Resilience of criminal networks

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Group 3 - Crime hunters

Introduction

- Struggle to find effective strategies to control criminal networks

- Drug trafficking network was structurally targeted over a substantial period of time, but the trafficking activities still continued

- Operate in secrecy, knowledge of the effectiveness of different criminal network disruption strategies is very limited.
- Computational methods

Research Questions

-Resilience of the network to different types of intervention

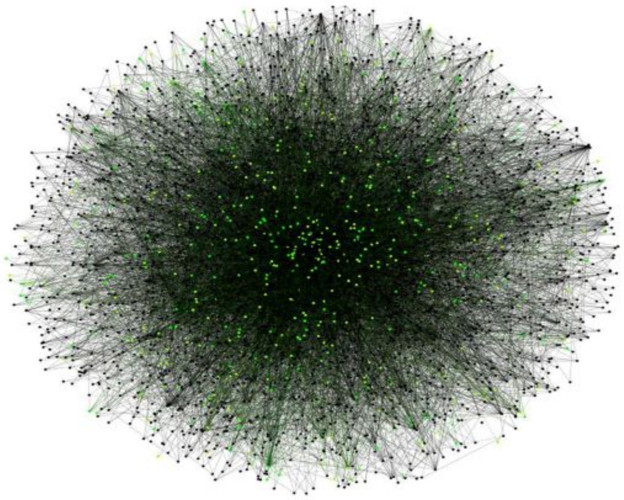
-Finding the most effective way to disrupt criminal networks

The criminal network

- Uses real data collected by the Dutch Police
- 29346 nodes
- Different roles for nodes

Original research paper:

Duijn, Paul A., et al. “The Relative Ineffectiveness of Criminal Network Disruption.” https://doi.org/10.1038/srep04238.



Our Approach to make a similar network

- Smaller scale to reduce computational cost

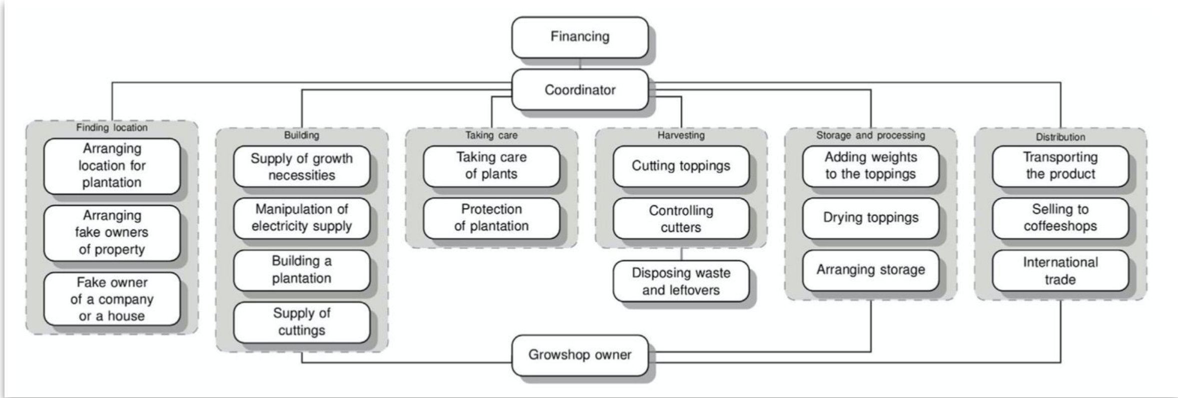
- Value-chain network of organized cannabis cultivation similar to the paper (~800 nodes)

- For the macro network we extended the value chain network with a barabasi-albert network with a total of 2000 nodes.

Complexity of the Criminal Network

- Need to be considered as social networks
- Dynamic, adaptive and resilient in nature
- Little theory about how they recover from attacks
- Greater social network with friends & family can take part, difficult to trace

Value Chain



Cannabis cultivation value chain

- Process for criminal production/activity
- Requires skills and knowledge (Human Capital)
- Some roles are highly connected while others not
- Important to identify roles that:
  - have specialized tasks
  - initiate criminal collectives
  - bridge roles
  - regulate information flow

No Data – Artificial Network

Use value chain network statistics from Appendix to rebuild network, which specifies:

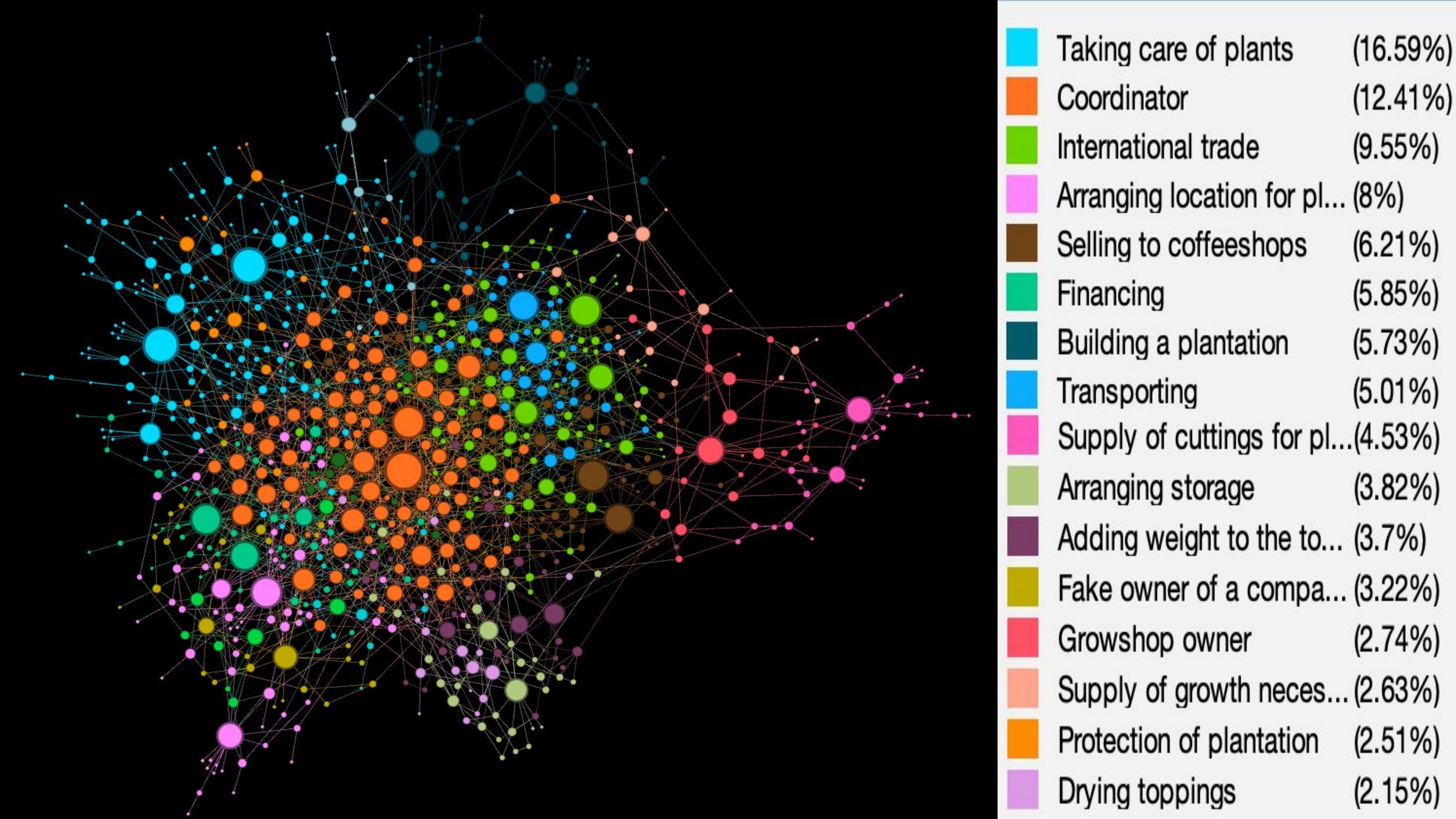
- **N**: number of nodes per role
- **D**: average degree per role
- **E**: number of edges between every pair of roles

Step 1: Barabasi Albert network for every role: n = **N**, m = **D** / **N**

Step 2: Disjoint union

Step 3: Between every pair of roles, randomly pick nodes to add **E** edges

⇒ Overall network statistics matches, but role-specific statistics and structures do not exactly match


Taking care of plants (16.59%)
Coordinator (12.41%)
International trade (9.55%)
Arranging location for pl... (8%)
Selling to coffeeshops (6.21%)
Financing (5.85%)
Building a plantation (5.73%)
Transporting (5.01%)
Supply of cuttings for pl...(4.53%)
Arranging storage (3.82%)
Adding weight to the to... (3.7%)
Fake owner of a compa... (3.22%)
Growshop owner (2.74%)
Supply of growth neces... (2.63%)
Protection of plantation (2.51%)
Drying toppings (2.15%)

Measures

Efficiency and Density

- Both vary from 0 to 1
- 1 means completely interconnected network
  - high efficiency (information & goods), high density (exposed)
- 0 means separated components
  - low efficiency (information & goods), low density (secure)
- Trade-off between efficiency and security (criminal networks)

Average reconnection distances (Temporal)

- View distance as time
- How easily a node can find a new connection (after disruption)

$$Efficiency(G_{VC}) = \frac{1}{N(N-1)} \sum_{i,j=1}^{N} \frac{1}{d_{ij}}$$

$$Density(G_{VC}) = \frac{2E(G_{VC})}{N(N-1)}$$

d_{ij} : distance between node i and j of G_{VC}

N : number of nodes in G_{VC}

$E(G_{VC})$: Number of edges in G_{VC}

Strategies used

Disruption (removal of nodes):

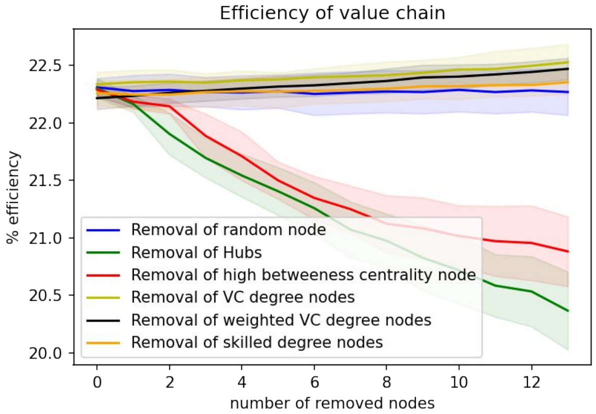
- Random
- Degree based (hubs)
- Highest betweenness centrality (bridges)
- Specific role targeting
- highest VC degree
- highest VC degree weighted

Recovery (Done in the same group as of the node that was removed):

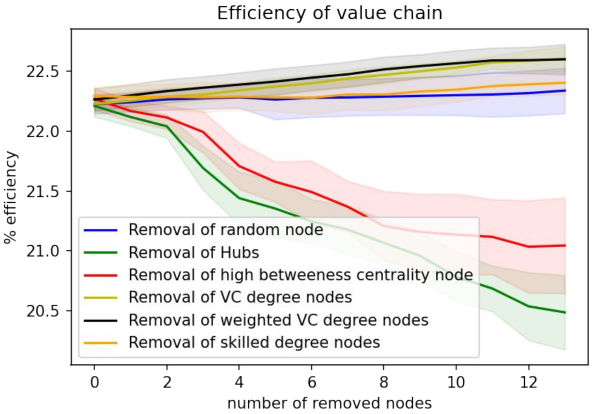
- Random
- Degree based
- Distance

Results : Efficiency Value Chain

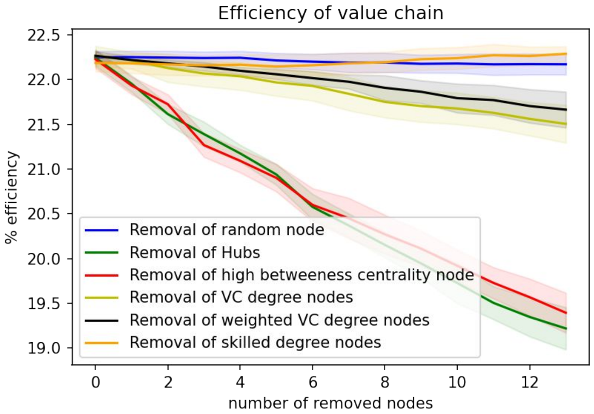
Random recovery



Degree recovery

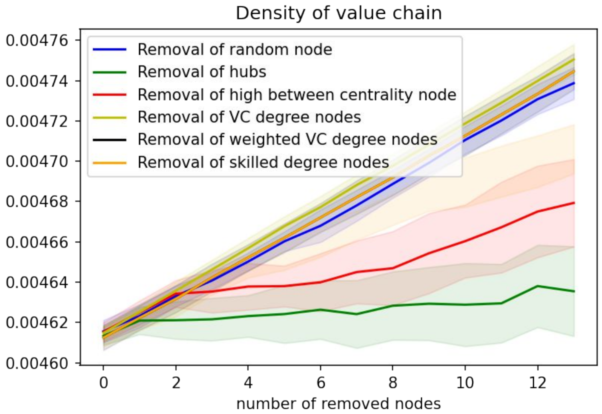


Distance recovery

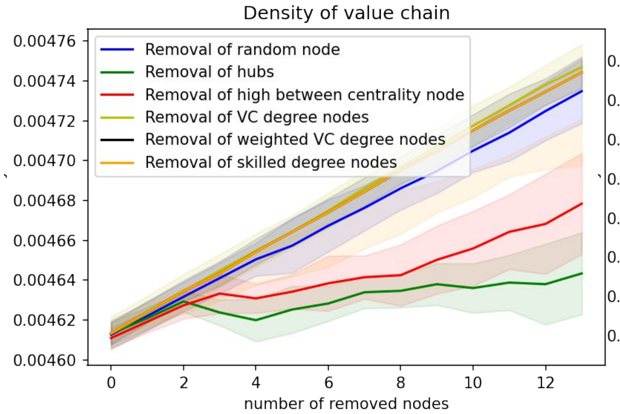


Results : Density Value Chain

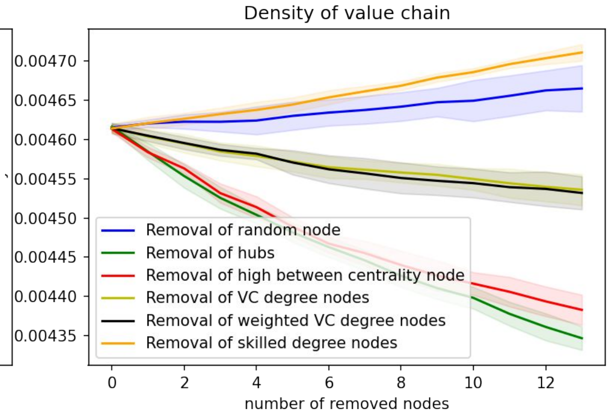
Random recovery



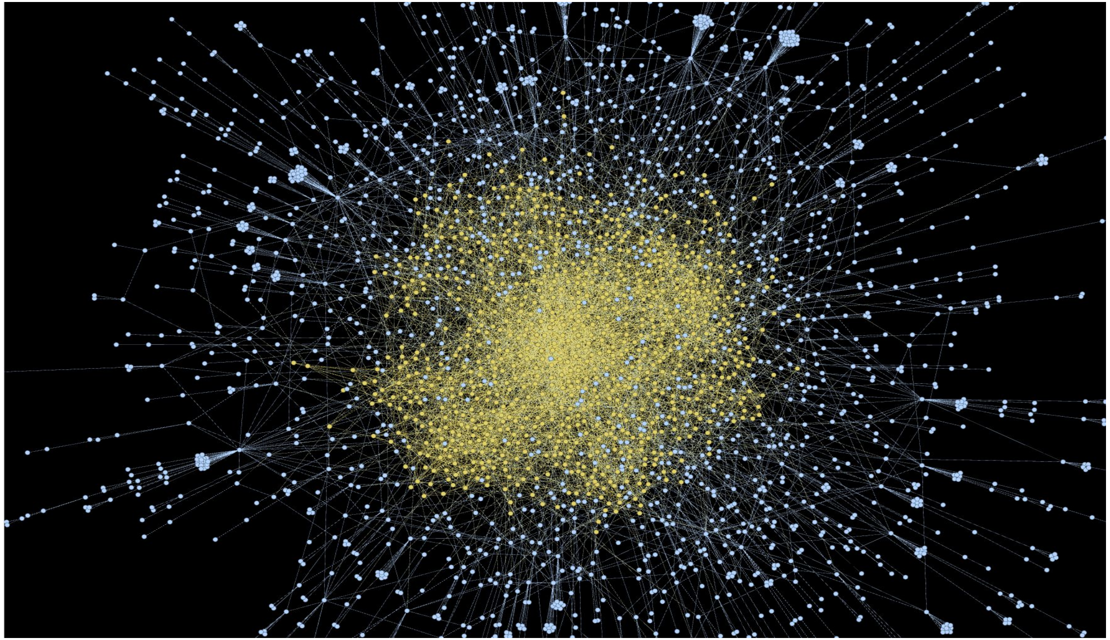
Degree recovery



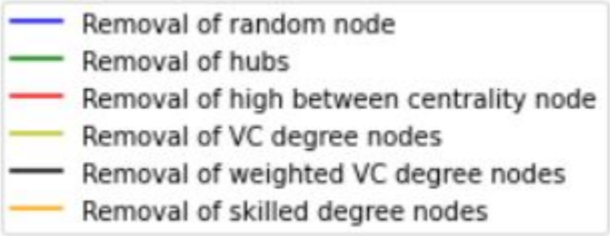
Distance recovery



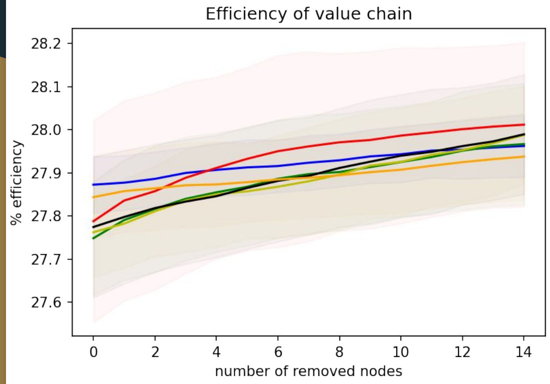
Value chain + outer network



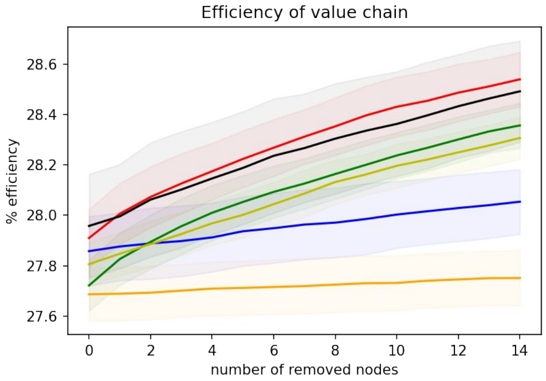
Results: Efficiency value chain with outer network



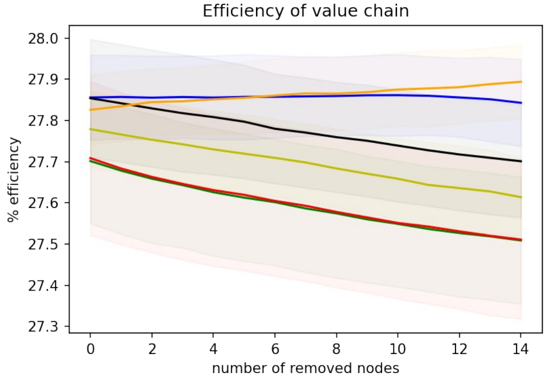
Random recovery



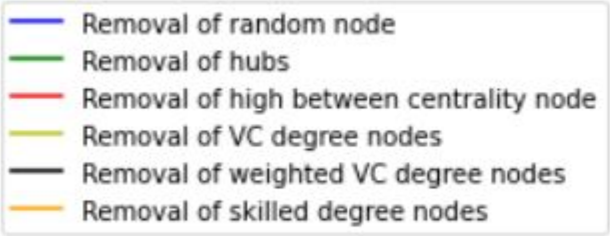
Degree recovery



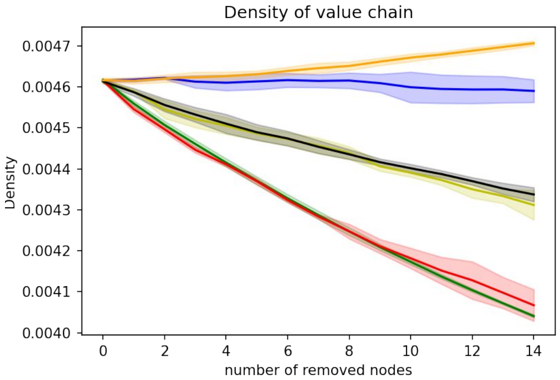
Distance recovery



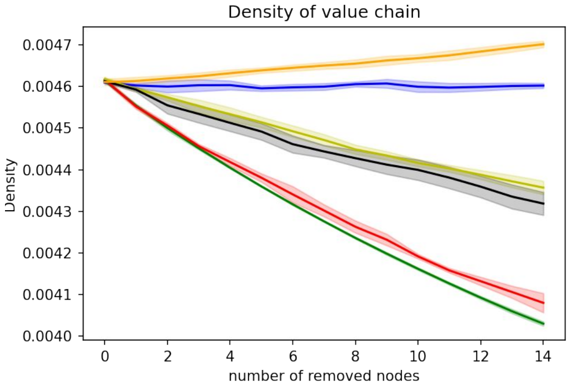
Results: Density value chain with outer network



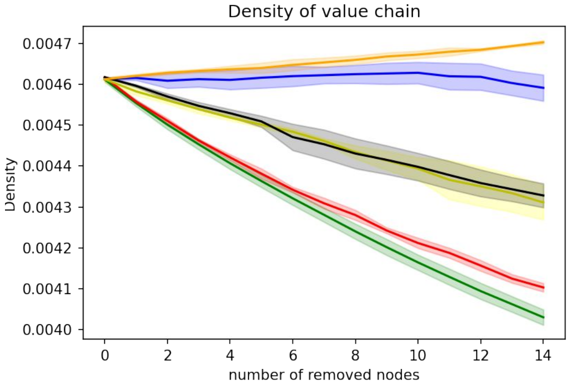
Random recovery



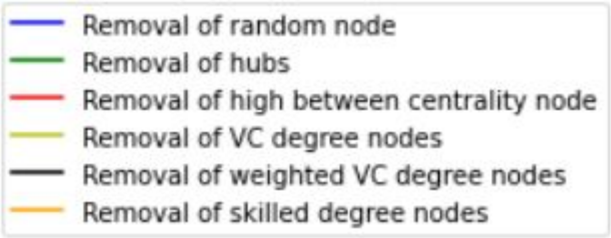
Degree recovery



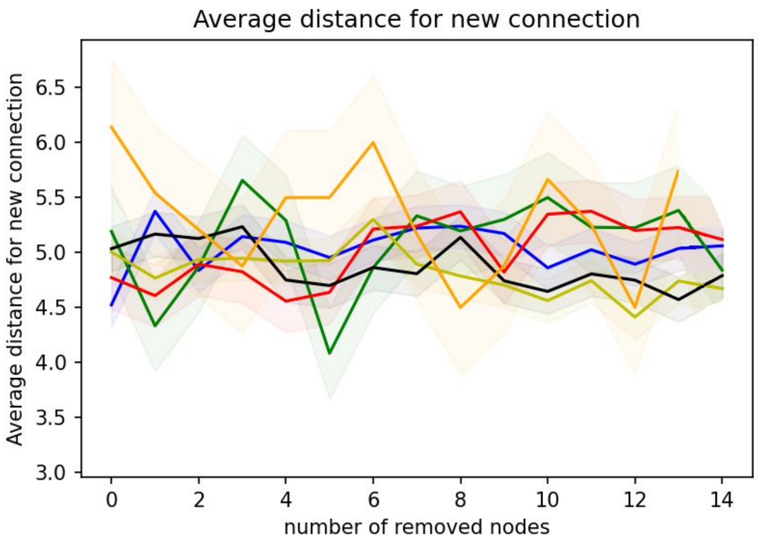
Distance recovery



Results connection distance value chain with outer network



Random recovery



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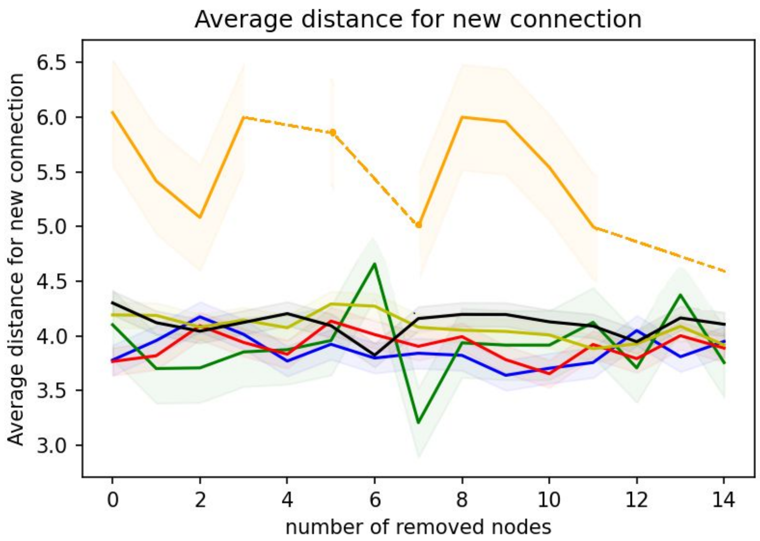

Results analysis

- Disruption generally ineffective
- Disparities between our results and the paper’s could be due to our more abstract network structure.
- This shows that value chain and the macro network dynamics have a significant effect on the resilience of the network.
- Using outside network gives different results (similar to paper), indicating that recovery from outside value chain is essential to network efficiency

Questions

Macro Network

Outer Barabasi Albert network, n = 2000, m = 1

For every node in G_{VC}:

If bridging role

like Coordinator, Growshop owner, Financing

add 1-10 edges to outer network

otherwise 1-2 edges