The Effects of Shocks on International Networks: Reduced Tie-Capacity of States and the Structure of International Trade and Alliance Networks

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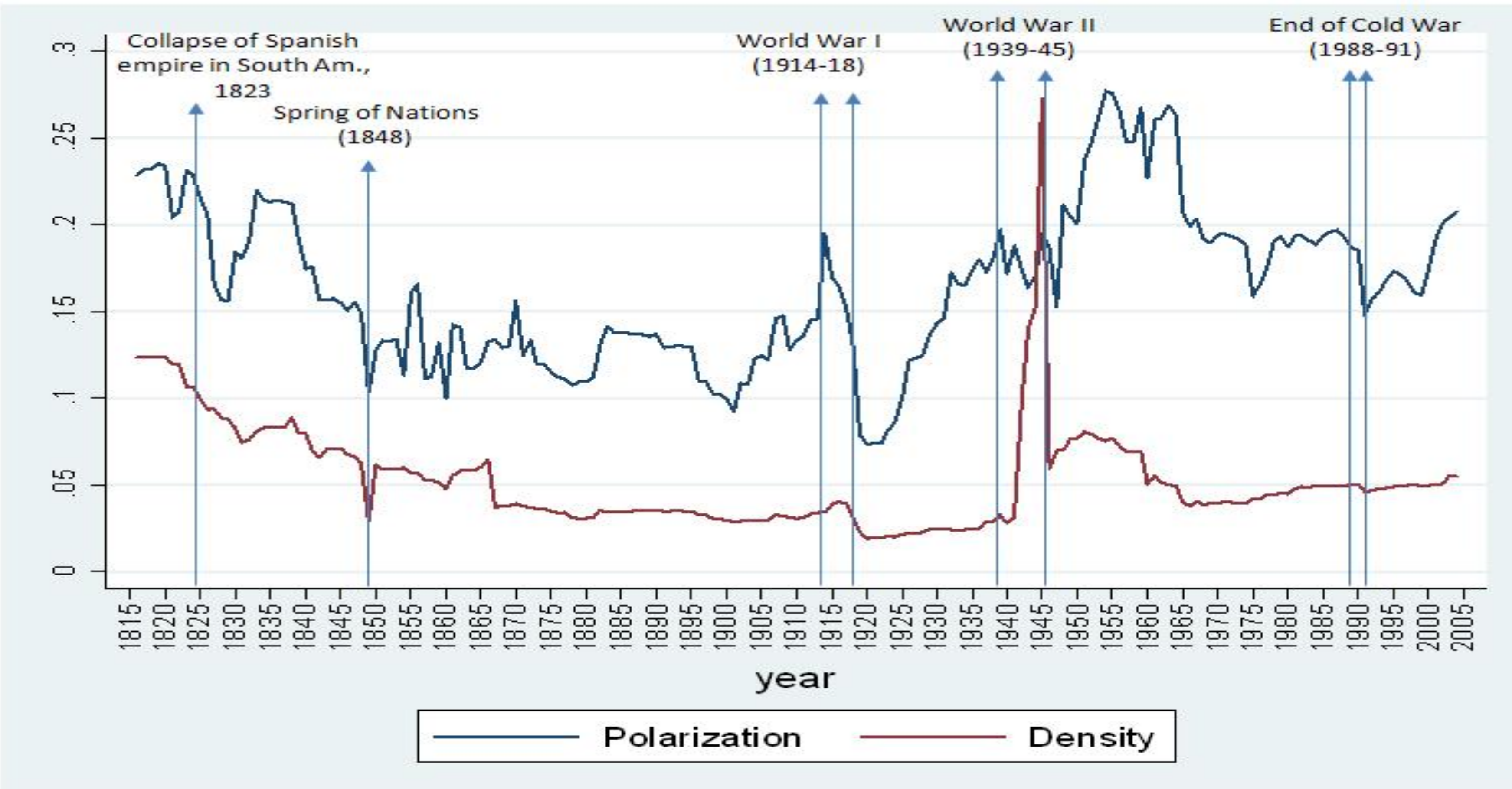
The polarization and density of international alliance networks, 1816-2004




Log World Trade, 1870-2012
Log World Trade
18
16
14
12
10
1870
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
Year
logtrade
Fitted values

Research Questions

- **What causes states to form ties across different types of cooperative networks (e.g., alliances, trade, institutions)?**
- **What kind of network-related equilibria emerge from these processes of tie-formation?**
- **Given a shock of a predefined 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)?**

Focus of Current Project

- **Analyze different network formation models**
- **Analyze shocks as reduction in edge-capacity of a certain percentage of nodes in a network**
- **Analyze differences between pre-shock and post-shock network characteristics**

Basic Assumptions

- Networks are emergent structures
- Agents' calculations of tie-formation and choice of partners 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
- Shock effects are a function of network dynamics and shock characteristics

Research Strategy

- **Develop an Agent-Based Models (ABM) using random network data, which simulates**
  - **different network formation processes**
  - **the characteristics of the resulting networks**
  - **different shock characteristics**
  - **post-shock network re-organization**
  - **post-shock network characteristics**

- **Deduce propositions about the effect of shocks given**
  - **different network formation processes**
  - **shock characteristics**

- **Test these propositions via**
  - **empirical tests of the propositions from ABM on real-world data**

Current ABM

Pre-Shock Process

- Two network formation models:
  - Preferential Attachment (PA)
  - Homophily (H)
  - Network sizes 20-200 nodes
- Nodes have a maximum capacity for tie-formation: range [0,0.7]
- Nodes have 3 binary attributes: joint democracy, common enemies, cultural similarity
- 10% of the nodes randomly chosen to form ties
- Other nodes enter the network sequentially

Current ABM

Pre-Shock Process

- **Each node defines a utility for forming a tie with other nodes**
  - **PA:** $u_{ij} = d_j + 1/(|E|+|V|)$
  - **H:** $u_{ij} = 0.5r_j + 0.3e_{ij} + 0.2c_{ij}$ if $i=r$

    $0.1_{rj} + 0.6e_{ij} + 0.3c_{ij}$ if $i \sim= r$
- **Focal node offers to form a tie with existing node with highest utility; if existing node is below their tie-capacity the offer is accepted; otherwise offer is rejected.**
- **Process continues until equilibrium is reached (no node changes ties)**
- **Measure network characteristics at equilibrium**

Current ABM

Shock and Post-Shock Process

- Induce shock that reduces nodal tie-capacity
- Shock characteristics:
  - Shock Size: the percentage reduction in tie-capacity
  - Shock Spread: the percentage of nodes that experience the shock
  - Shock Magnitude: shock size x shock spread; weighted by the degree centrality of the node shocked
- Network re-organizes after shock according to previous network formation models
- Measure post-shock network characteristics
- Compare pre- and post-shock network characteristics
- Deduce hypotheses regarding effects of shocks on real-world networks

Next Steps

- Analyze other shocks: change in other nodal attributes and size of network
- Develop a strategic model of network formation
- Examine endogenous shocks
- Insertion of real-world data into the ABMs and comparing output data from ABM with real-world network data