Statistical Inference for Multilayer Networks

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Overview

Political phenomenon are characterized by interdependence across multiple relational contexts.

I present a multilayer network approach to modeling these complex phenomenon.

This approach:

- Does not require assumptions about independence between connected systems;
- Affords inferential leverage in the type of theoretical tests we can conduct;
- Yields models with better fit to the observed data.

Illustration: Conflict in the Levant

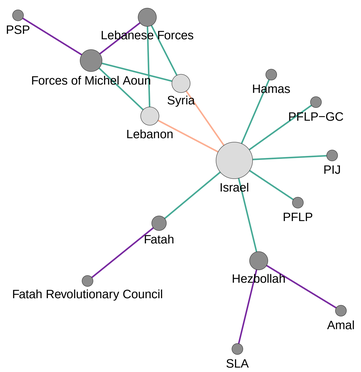

Figure 1. Conflict in the Levant, 1985-1992

- Strategic considerations for actors facing political conflict span across different types of conflicts.
- For example, different types of conflict two-star clusters involve different strategic considerations.

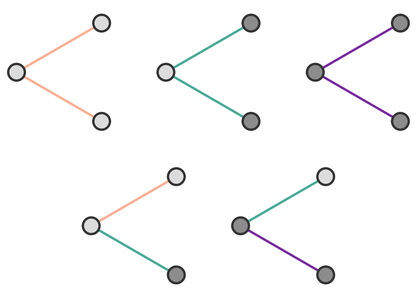

Figure 2. Different Types of Conflict Clusters

Methodological Approach

An exponential random graph model is a statistical model that can test the different kinds of factors that underly the generative process of the observed network.

In an ERGM, the probability of observing a network $\mathbf{Y} = \{Y_{ij}\}$ is specified as

$$\Pr(\mathbf{Y}, \boldsymbol{\theta}) = \kappa^{-1} \exp\{\boldsymbol{\theta}' \mathbf{x}(\mathbf{Y})\},$$

where $\mathbf{x}$ is a vector function that yields observed network statistics computed on $\mathbf{Y}$.

The multilayer network approach extends the $\mathbf{Y}$ matrix and the function vector $\mathbf{x}$.

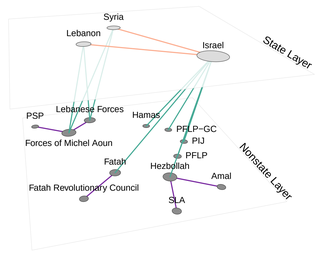

Figure 3. Levantine Conflict, Multilayer Representation

- *Layers* are the organizing principle of multilayer networks.
- Nodes are organized by types onto layers.
- Types are defined by the combination of all relevant node-attributes.
- Incident layers define tie type.

- The adjacency matrix of a multilayer network is partitioned into blocks.
- Main diagonal blocks are intralayer ties; off diagonal blocks are interlayer ties.
- Network configurations are counted on the relevant blocks.

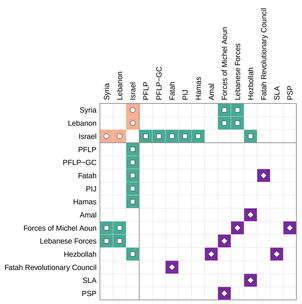

Figure 4. Levantine Conflict, Matrix Representation

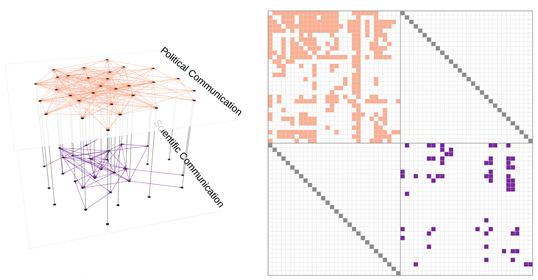

Figure 5. Policy communication as a multilayered network

Application: Policy Communication

Leifeld and Schneider, 2012, "Information Exchange in Policy Networks," *AJPS*

- Transaction cost approach to political and scientific communication
- Reciprocity and influence in different types of communication channels should span multiple layers.

I fit two models, one with dependence across the two communication networks and one without. I find that the cross-layer dependence term fits better and affords better understanding of policy communication networks.

Figure 6. Network configurations for a dyad on two layers

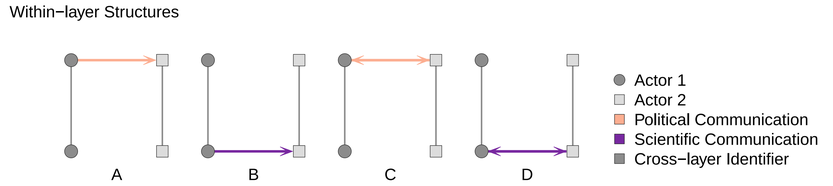

Figure 7. Model Fit Comparisons

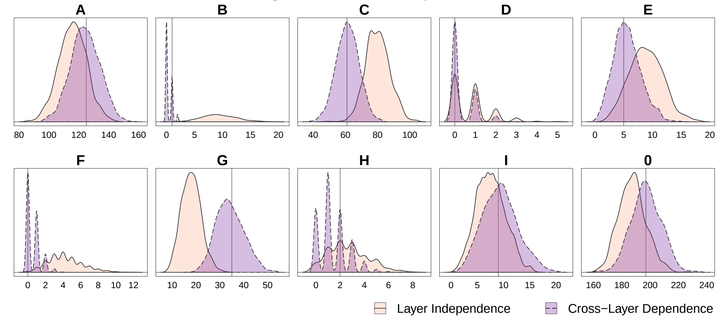

Table 1. Policy communication as a multilayered network

	Layer Independence		Cross-layer Dependence	
Term	Estimate	s.e.	Estimate	s.e.
Political Communication				
Influence of Scientific Comm.	2.88*	0.65		
Intralayer Reciprocity (C)	0.81*	0.25	0.50	0.26
Scientific Communication				
Influence of Political Comm.	2.87*	0.62		
Intralayer Reciprocity (D)	1.76*	0.53	7.60*	2.53
Cross-layer Dependence				
Interlayer Reinforcement (E)			1.75*	0.62
Interlayer Reciprocity (F)			0.87	0.54
Scientific Arc Political Reciprocity (G)			0.08	0.52
Political Arc Scientific Reciprocity (H)			-1.71*	0.65