State-Level Decision-Making in a Regional Model of Proliferation

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Why do States Choose to Proliferate?

• States believe it is in their security interests to develop a latent weapons capability

• States first acquire nuclear technology for energy purposes

• They then develop a weapons program
Outline

• Cyclus Models Interactions Between Actors

• The Regional Proliferation Model

• Scenarios to Explore Policy Proposals
Cyclus Is Agent-Based

- Agents have customizable behavior
  - Each agent in the fuel cycle has its own decision-making logic
  - Agents choose what to trade, and *who* to trade with
• Managing agents control where trade flows

• Sanctions, trade agreements
Outline

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Diverse Factors Influence Proliferation

• Internal factors
  – Economic
  – Political
  – Technical

• External factors
  – Regional Stability
  – Scientific Network

Pursuit Equation

- Enrich/Repro: 16
- Authoritarian: 15
- Conflict: 15
- Military Spending: 15
- Reactors: 10
- Military Isolation: 10
- Scientific Network: 10
- U Reserves: 9
Informed by Historical Data

Pursuit Scores
Factors Evolve in Time

- Political upheaval
- Economic growth or disruptions
- Proliferant neighbors
- New treaties or security assurances
Cyclus Manager Agents

• State Institution
  – Tracks time-evolution of factors
  – Factors determine likelihood of pursuing weapon
  – Converts likelihood into a pursuit decision

• Interaction Region
  – Oversees all States in simulation
  – Manages and shares conflict information
One-State Scenario Follows Exponential Decay

5 Single State

Time Steps/Simulation: 100
# Simulations: 1000
# Proliferation Events: 1000
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• Cyclus Models Interactions Between Actors

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• Scenarios to Explore Policy Proposals
Develop Policy-Based Scenarios

• Multilateral Paradigm
  – Proliferant States control enrichment technology
  – Non-proliferant States participate in operations and economics

• Reduced technology expansion

• Increased knowledge transfer and networking
Demonstrate Risk Reduction to Change the Conversation?

• Compare likelihood of regional proliferation under two paradigms
  – Under what conditions is risk decreased?

• Outcomes are indicative, not predictive
Cyclus for Nonproliferation

• The agent-based framework of Cyclus facilitates modeling of actor behavior

• Regional Proliferation model captures motivations to pursue weapons

• Scenarios such as multilateral enrichment will be examined
Sources for Historical Data on Proliferation Factors

- Military Spending/GDP – World Bank
- Military Isolation – Alliances with Defensive pacts, Bryce University Database of Formal Treaties
- Authoritarian – Polity Index, Center for Systemic Peace
- Commercial Reactors – IAEA database, includes planned/under construction
- Enrichment & Reprocessing (Y/N) – Nuclear Latency Dataset, Furman, Texas A&M
- Uranium Reserves (Y/N) – OECD Report on world uranium reserves
- Scientific Network – Personal assessment low/medium/high. To be quantified using objective criteria
Extrema Behave as Expected

2.5 Single State Results

- Time Steps/Simulation: 100
- # Simulations: 1000
- # Proliferation Events: 340

7.5 Single State Results

- Time Steps/Simulation: 100
- # Simulations: 1000
- # Proliferation Events: 1000
Cyclus Tracks The Flow of Nuclear Material

• Facilities trade nuclear material over time
  – Quantity & isotopic composition