Agent Based Models

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ABM in Political Science

- We are extending our knowledge
- Complexity limits what we can do
- Statistical Models have been the most frequent solution
- Simulation offers important opportunities to advance our knowledge

Social Science Methods

- A Social Science
  - We're not chemistry or physics
  - But we'd like to be
- We don't get the precision of lab experiments
- We have to approximate laboratory science methods

Progress

- We have gradually improved our ability to model the world
- Traditional statistical models have taken us a long way
- But problems are mounting

Theory Testing in Soc Sci

- Theory testing is key
- We can’t go into the lab like a chemist
- We need different methods
  - Experiments are tricky on the best day
- But we still need to test our theories

Hypotheses Testing

- Qualitative Methods
  - Case Studies
- Quantitative Methods
  - Mathematical models

Stochastic Models

- Useful in many ways
- Limited by the nature of the model
  - Linear assumption

$$y = x_1\beta_1 + x_2\beta_2 + x_3\beta_3 + \varepsilon$$

Limits of Statistics

- They cannot model a non-linear process
- They require observations of the phenomenon of interest
- They have a difficult time modeling complex systems

Simulation

- What is simulation?
  - Method of modeling the world
  - Can be human based
    - Axelrod's Prisoners' Dilemma Tournament
  - Can be machine based
    - Schelling's Segregation Models

Agent Based Models

- A type of simulation
  - “Agents” are individuals programmed to act in specific ways
  - They interact in a programmed world
  - They interact within defined parameters
- Allows the modeling of systems
- Allows complex interactions
- Does not require linear relationships

Three Components of ABM

- Agents
  - Decision and action rules define behavior
- Environment
  - Characteristics of the “world”
- Process Tree
  - How and when the agents act
  - How the agents interact with each other
  - How the world interacts with the agents

Complex Systems

- Agents can be programmed with behavioral parameters that simulate members of a dynamic system
- Environmental conditions can be controlled within the design
- Complex social systems can be generated even from relatively simple rules

Emergent Properties

- Simple rules can generate complex results
- Outcomes are the result of individual interactions and decisions
- Models disaggregated decisions
- Can be unexpected

Advantages of ABM

- Can model complex, dynamic systems
- Does not require linear assumptions
- Can model autopoietic systems interaction with institutions
- Can be used with conventional statistical models for the study of unobservable phenomenon

Key Considerations

- Require careful though to set up
- Sensitive to assumptions about the system
- Have significant pitfalls that must be avoided
- Can easily be abused for narrow purposes

ABM Software

- ABM Software is easy to get and its free:
  - NetLogo (http://ccl.northwestern.edu/netlogo/)
  - Repast (http://repast.sourceforge.net/)
  - Swarm (http://www.swarm.org/index.php/Main_Page)

Demonstration of NetLogo