



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 phenomena.

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

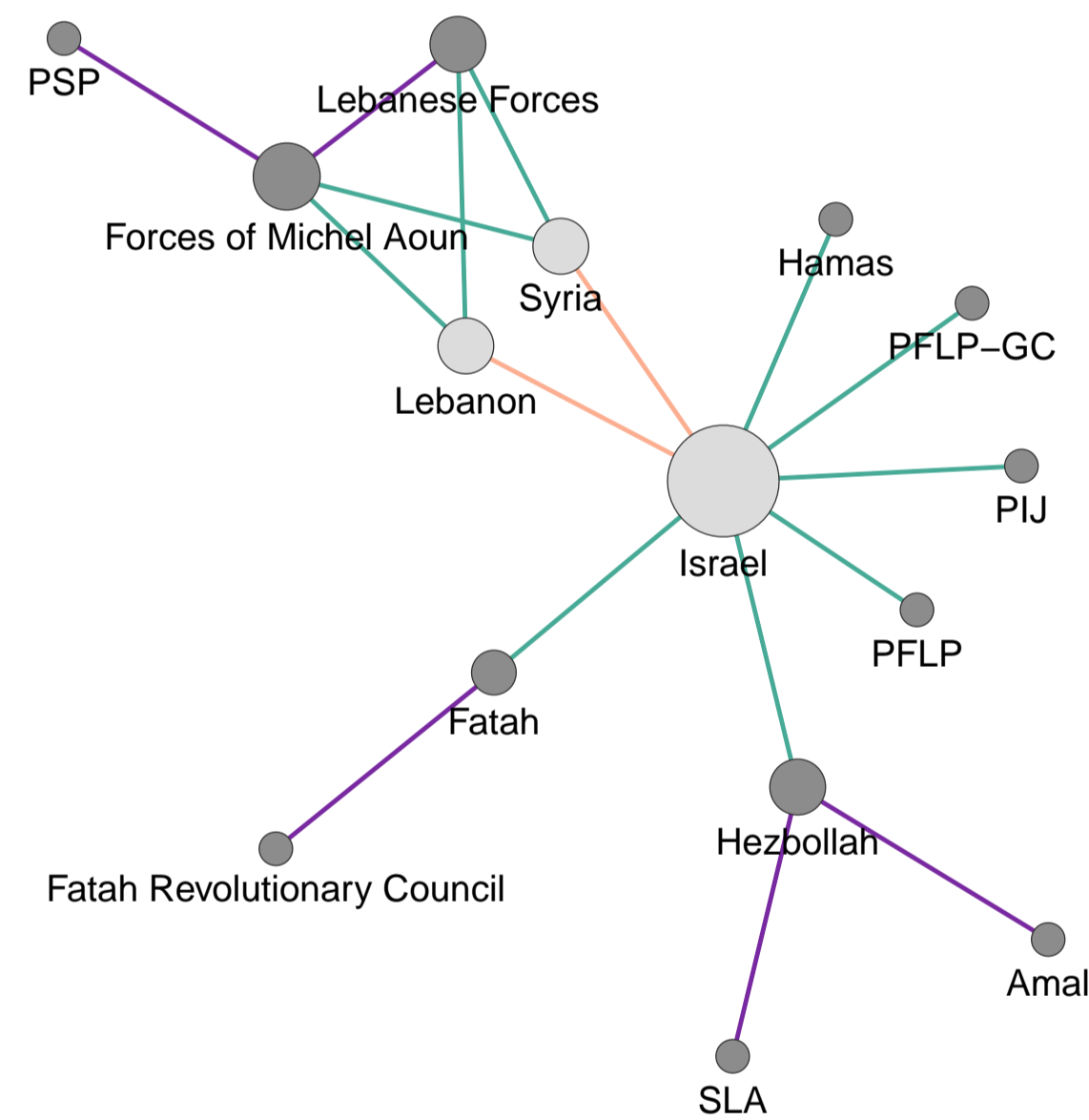


Figure 1. Conflict in the Levant, 1985-1992

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

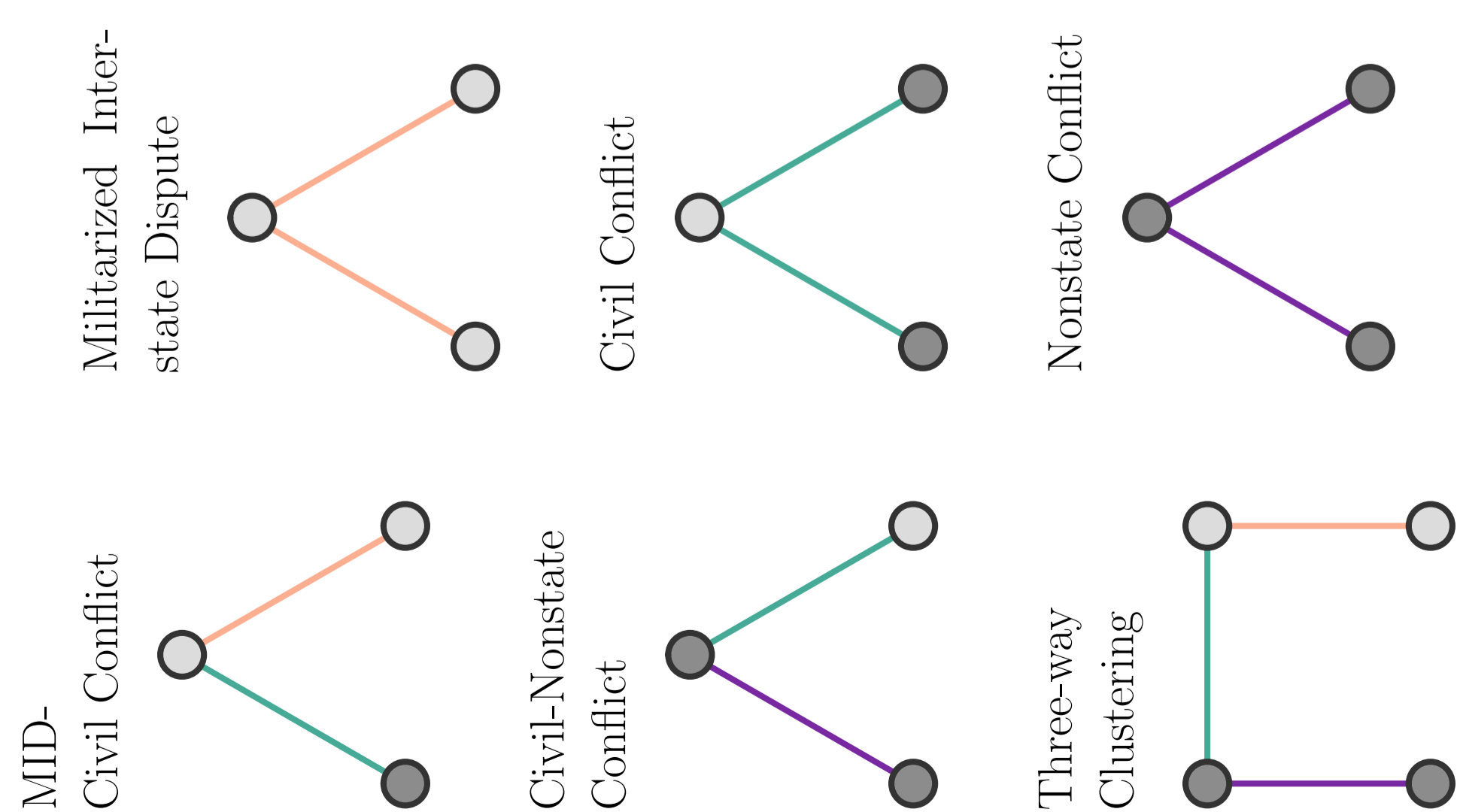


Figure 2. Different Types of Conflict Clusters

Methodological Approach

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

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

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

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} .

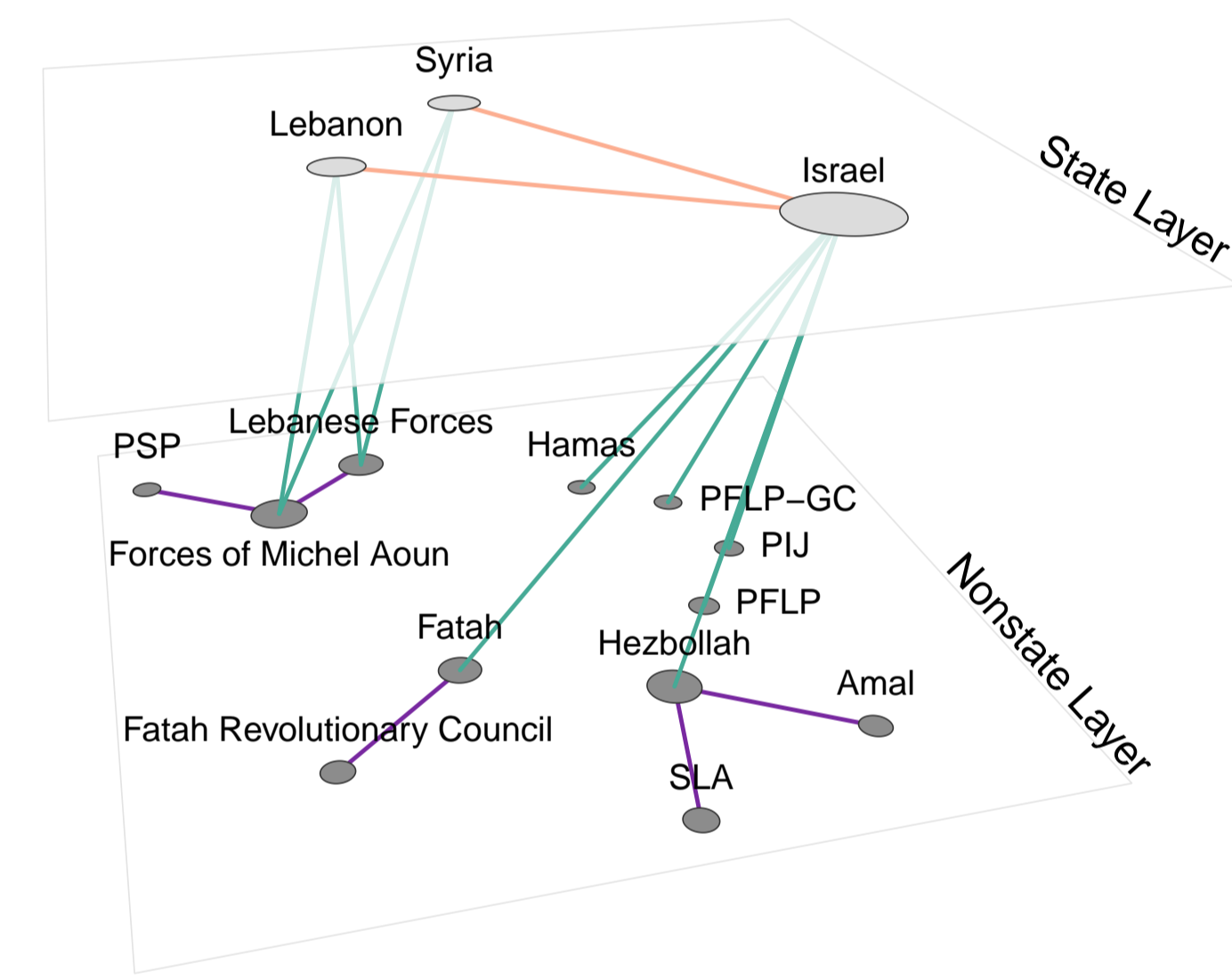


Figure 3. Levantine Conflict, Multilayer Representation

- Nodes are organized by types onto layers; incident layers define tie type.
- Adjacency matrix \mathbf{Y} of a multilayer network is partitioned into blocks.
- $\mathbf{x}()$ counts configurations on only the relevant blocks.

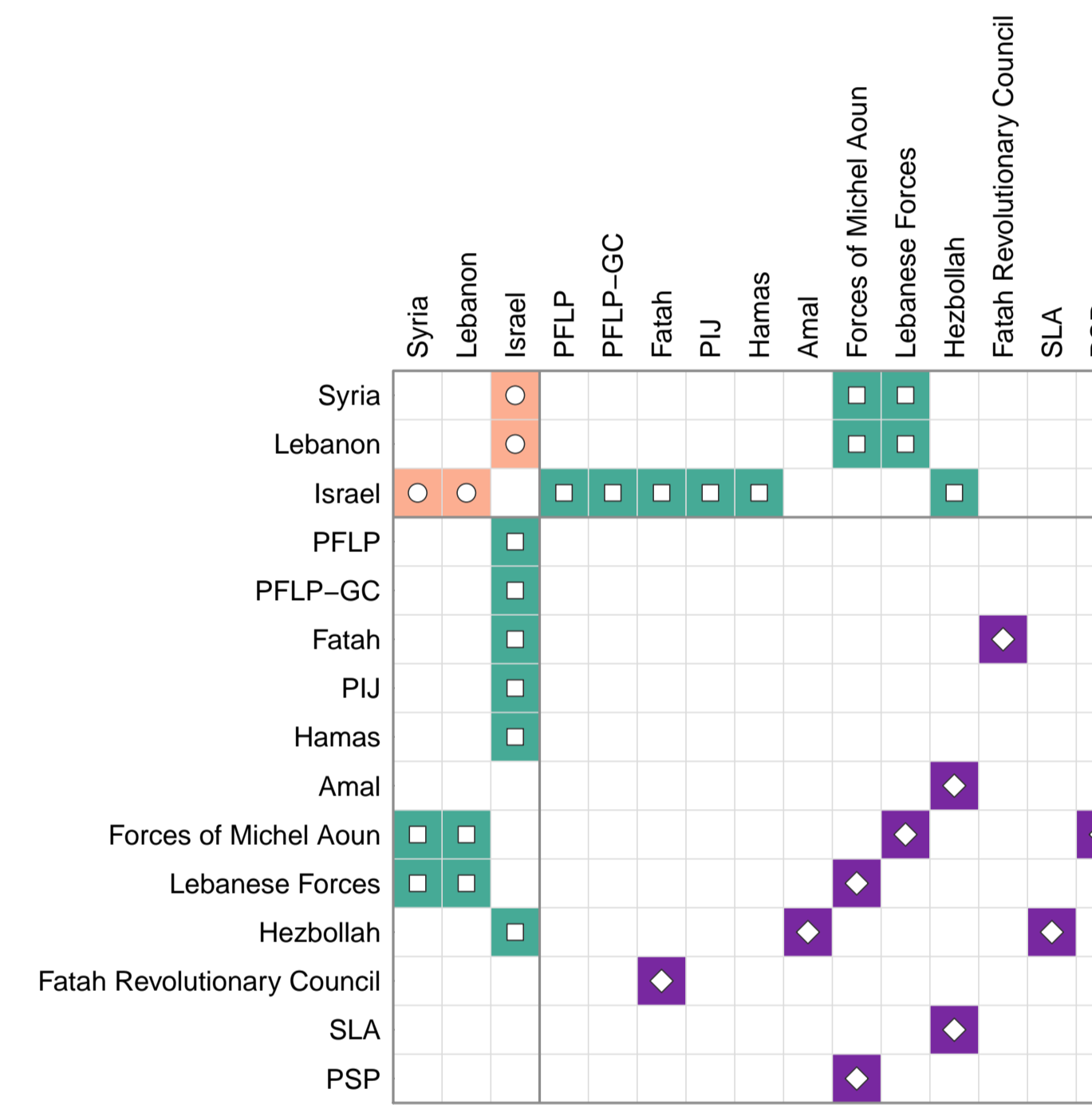


Figure 4. Levantine Conflict, Matrix Representation

Application I: Clustering in Global Conflict

The global conflict system comprises militarized interstate disputes, civil conflicts, and nonstate conflicts.

Clustering should exist within each conflict subsystem, and also across subsystems.

A model of all three subsystems indicates that:

- There is clustering within subsystems;
- There is clustering in MID and civil conflict but not in civil and nonstate conflict;
- Conflict clusters involving all three subsystems is more likely than those with just two.

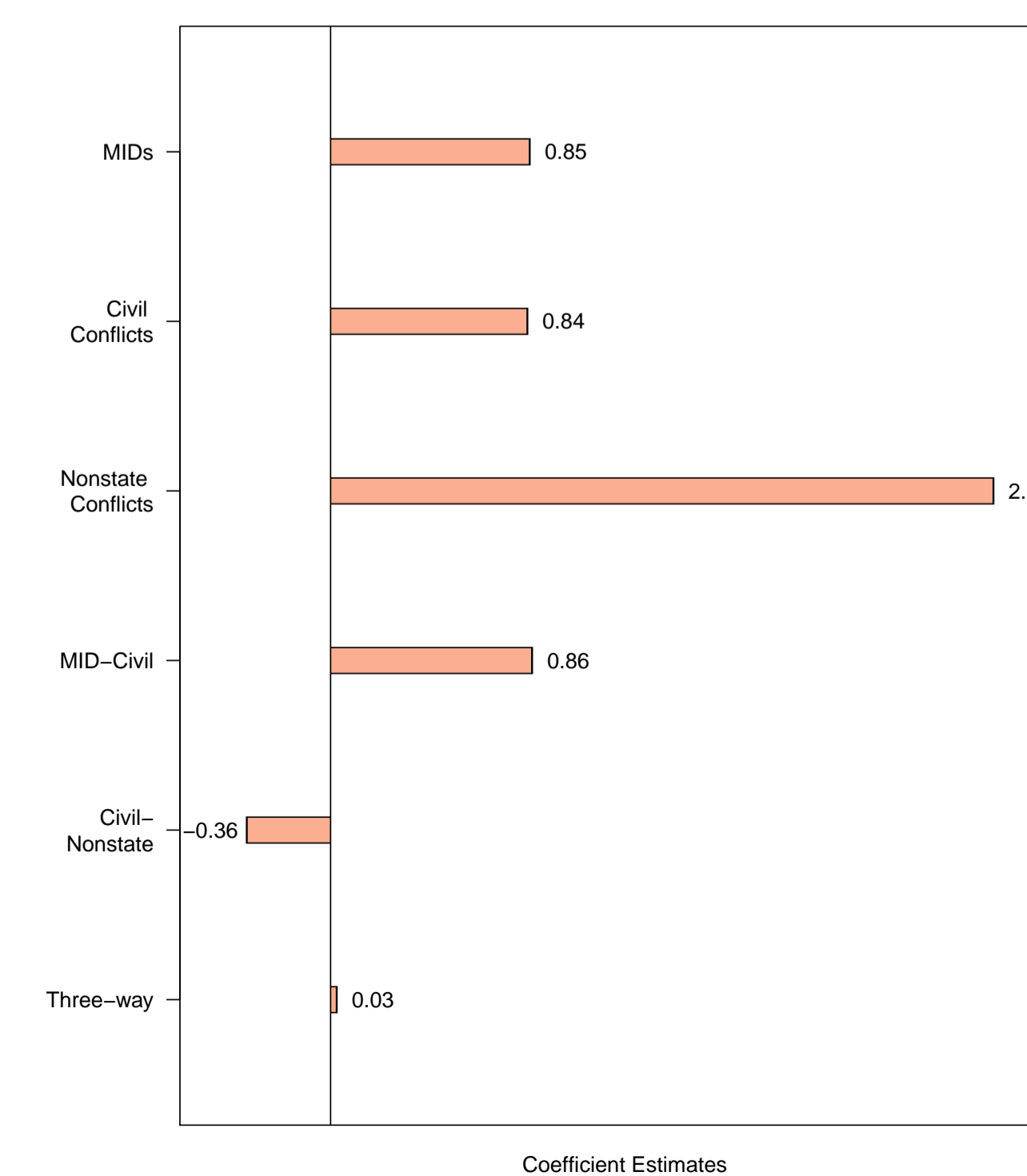


Figure 5. Coefficients for terms related to clustering

Application II: Policy Communication

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

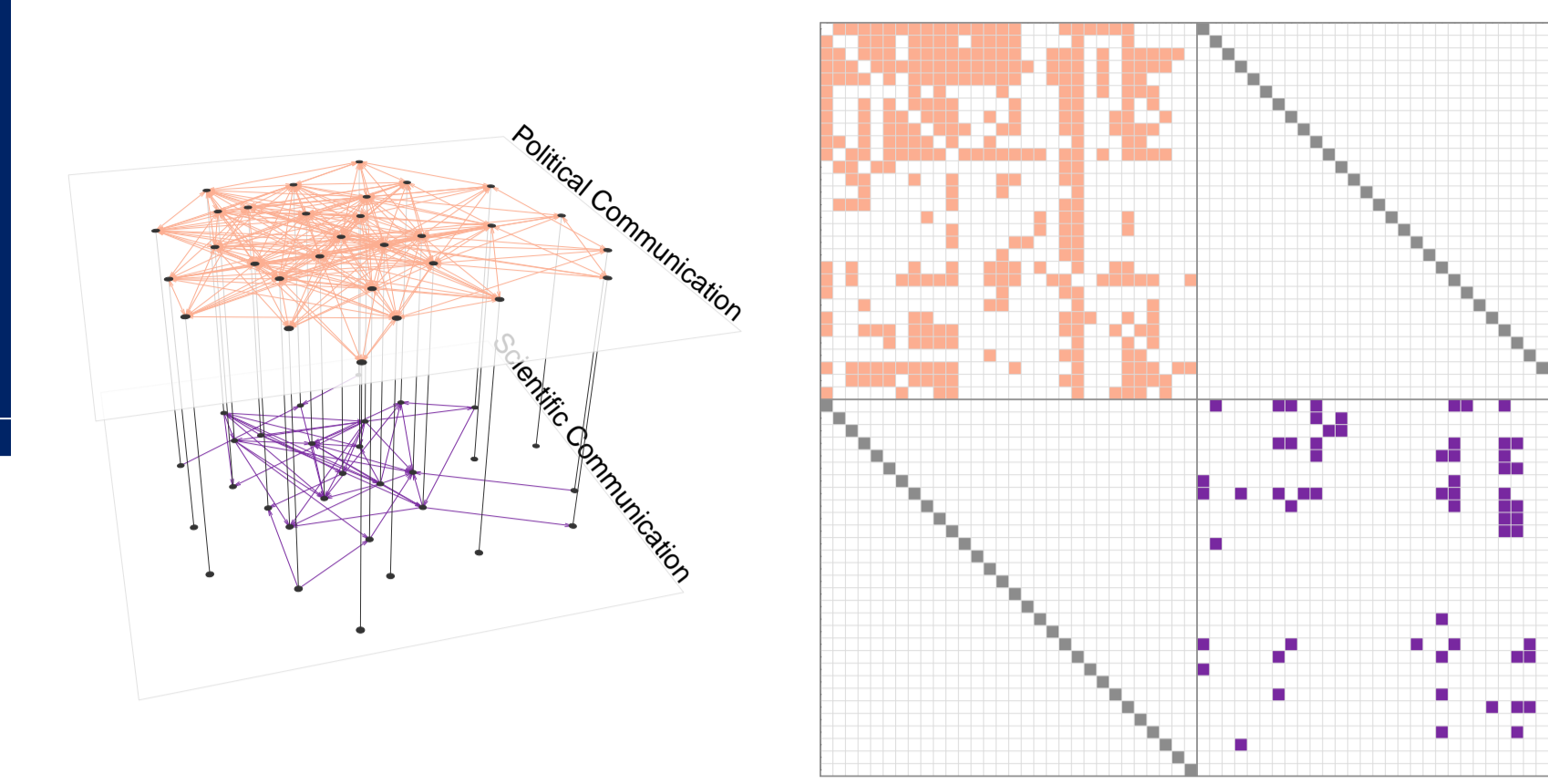
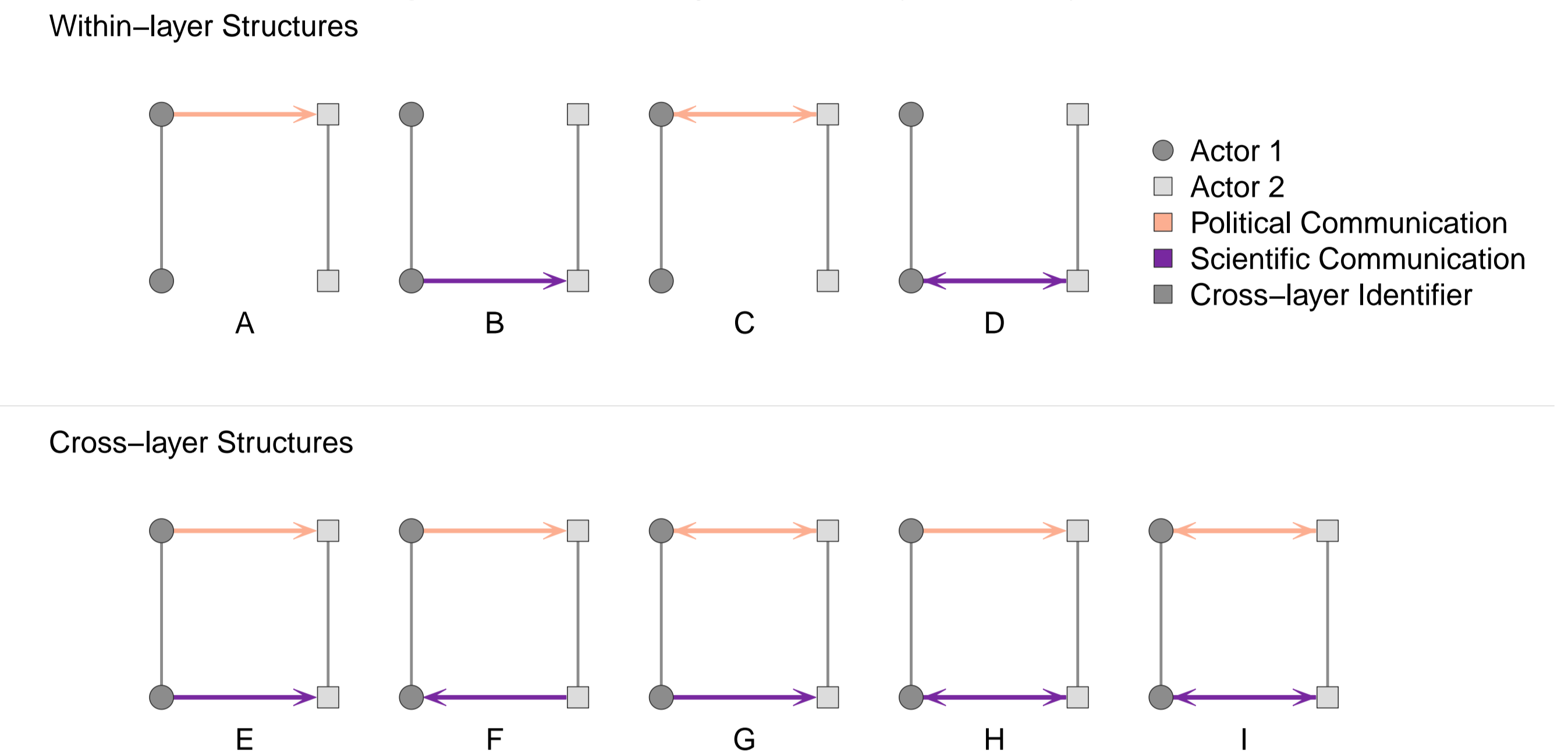


Figure 6. Policy communication as a multilayered network

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

Figure 7. Network configurations for a dyad on two 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.

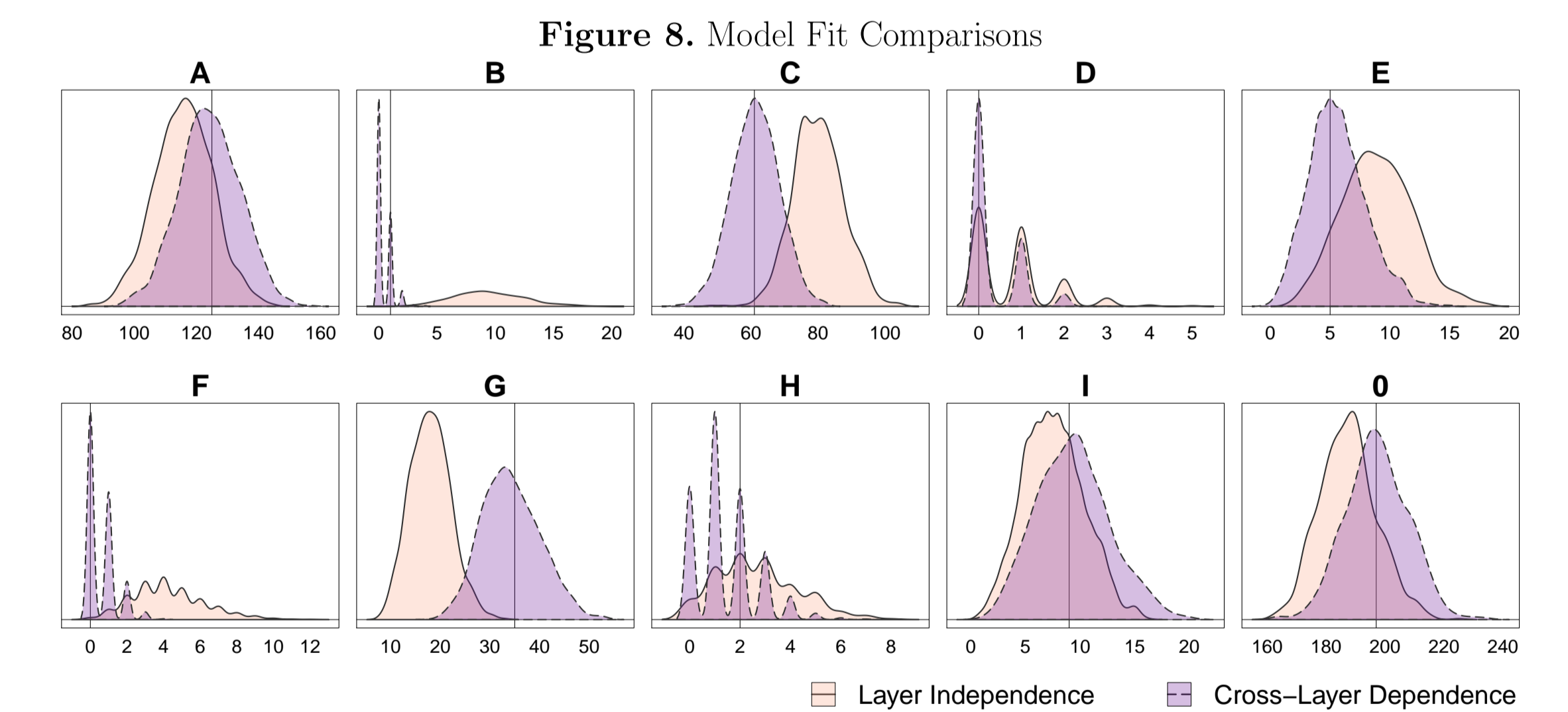


Table 1. Two Models for Policy Communication

Term	Cross-layer Independence		Cross-layer Dependence	
	Estimate	s.e.	Estimate	s.e.
<u>Political Comm.</u>				
Arc	-5.20*	1.32	-5.36*	1.24
Reciprocity	0.81*	0.25	0.50	0.26
Scientific Arc	2.88*	0.65		
<u>Scientific Comm.</u>				
Arc	-5.99*	0.80	-7.53*	1.35
Reciprocity	1.76*	0.53	7.60*	2.53
Political Arc	2.87*	0.62		
<u>Cross-layer Dependence</u>				
Reinforcement			1.75*	0.62
Reciprocity			0.87	0.54
Configuration G			0.08	0.52
Configuration H			-1.71*	0.65

Full model not presented here.