Computational Models of IR

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Gartzke & Weisiger (BJPS, 2013)

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- Affinity implies that the demand for alliances changes as friends or threats change.
- Question: what causes states to create new or break existing friendships?

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- If alliances are more than capability aggregating mechanisms, then what influences the choice of partners?

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- States that are similar on various dimensions are attractive because costs are lower.
- Regime type is one dimension of similarity that can lead to friendships.

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- Does this explain why there is not an increasing tendency for democracies to ally?

Why ABM?

- A game-theoretic approach would impose strong rationality assumptions given the requirement that actors anticipate the possible alliance decisions of all other actors in the system.
- Main interest is in changing system dynamics among numerous actors.

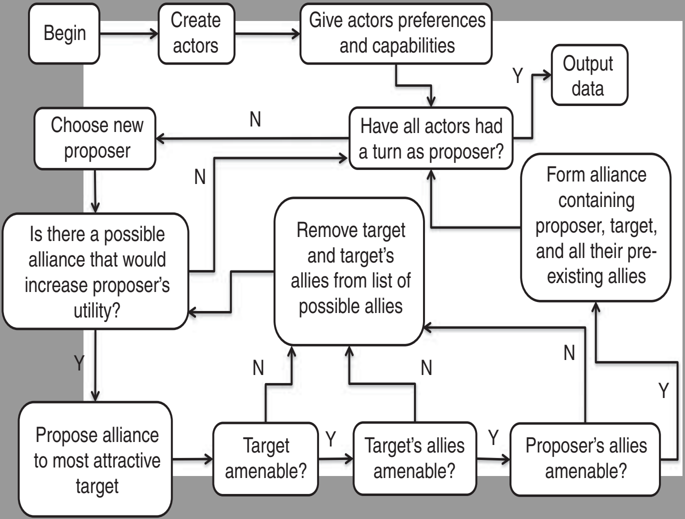

Fig. 2. Overview of the simulation model

- Set of A actors (N=40), where each actor $i \in A$ is defined by:

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- Ideal Point, $S_i = \{r_i, s_i^\sigma\}$, with $r, s \in [0, 1]$ and $\sigma \in 1, 2, 3, 4$.

Capabilities

- $c_i \sim \mathrm{U}[0,1]$ and then raised to $-\alpha$, where $0 \leq \alpha \leq 1$.
- α determines the degree of variation in actor strength; $\alpha = 0$ means no variation, $\alpha = 1$ means high variation.
- Set $\alpha = 0.5$.

Ideal Point

- $S_i = \{r_i, s_i^\sigma\}$, with $r, s \in [0, 1]$ and $\sigma \in 1, 2, 3, 4$.
- r_i represents regime type.
- s_i^σ represents up to 4 additional issue dimensions.
- $s_i^\sigma \sim \mathrm{U}[0, 1]$.

Democracy

- Predetermined set of actors are democracies, the rest are autocracies.
- A threshold r_θ separates democracies from non-democracies.
- Regime scores for democratic states are drawn from $\mathrm{U}(r_\theta, 1]$.
- Regime scores for non-democratic states are drawn from $\mathrm{U}[0, r_\theta]$.
- $r_\theta = 0.85$ to reflect regime coding in empirical applications.

Capability Aggregation

- $F_i \subseteq A$ is the subset consisting of actor i and all of i's allies, with f corresponding to the size of F.
- The alliance's combined capabilities are: $c_{F_i} = k \sum_{F_i} c_i$
- k, where $0 < k \leq 1$ represents the efficiency of capability aggregation.
- Set $k = 0.9$.

Alliance Effective Ideal Point

- $S^*_{F_i} = \{r_{F_i}, s^\sigma_{F_i}\}$ is the capability-weighted mean of member ideal points.
- $r_{F_i} = \dfrac{\displaystyle\sum_{j \in F_i} c_j d_j}{\displaystyle\sum_{j \in F_i} c_j}$
- The elements $s^\sigma_{F_i}$ of $S^*_{F_i}$ are defined analogously.

Policy Outcomes

- Given actors' capabilities and preferences and each alliance's joint capabilities and effective ideal point, one can calculate policy outcomes from actor interactions and actor utilities from those policy outcomes.
- Each interaction between non-allies produces a policy outcome O_{ij} with elements o_{ij}.
- $O_{ij} = \left\{ \dfrac{c_{F_i} r_{F_i} + c_{F_j} r_{F_j}}{c_{F_i} + c_{F_j}}, \dfrac{c_{F_i} s^1_{F_i} + c_{F_j} s^1_{F_j}}{c_{F_i} + c_{F_j}}, \ldots \right\}.$

Overall Agent Utility

- Interaction with allies produce outcomes at the alliance effective ideal point $S^*_{F_i}$.
- $u_i = -\sum_{A/F} \sqrt{\sum_S (s_i - o_{ij})^2} - (f-1)\sqrt{\sum_S (s_i - s^*_{F_i})^2}$
- First term captures i's utility from interactions with non-allies.
- Second term captures utility from the $f-1$ allies.
- In every alliance formation decision, all actors compare the utility they would gain under the current alliance to what would be gained by forming a new alliance.
- State's will join a new alliance if the new alliance raises their utility.

Simulations

- Each run consists of several thousand iterations (the process in Figure 2 is one run).
- Produces approximately 1,000 dyadic observations for each level of systemic democracy.
- Main interest: how does changing the level of systemic democracy influence the probability that similar actors ally?

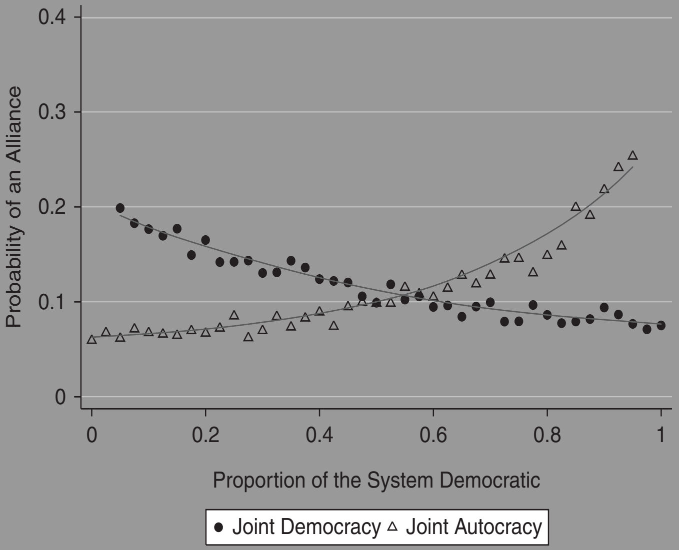


Fig. 4. Probability that similar-regime actors ally at different values of systemic democracy

Hypotheses

- H1: the probability of an alliance in democratic dyads declines as the system is more democratic.
- H2: the probability of an alliance in an autocratic dyad increases as the system is more democratic.

Empirical Evaluation

- Examine the determinants of alliance status between 1816 and 2000.
- Use same dyadic set up that was output by the simulation.
- Include interaction terms for democracy and proportion of the system that is democratic (autocratic).
- Include standard set of control variables.

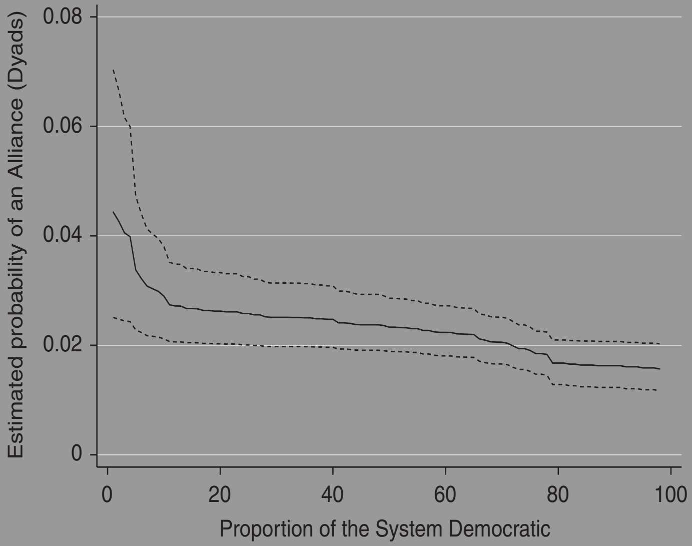


Fig. 8. Probability of an alliance in a democratic dyad for values of systemic democracy

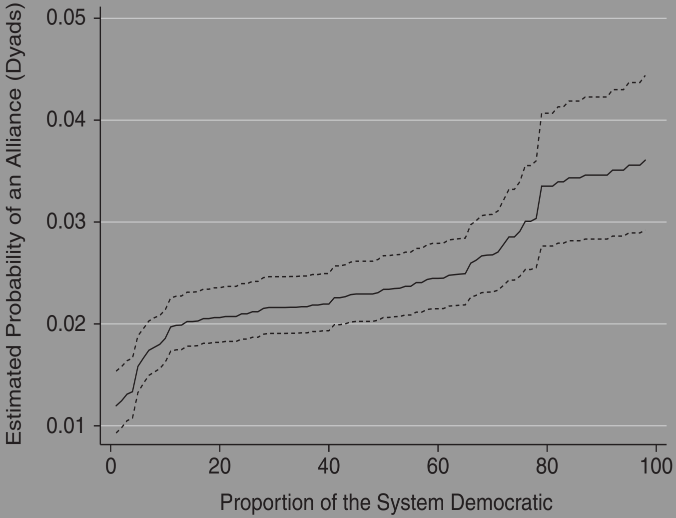


Fig. 9. Probability of an alliance in an autocratic dyad for values of systemic democracy

Conclusions

- ABM appears to capture an important dynamic in world politics.
- Affinities and animosities are contextual, evolving at the dyad level in response to changes in salient attributes at the system level.
- The appeal of alliances among democracies has declined as the security and heterogeneity of the democratic community has grown.

Take-Away Points

- Why ABM?
- Micro-level approach
- Agent characteristics based on empirical data
- Use illustrative runs to highlight model features
- Has shown one specification that can produce relationship
- Empirical testing

Joyce & Maoz (Working Paper)

Research Questions

- What causes states to form ties across different types of international networks (e.g., alliance, trade)?
- What kind of network-related equilibria emerge from these processes of tie-formation?
- Given a shock of a pre-defined type (e.g., political or economic) and a specific tie-formation process, how do the network-related equilibria change?
- How do networks respond to different attributes of shocks (e.g., with regard to location, magnitude, scope, and spread)?

Research Strategy

- Develop a set of agent-based models (ABMs) using random network data, which model
  - different network formation processes
  - pre-shock network characteristics
  - different types of shocks
  - post-shock network re-organization
  - post-shock network characteristics
- Deduce propositions about the effect of shocks given
  - different network formation processes
  - characteristics of shocks
- Test these propositions via
  - empirical tests of the propositions from the ABMs
  - insertion of real-world data into the ABMs and comparing output data from the ABM with real-world network data

Basic Assumptions

- Networks are emergent structures.
- Agents' calculations of tie-formation and choice of partner vary by domain.
- All agents use the same rules of tie-formation and partner-selection.
- Shocks induce a dramatic change in agents' attributes or in network size.
- Shocks do not alter the logic of tie-formation of agents.

Current Model

- Analyze two different network formation models: 1) preferential attachment, 2) homophily.
- Analyze two different kinds of shocks: 1) drop in tie capacity, 2) change in nodal attributes.
- Analyze differences between pre-shock and post-shock network characteristics.

Pre-Shock Process

Nodal attributes

- Maximum capacity for tie-formation [0,0.5]
- Regime type (binary)
- Enemy of my enemy (binary)
- Cultural similarity (binary)

Two network formation models:

- Preferential Attachment (PA)
- Homophily (H)

Measure network characteristics at equilibrium

- No node changes ties

Shocks

Induce shock: tie-capacity

1. Most central node loses tie capacity by a certain percentage of pre-shock capacity [0,100]
2. Certain percentage of nodes lose tie capacity [25,50,75]

Induce shock: nodal attributes

- Certain percentage of nodes change common enemy attribute [25,50,75]

Post-Shock Process

- Network re-organizes after shock according to the previous network formation model
- Measure characteristics of post-shock network
- Compare pre- and post-shock characteristics

Computer Simulations

Parameters

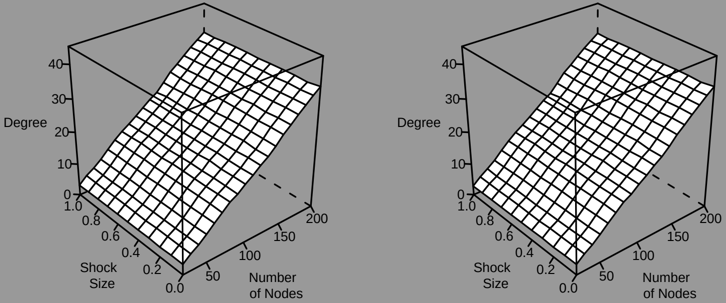
- Network sizes: 20-200 nodes
- Size of shock: 0-100%
- Nodes affected by shock: central, 25%, 50%, and 75%

Metrics

- Network, Group, Dyadic, Nodal

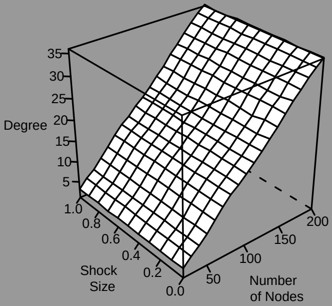
Example Simulation Results

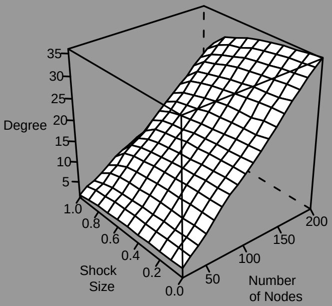
Preferential Attachment: Central Node Shock



Example Simulation Results

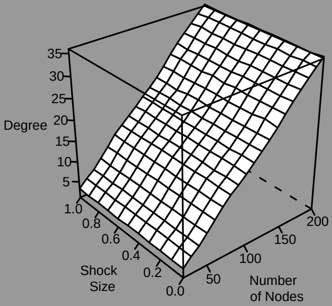
Preferential Attachment: 25% of Nodes Affected by Shock

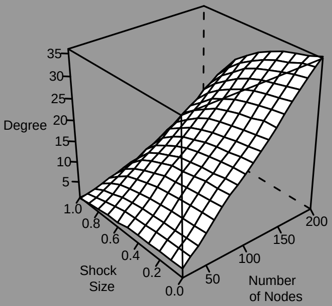




Example Simulation Results

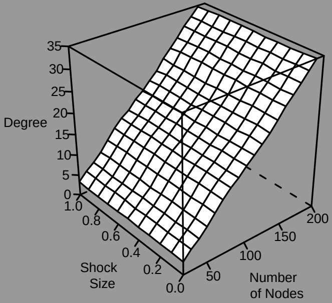
Preferential Attachment: 50% of Nodes Affected by Shock

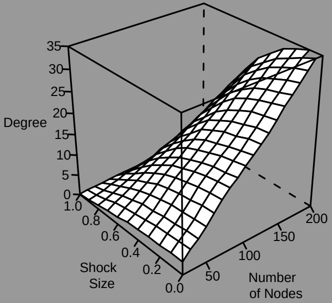




Example Simulation Results

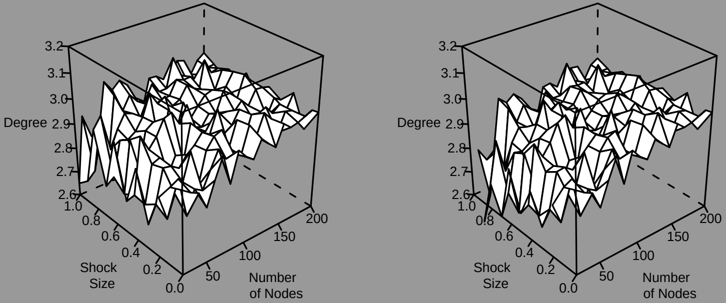
Preferential Attachment: 75% of Nodes Affected by Shock





Example Simulation Results

Homophily: Central Node Shock



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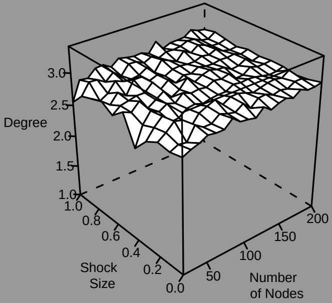
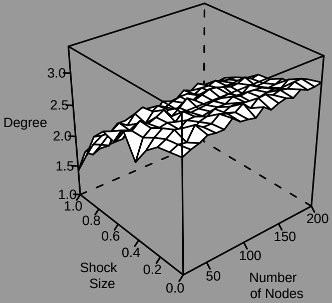
Homophily: 25% of Nodes Affected by Shock





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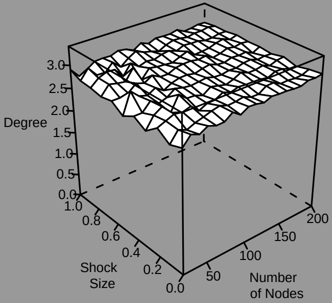

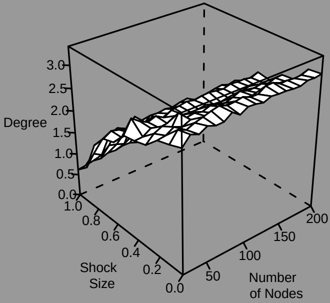

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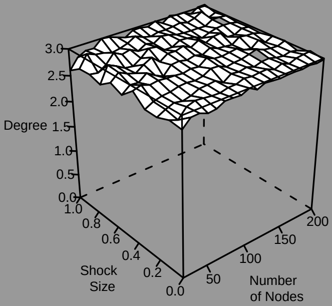

Conclusions

- When the shock is limited to the most central node the effects are minimal; networks return to their pre-shock structure.
- When the shock affects multiple nodes the effects are much more pronounced (e.g., reduce the average degree of the network).
- These effects are a function of both the shock size and of the number of nodes affected.

Conclusions

Next Steps

- Develop a strategic model of network formation
- Analyze other types of shocks: change in other nodal attributes and size of network
- Examine directional networks
- Examine endogenous shocks
- Begin the ABM with real-world data on international networks

Take-Away Points

- General model not based on empirical target
- Micro-level approach
- Focus on network formation and dynamics
- Insert real-world data into the model