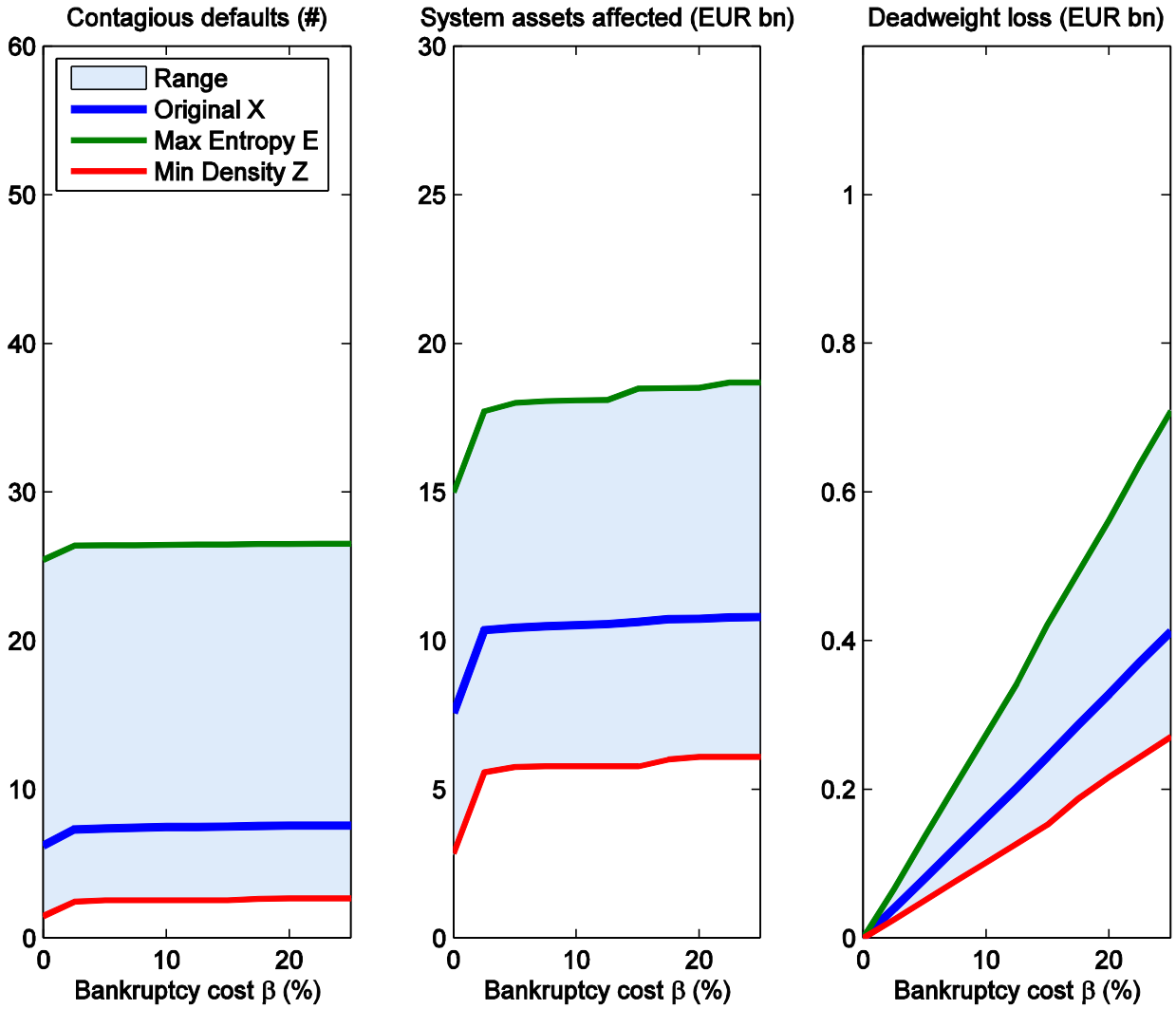


Part III: Interlinkages and systemic risk

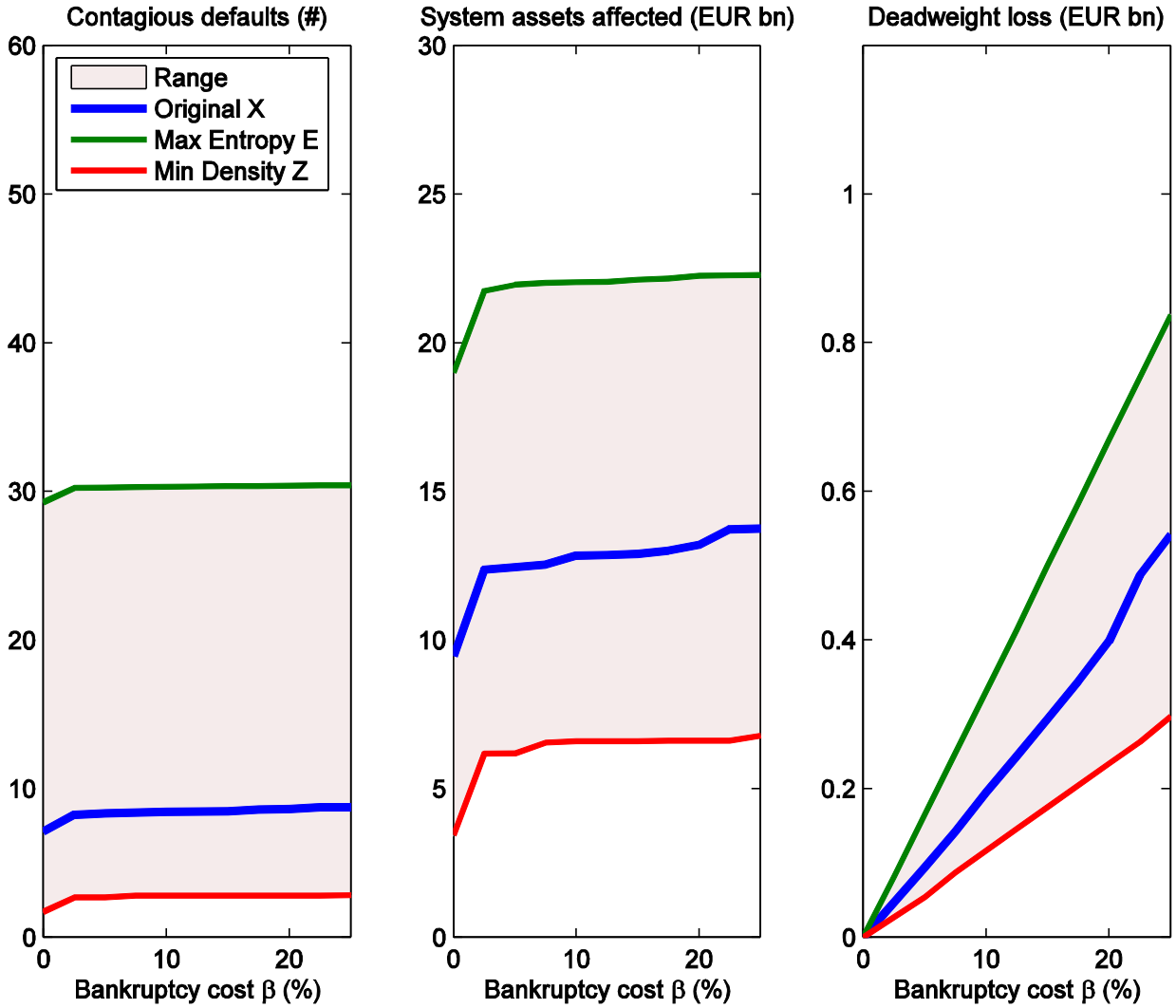
- Run stress tests to compare ME, MD with “true” network in practice
- Standard simulation methodology:
  - Trigger: single bank failure (+ a capital shock in Test II)
  - Mechanism: Eisenberg-Noe clearing vector (consistent)
  - LGD is endogenous + allow for liquidation/bankruptcy cost β

- Let each of 1800 banks fail 1x1, and solve for EN clearing vector,
  - # banks in default as a consequence of contagion (excludes i)
  - Interbank liabilities in default (plus bankruptcy costs)
  - Repeat for all bankruptcy costs β, and report average over i’s
  - Run separately for the 3 input networks: **true X**, **ME**, **MD**

Stress Test I: Single bank failures



Test II: Single failures + system-wide loss of 4% in K-ratio



Conclusion

- The paper has a simple goal: to provide a meaningful alternative to maximum entropy (minimum density)
- Derived using some information theory and economic rationale
- The approach retains more information on network structure
- In stress testing it may not do better than ME …
- … but together with ME provide reasonable confidence bands
- The broad range shows: linkages matter for systemic risk!

Thank you for your attention.