Transnational Scientific Communities Facilitate Cooperation in the International Nuclear Regime: Evidence from the Pugwash Movement

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ABSTRACT: In this paper I show how transnational scientists influence international cooperation on nuclear treaties. I propose a delegation-based theory for how the transnational scientific community can influence state behavior by providing informational resources to help governments overcome hurdles to cooperation. Internationalist-oriented scientists obtain these informational resources by engaging each other through informal diplomacy. At the same time, they are constrained by what states consider to be permissible, which results in the observed bidirectional influence between state and scientist behavior. In the empirical analysis, I create a network data set from archival data on the Pugwash movement, a transnational community of scientists lobbying for increased extranational control over nuclear technology. I jointly model the international nuclear treaties and transnational Pugwash networks as a multilayer network. Results indicate that mutual reinforcement between the two sets of cooperative ties is a generative feature of the network. Additional evidence showing that results are stronger in open political systems, which afford scientists access to state officials, provides support for the proposed informational mechanism behind this relationship.

Overview

- What is the relationship between transnational scientists and interstate cooperation?
- Evidence of mutual reinforcement between interstate nuclear cooperation and transnational scientific cooperation
- Results support informational mechanism behind this relationship

Transnational Influence on International Cooperation

- Interstate cooperation is difficult but transnational actors can help.
- Transnational experts anticipate plausible areas of cooperation, and influence interstate cooperation by providing informational resources that help states overcome hurdles to cooperation.
- The result is a mutually reinforcing relationship between the two sets of cooperation.

Diplomacy is an antiquated vehicle. Our role is to remove obstacles from the path of this antique chariot.

—Lev Artsimovich, Soviet physicist
Addressing other Pugwash participants in 1963

The global system is a multilayer network

- States cooperate with one another on matters pertaining to control over nuclear arms (and nuclear technology more broadly)
- Transnational scientists cooperate with one another to share information that facilitates interstate cooperation
- Scientists are tied to states through their national affiliations
- This is a multilayer network (i.e. a network with multiple qualitatively distinct types of ties) with two layers
- Tie formation in a network depends on the existence of other ties; how do scientific cooperation influence interstate cooperation and vice versa?

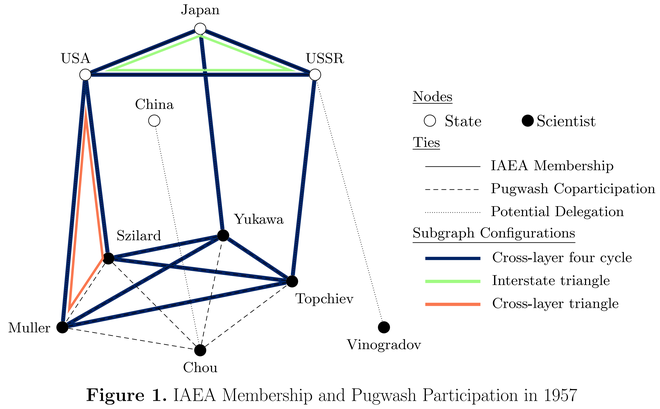


Figure 1. IAEA Membership and Pugwash Participation in 1957

Methodological Approach

An exponential random graph model is a statistical model that tests the different factors that underlie the generative process of an observed network.

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

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

where $\boldsymbol{x}$ is a function that yields observed network statistics computed on $\mathbf{Y}$. Generative features at the node-, dyad-, and network-levels are specified as counts of local network configurations (i.e. network statistics from $\boldsymbol{x}$).

The multilayer approach extends the basic ERGM framework:

- Nodes are sorted by types onto layers; incident layers define tie type.
- Different types of ties have different probabilities for being observed.
- Network configurations take tie type into consideration.

Model Specification

- *Concept*: Mutual reinforcement between interstate and transnational cooperation
- *Measure:* Cross-layer alignment between network layers
- *Network configuration:* Cross-layer four cycle
- Interaction between cross-layer alignment and open political systems

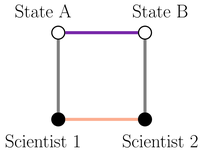


Figure 2. Cross-layer four-cycle

Table 1. Additional Model Terms

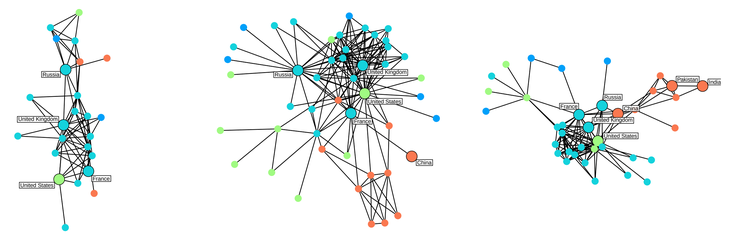
Effect	Description	Expectation
State Layer: Interstate Cooperation		
Triadic Closure (geometrically-weighted edgewise and dyadwise partner terms)	The tendency for dyads with shared partners to also form ties	A **positive** GWESP term combined with a **negative** GWDSP term indicates a tendency for triadic closure.
Treaty Commitment Distance	Distance between two states' general treaty positions	**Negative:** States with dissimilar treaty commitments are less likely to form ties.
Regional Homophily	Whether two states come from the same region of the world.	**Positive:** States in the same region are more likely to form ties.
Node-level Trade Embeddedness	Ratio of Trade to GDP.	**Positive:** States more exposed to the international economic system are more likely to opt into the regime.
Node-level Nuclear Power Status	Binary measure of whether a state possesses nuclear weapons.	**Positive:** Nuclear states have greater incentives to maintain the nuclear status quo.
Scientist Layer: Transnational Cooperation		
Transnational homophily (region)	Whether two scientists come from the same region of the world.	**Positive:** Scientists living in the same region are more likely to form ties.
Transnational homophily (state)	Whether two scientists share the same national affiliation.	**Positive:** Scientists with the same national affiliation are more likely to form ties.

Data and Network Construction

Data on joint-activity collected from various archival sources.

- Bilateral and multilateral international nuclear treaties.
- Participation in Pugwash meetings for approx. 5000 scientists.

Partitioned into five periods, then obtained monopartite projections.



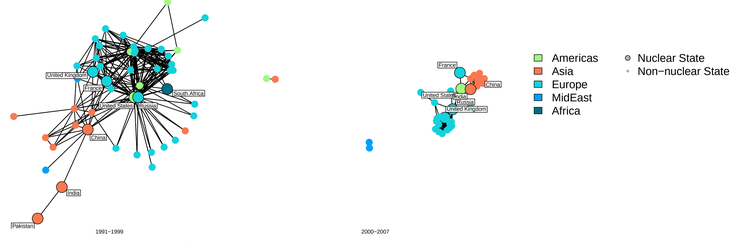


Figure 4. Nuclear cooperation across five periods.

Results

- Evidence of cross-layer alignment between the two network layers in four of the five periods.
- Support for the information mechanism in periods three and four: cross-layer alignment is driven by states with open political systems.

Figure 3. Coefficients for cross-layer alignment over five periods (purple indicates $p < 0.05$)

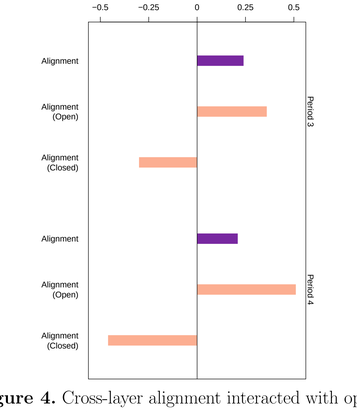


Figure 4. Cross-layer alignment interacted with open political system (orange indicates models with interaction)