Systemic Risk in the Global Banking System: A Graph Neural Network Surrogate Approach

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Motivation

1. The 2007–09 crisis showed micro-prudential, bank-in-isolation supervision misses network amplification
2. Financial distress propagates non-linearly across borders
   - Channels: credit exposures, common asset overlaps, wholesale funding markets
3. Key obstacle: bilateral interbank exposures are confidential
   - Inaccessible even from most regulators — blocking direct measurement
4. This thesis: rebuild the network from public data and learn its contagion dynamics

This Paper

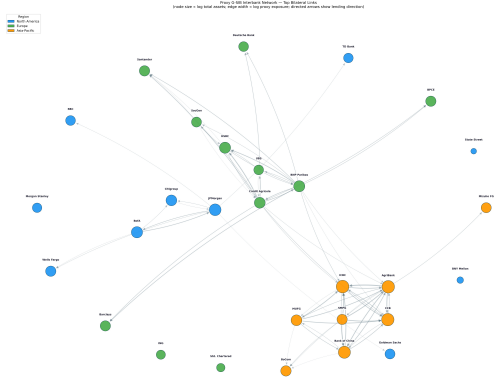
1. Contribution
   - Proxy network of all 29 G-SIBs (2024) from BIS data and regulatory disclosures
2. Method
   - Multi-channel contagion simulation generates 1,449 labelled stress scenarios
   - A Graph Transformer surrogate learns to approximate the simulation
3. Validation
   - Against an alternative max-entropy network and market-implied ΔCoVaR

Methodology: A Four-Phase Pipeline

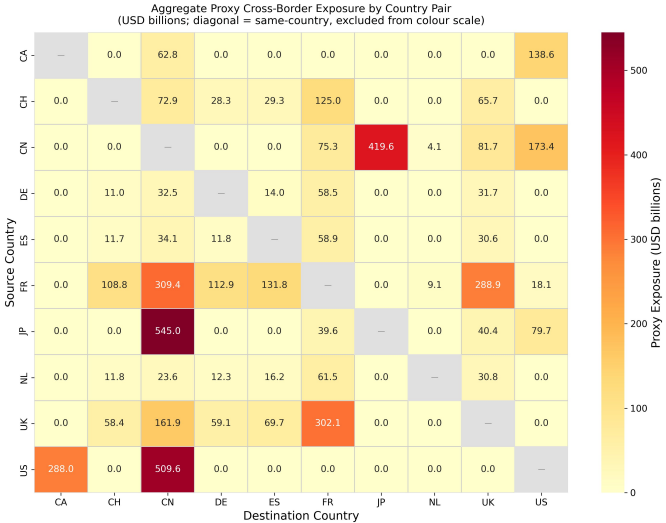
1. **Gravity network** — BIS-calibrated proxy; 29 nodes, 331 edges; sparse core–periphery
2. **Contagion engine** — multi-round cascade; 5 channels $\times$ 3 LGD regimes; 1,449 scenarios
3. **GNN surrogate** — 4-layer graph transformer; near-instant inference
4. **Validation** — max-entropy network; market ΔCoVaR; robustness checks

Interbank Network Construction

1. Node size $\propto$ outbound exposure
2. Colours represent geographic regions
3. Lines (edges) showcase bilateral exposures
4. Dense Chinese clustering compared to Europe and NA
5. Sparse core–periphery topology: 29 nodes, 331 directed edges



The Geography of Exposure



1. Country-pair exposure matrix from the gravity network (USD billions)
2. China absorbs the most inbound exposure
3. Exposure clusters regionally and is asymmetric
4. France most diversified creditor; US concentrated in only Canada and China

How Distress Cascades

1. Shock: a bank's assets are impaired, depleting its equity buffer
2. Absorb: creditor loss $\propto$ bilateral exposure $\times$ channel-specific LGD
3. Default & repeat if buffers are exhausted
4. Plus funding-stress haircuts and asset fire-sale spillovers each round

Design space: 3 capital buffers $\times$ 3 LGD regimes $\rightarrow$ **1,449 scenarios**

Channel (LGD %)	Benign	Base	Stress
Interbank loans	40	60	80
Cross-border claims	30	50	70
Derivatives	15	30	50
Common overlap	8	15	30
Payment links	2	5	10

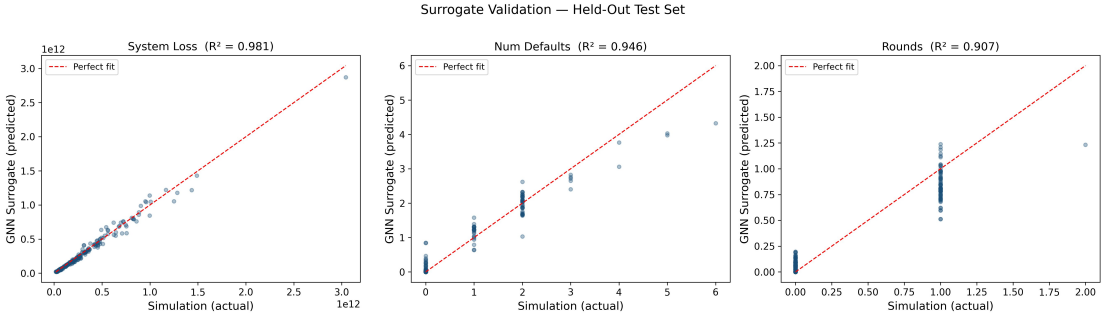
LGD rises with severity and with exposure seniority

A Graph Transformer Surrogate

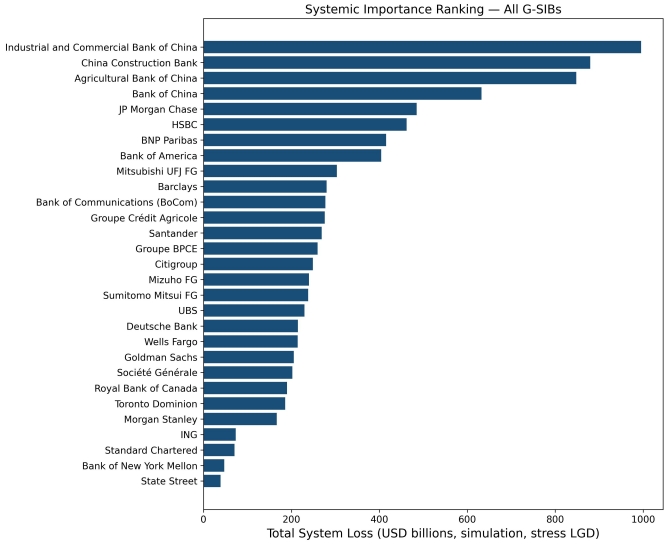
1. **Architecture:** 4 message-passing layers, 4 attention heads
2. **Inputs:**Inputs: 19 bank-level features (size, capital, shock status) + 5 exposure channels per link
3. Predicts both individual bank defaults and system-wide outcomes (total loss, defaults, duration)
4. Trained on 1,449 simulated crises (70/15/15 split), with safeguards against overfitting
5. **Result:** replicates the full simulation in milliseconds instead of minutes

Surrogate Performance

- Each dot = one scenario: simulation result (x-axis) vs GNN prediction (y-axis)
- Predictions closely match the simulation — reliable enough for rankings and stress tests

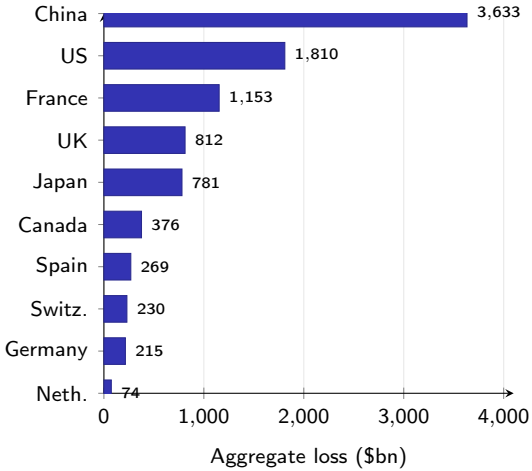


Systemic Importance Ranking



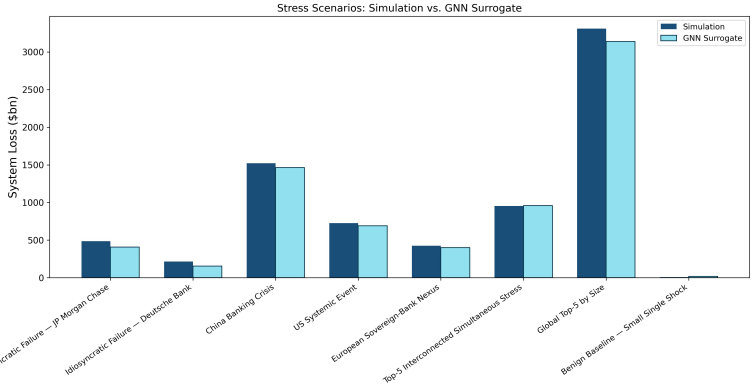
1. ICBC tops the ranking at $995bn system loss
2. The four Chinese megabanks plus JP Morgan lead
3. Size matters — but not alone: Citigroup ranks 15th (low cross-border, strong funding)

Country-Level Concentration



1. China $3.6tn (5 banks) $\approx 3\times$ the US per-bank average
2. US $1.8tn (8 banks); France $1.2tn (4 banks)

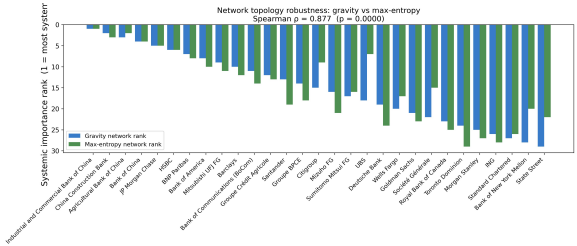
Stress Scenarios: Loss ≠ Cascade



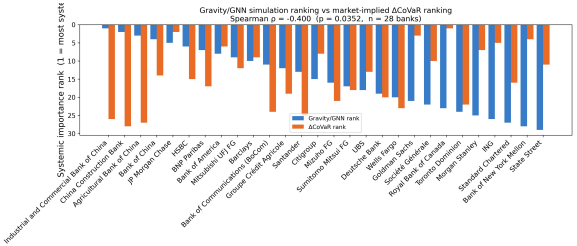
1. Eight scenarios tested: from a single mild shock to five largest banks collapsing at once
2. China crisis: $1.52tn in losses but zero domino effects
3. Only Global Top-5 ($3.31tn) cascades — 6 defaults

Robustness

1. Gravity vs. max-entropy network: $\rho = 0.88$, top-5 banks preserved
2. Stable across 9 capital $\times$ LGD combinations (≤ 1 default per single failure)
3. vs. market ΔCoVaR: $\rho = -0.40$ — structural and market views are complementary



Gravity vs. max-entropy ($\rho = 0.88$)



Simulation vs. ΔCoVaR ($\rho = -0.40$)

Conclusions

1. Systemic risk highly concentrated in Chinese megabanks
2. Size necessary but not sufficient $\rightarrow$ caution against size-only regulatory heuristics
3. Loss magnitude and cascade depth independent dimensions of systemic risk
4. System resilient to single-institution failures at current capital
5. A fast, accurate surrogate enables continuous supervisory monitoring