



# Null Models for Anomaly Detection



**COMCRIM**  
COMbatting CRIMes that undermine democracy and  
the rule of law in a comprehensive and smart manner

# COMCRIM

## Project Overview

For more information, visit [comcrim.nl](https://comcrim.nl) or email  
me at [n.w.brouw@uva.nl](mailto:n.w.brouw@uva.nl)

# CONSORTIUM



26 academics

Involved Academics



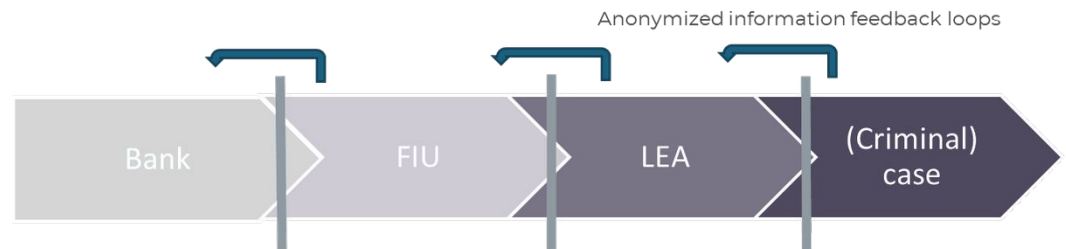
Jill Coster van Voorhout   Ana Barros   Huub Dijkstra   Yarin Eski   Drona Khandai   Mike Lees  
 Frank Pijpers   Marcel Worring   Martijn Scheltema   Zeno Geradts   Suzan van der Aa   Mervin Dolman

6 PhDs, Project Manager, Student-Assistant, PAC and IEG



22 partners

COMCRIM Project Stakeholders



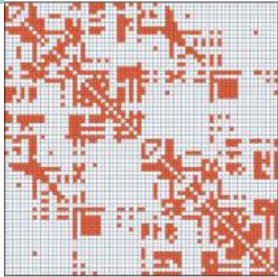
All parties remain within their legal powers and abide by privacy guarantees.



# **Null Models in Network Science**

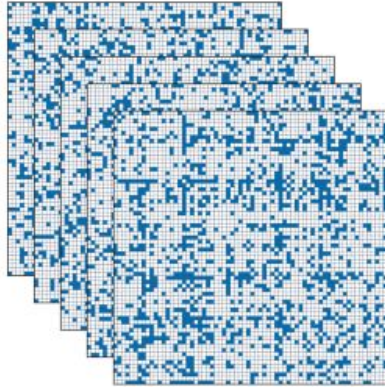
# What is a Null Model?

Empirical network



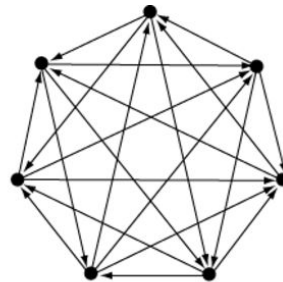
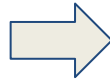
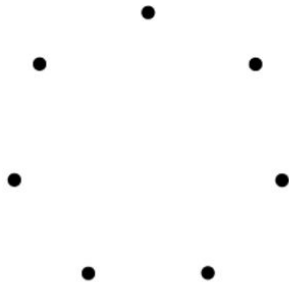
Estimate network feature  $x$

Null networks



Generate null distribution  
of network features

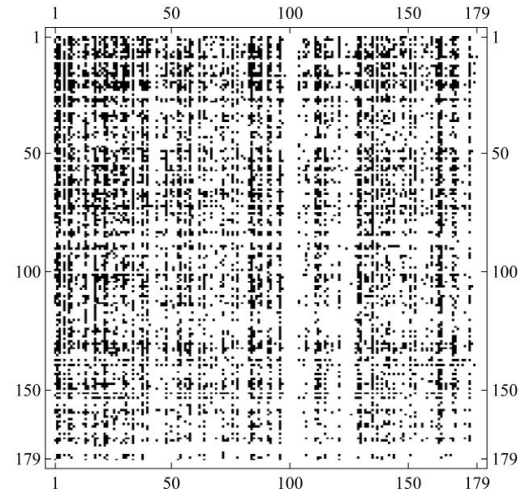
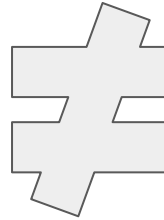
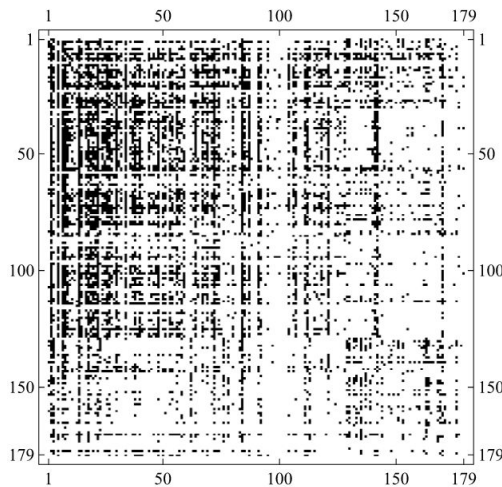
$v_1 v_2 v_3 v_4 v_5 v_6 v_7 v_8$



- **Observe empirical network**
- **Derive appropriate properties**
- **Create null networks through network reconstruction**
- **Compare empirical network with null networks**

# Network Reconstruction

## Adjacency Matrices of Italian interbank data



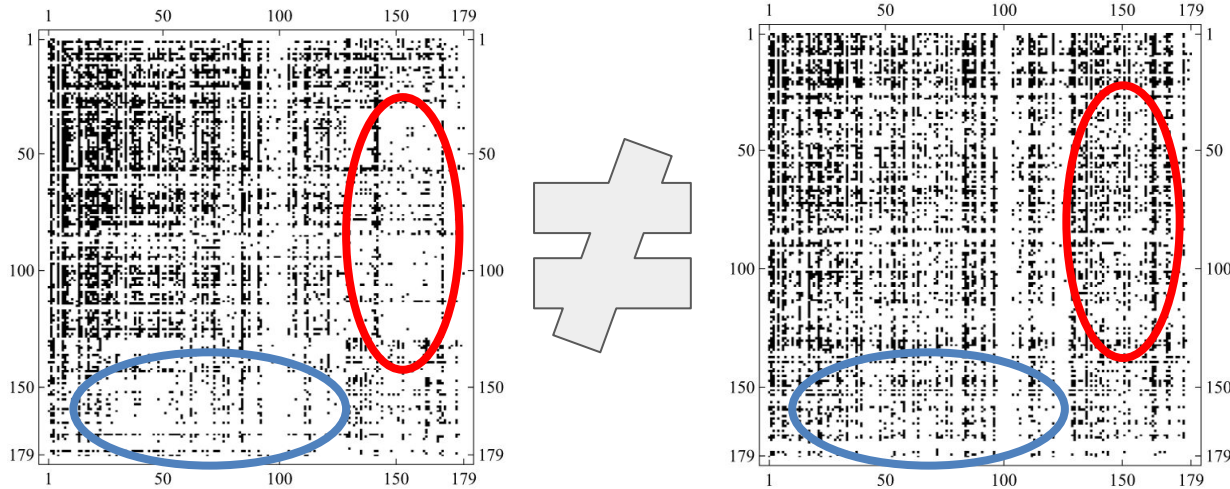
**Empirical**

**Reconstruction**

Squartini, T., Caldarelli, G., Cimini, G., Gabrielli, A., & Garlaschelli, D. (2018). Reconstruction methods for networks: The case of economic and financial systems. *Physics reports*, 757, 1-47.

# Network Reconstruction

## Adjacency Matrices of Italian interbank data

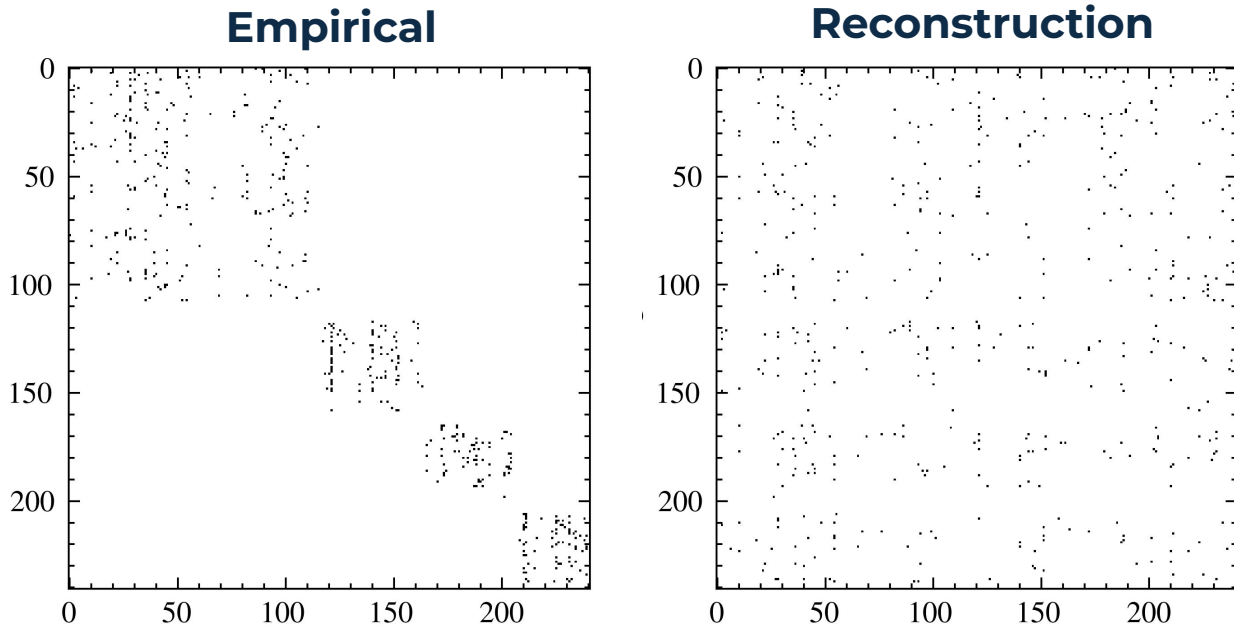


**Empirical**

**Reconstruction**

Squartini, T., Caldarelli, G., Cimini, G., Gabrielli, A., & Garlaschelli, D. (2018). Reconstruction methods for networks: The case of economic and financial systems. *Physics reports*, 757, 1-47.

# Community Structure



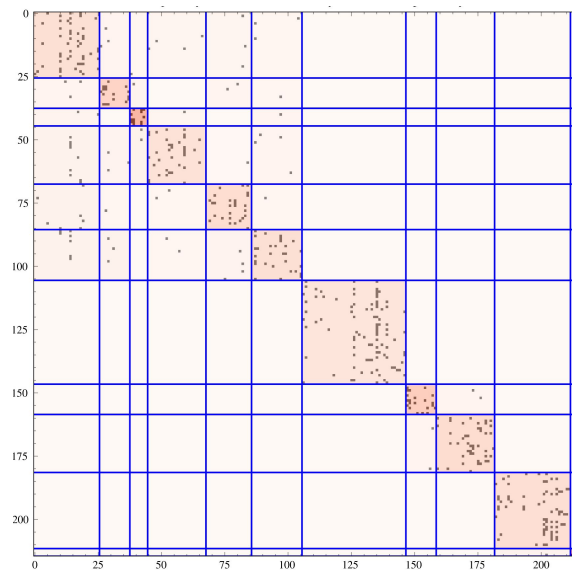
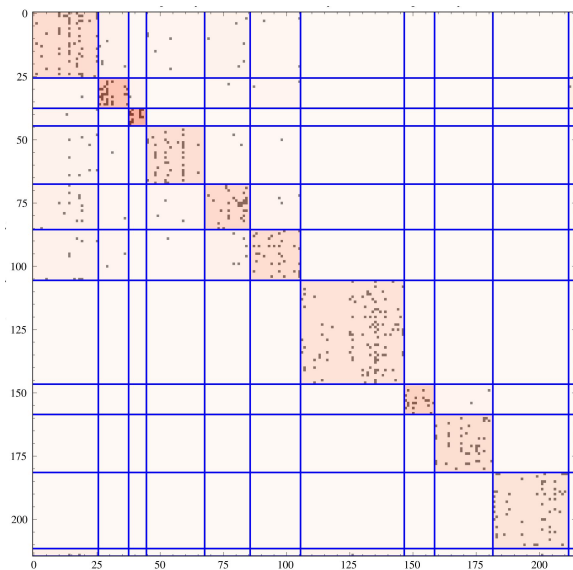
Dataset from:

J. Coleman, E. Katz, and H. Menzel.- "The Diffusion of an Innovation Among Physicians". *Sociometry* (1957) 20:253-270.

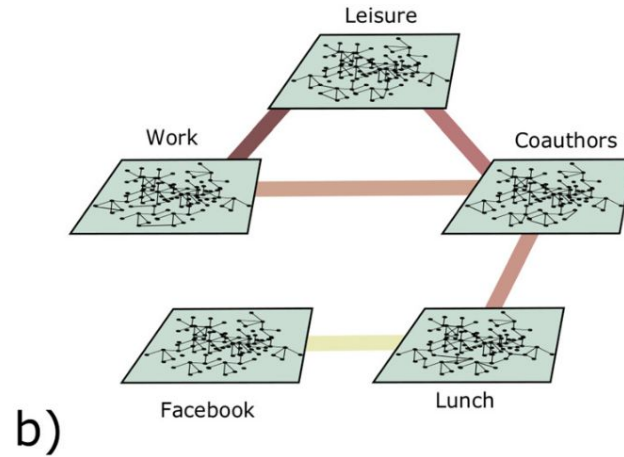
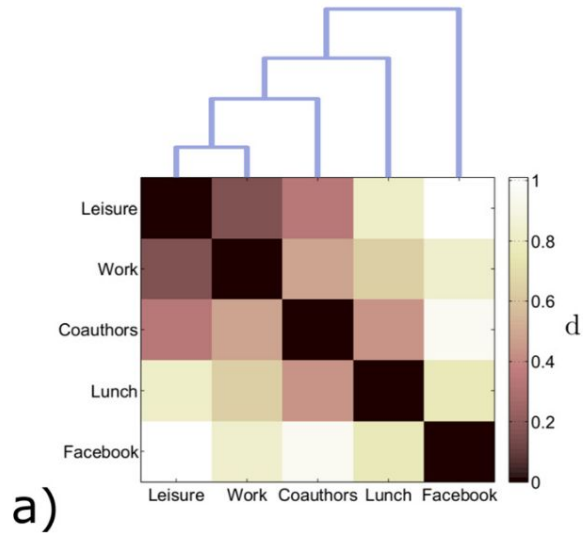
# Community Structure

Empirical

Reconstruction

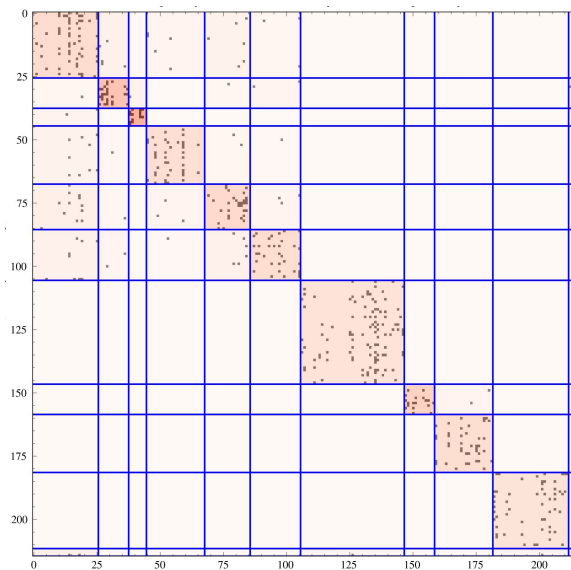


# Multilayer Networks

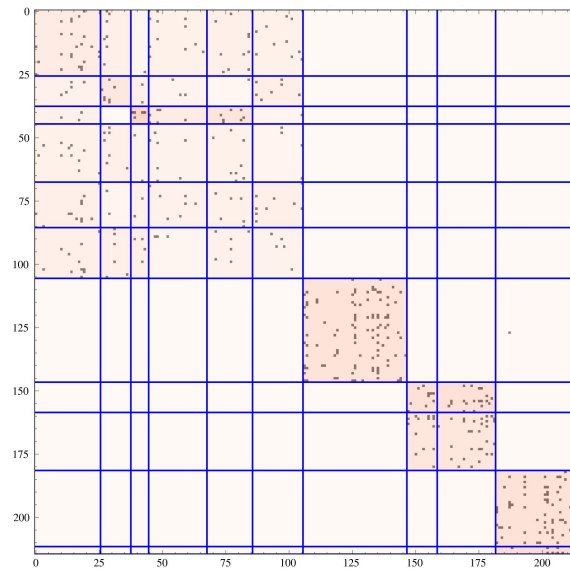


# Community Structure

Empirical

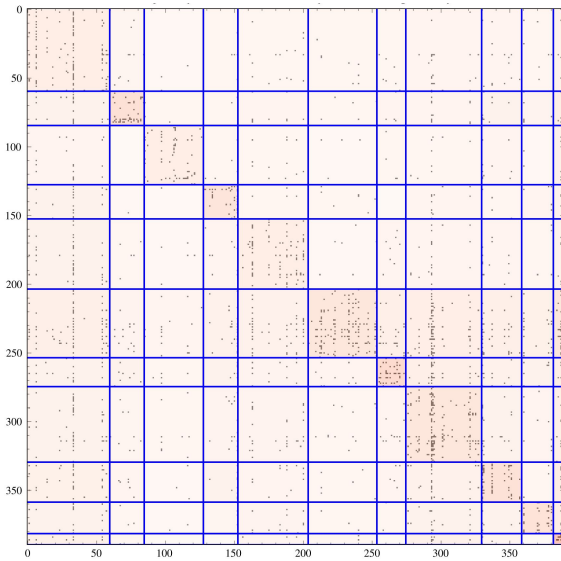


Reconstruction

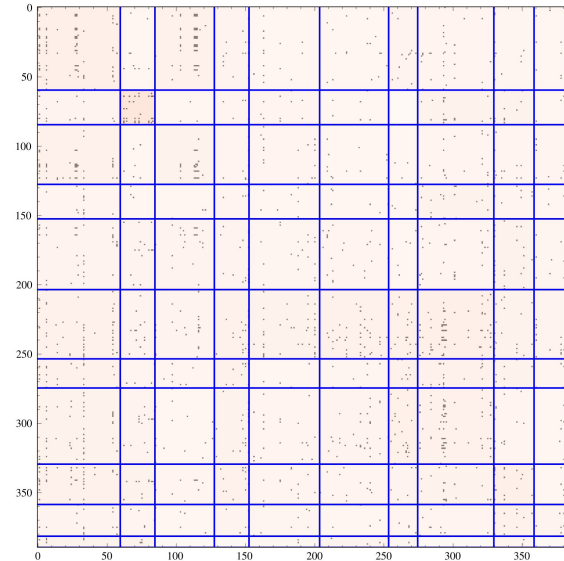


# Community Structure

Empirical



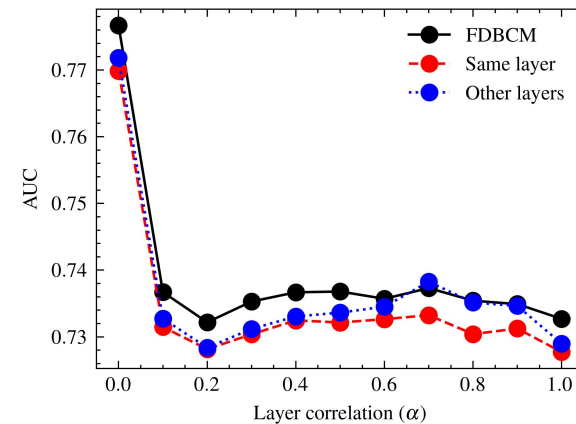
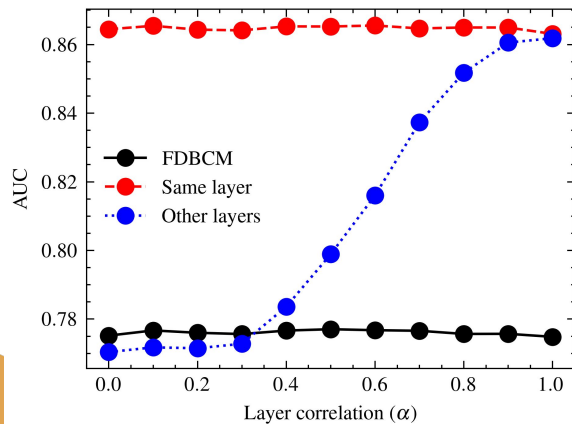
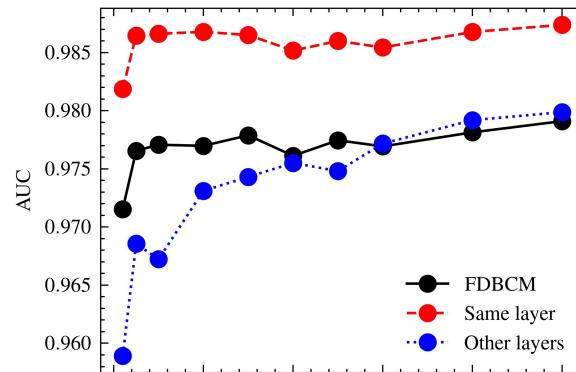
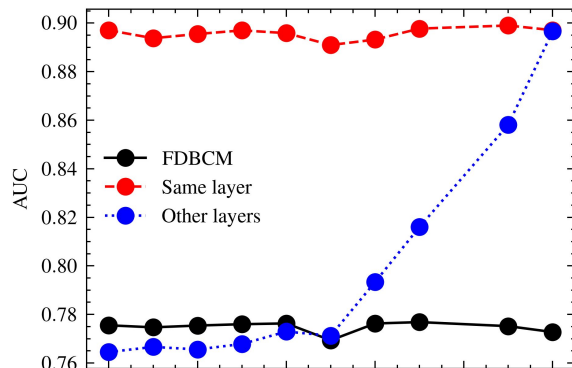
Reconstruction



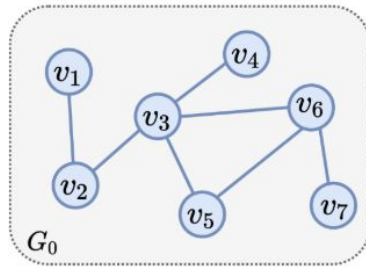
Dataset from:

E. Omodei, M. De Domenico, A. Arenas. - Characterizing interactions in online social networks during exceptional events.. *Front. Phys.* 3, 59 (2015)

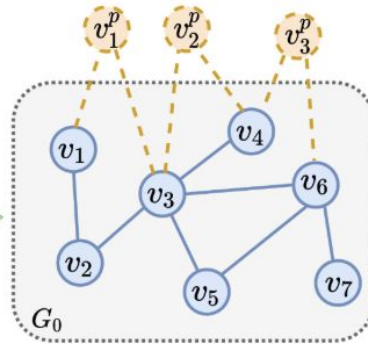
# Multilayer Networks



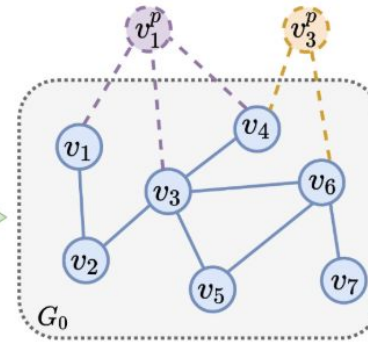
# Future work



(a) Networks analysis



(b) Missing node detection



(c) Duplicate missing nodes mergence