



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**



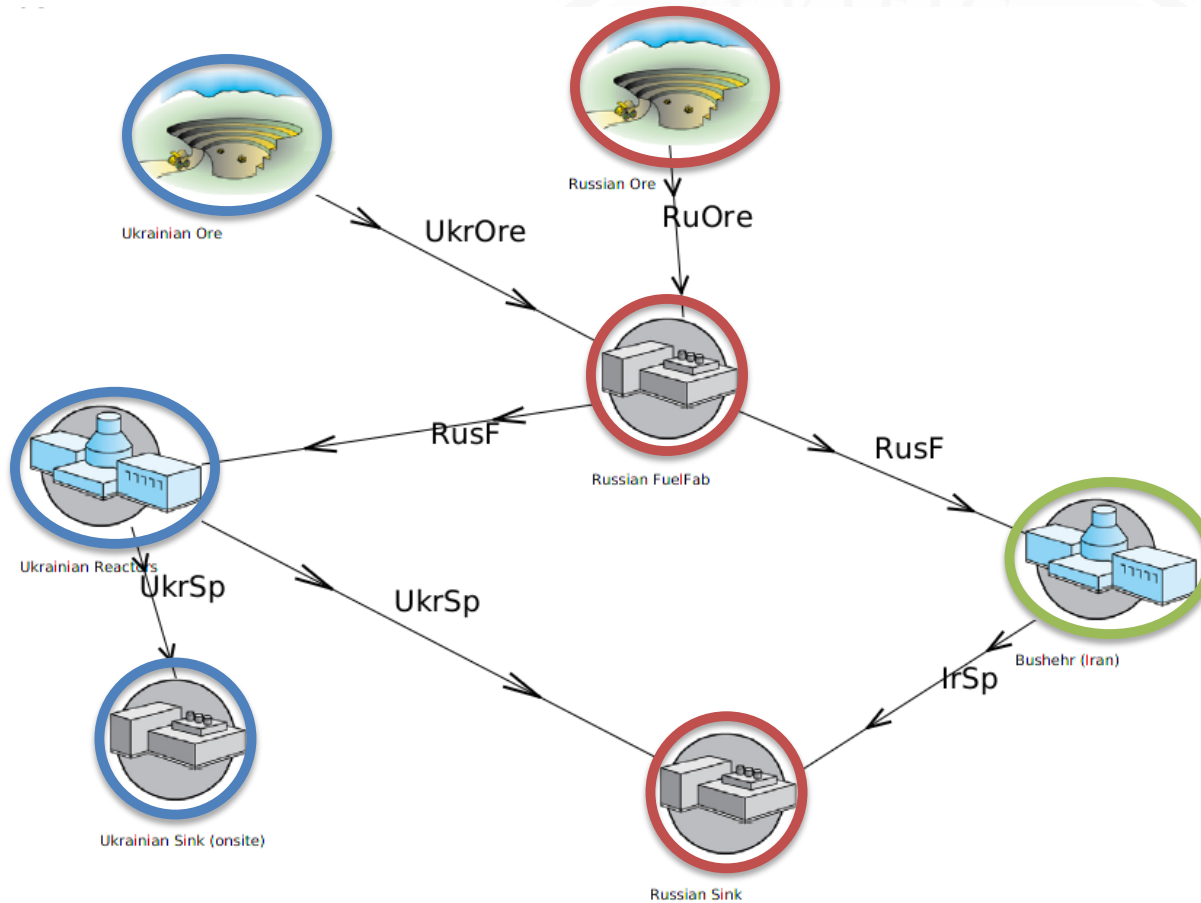
Cyclus Is Agent-Based



- 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



Region/Institution/Facility Hierarchy



- Managing agents control where trade flows
- Sanctions, trade agreements





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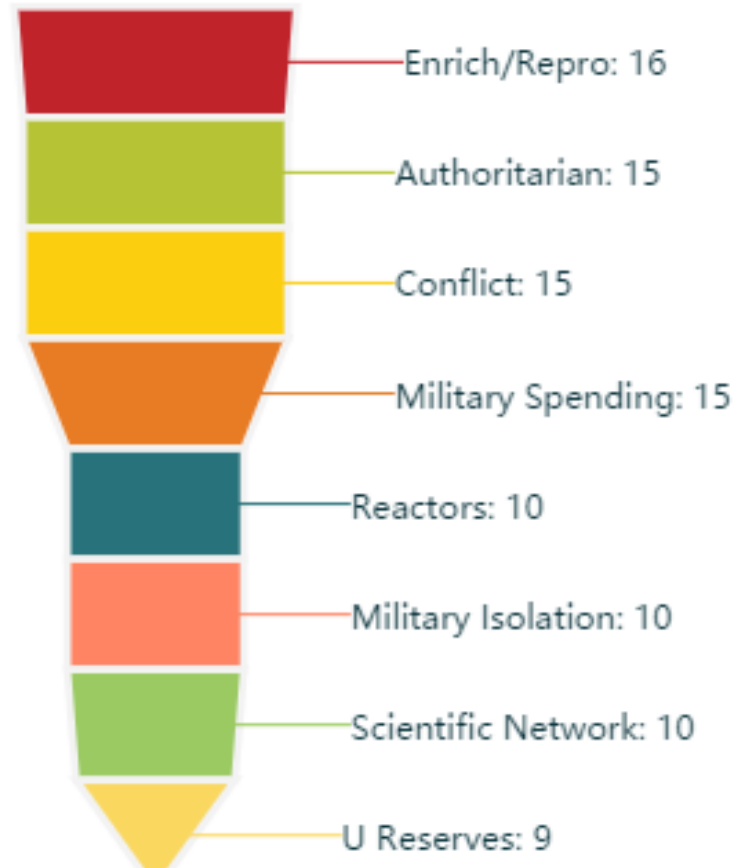


Diverse Factors Influence Proliferation



- Internal factors
 - Economic
 - Political
 - Technical
- External factors
 - Regional Stability
 - Scientific Network

Pursuit Equation

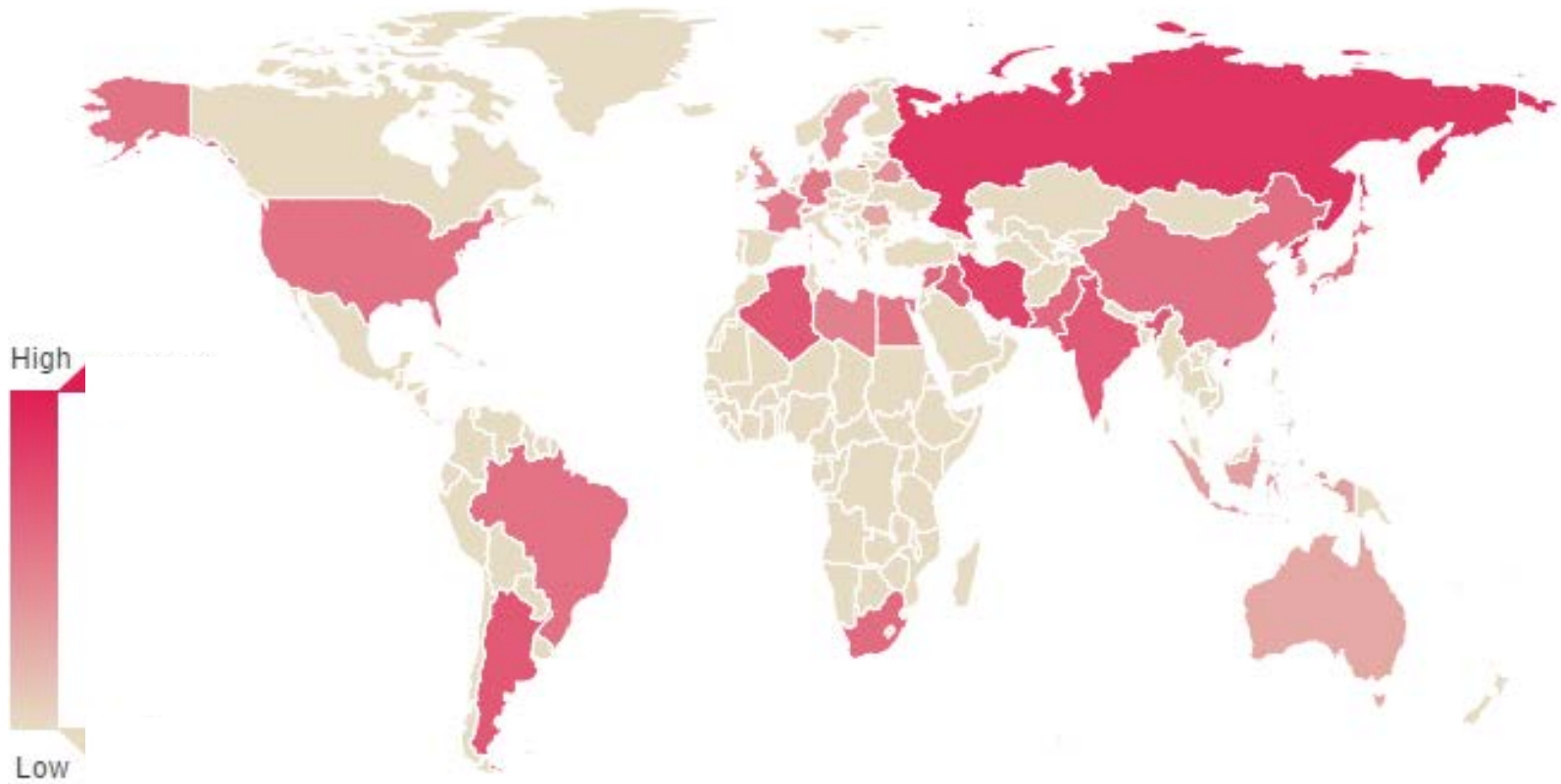




Informed by Historical Data



Pursuit Scores





Factors Evolve in Time



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



Cyclus Manager Agents



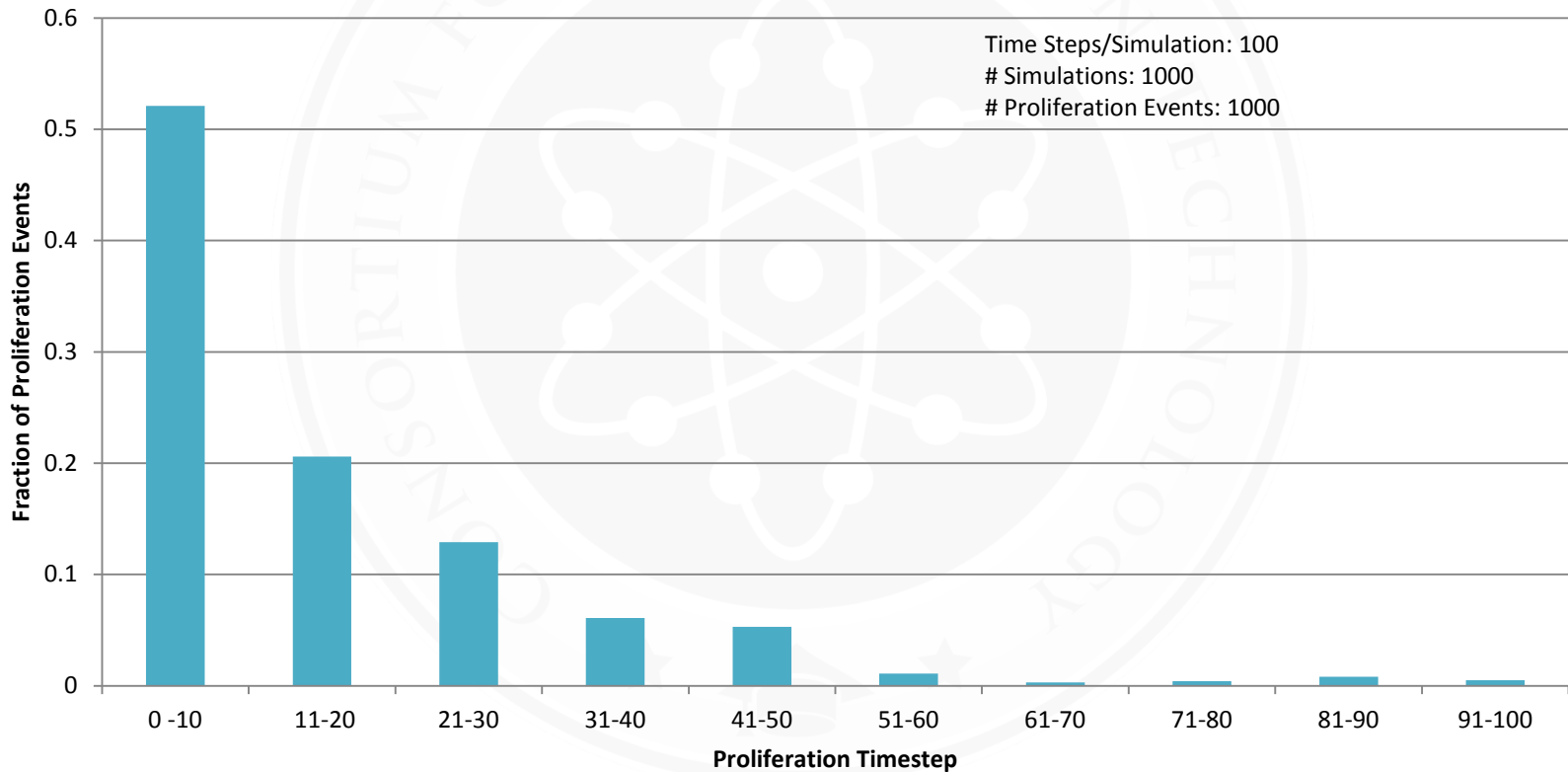
- State Institution
 - Tracks time-evolution of factors
 - Factors determine likelihood of pursuing weapon
 - Converts likelihood into a pursuit decision
- Interaction Region
 - Oversees all States in simulation
 - Manages and shares conflict information



One-State Scenario Follows Exponential Decay



5 Single State





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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
- Conflict – Global Peace Index, Institute for Economics and Peace (2015)
- 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*

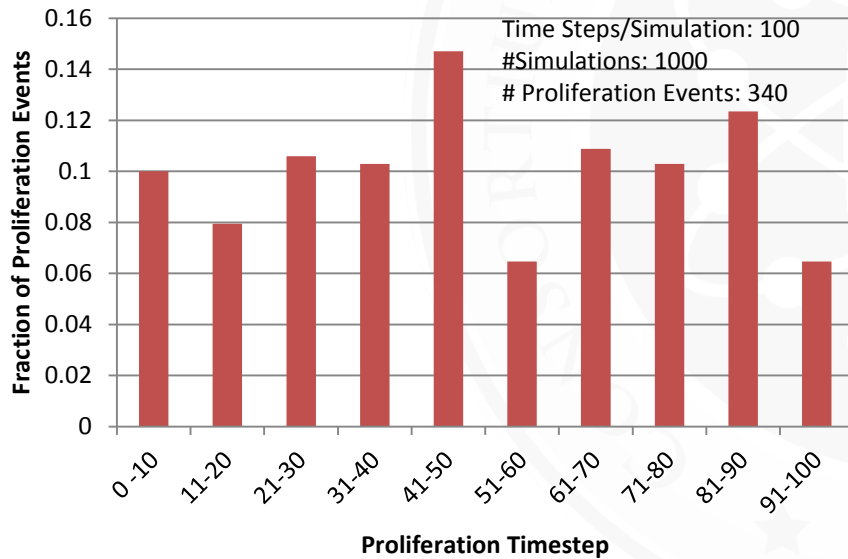




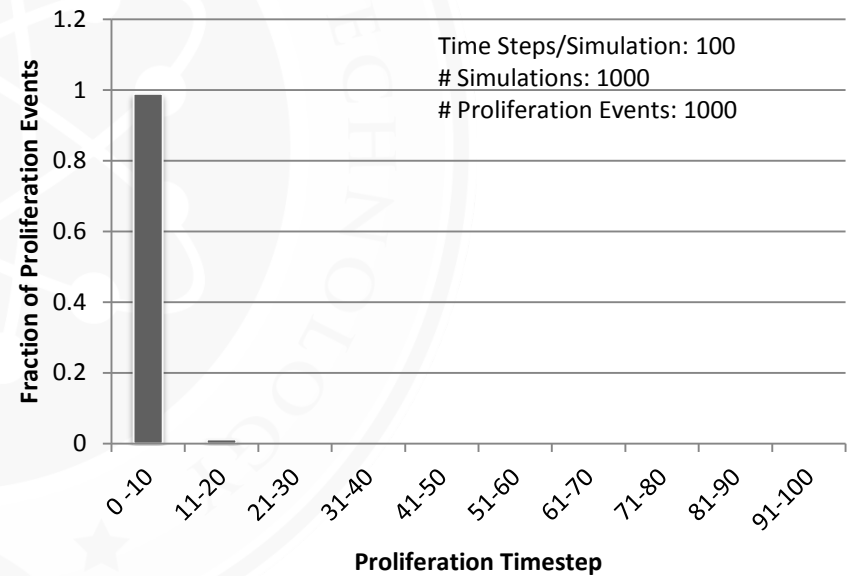
Extrema Behave as Expected



2.5 Single State Results



7.5 Single State Results





Cyclus Tracks The Flow of Nuclear Material

