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Agent-based modeling in Political Science, Sociology, and Social Psychology

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Outline

1. What do you know, what do you want to know about agent-based modeling?
2. What is agent-based modeling?
3. Who uses it for what purpose?
4. How do you do it?
5. Examples

What is an Agent-based Model?

- It is a **formal model**:

  A model is an **abstraction** which represents part of the real-world in a simpler form. Formal means: All objects and rules are precisely defined **mathematically and/or algorithmically**.
  - No difference to classical linear regression or structural equation model.
- **Agent-based** means that every agent in the real-world is represented in the model as an independent entity (no representative agent).
  - Similar to the typical datasets used in linear regression or structural equation model.
- Its focus is on the **interaction** of agents which is studied for example by **simulation** for a **longer time**.
  - That's the important difference!
- General side note: All models are wrong.

Who uses it for what purpose?
Social Psychology

Eliot R. Smith and Frederica R. Conrey (2007). **Agent-Based Modeling: A New Approach for Theory Building in Social Psychology**. *Personality and Social Psychology Review* 11 (1), 87–104

> *"The authors believe that the ABM approach is better able than prevailing approaches in the field, variable-based modeling (VBM) techniques such as causal modeling, to capture types of complex, dynamic, interactive processes so important in the social world."*

- Theory building
- ABM: Search for "generative explanations" of phenomena.
- VBM: Account for phenomenon by showing that it is an example of a more general statistical regularity.
- Example (Kalick and Hamilton 1984): Correlation of attractivity of dating or married partners ($\rho \approx 0.55$).
  - VBM: Preference for similar partners? (But no evidence.)
  - ABM: Random matching, dating offer with probability $\propto$ attractivity, if both offer $\rightarrow$ couple forms $\rightarrow$ both out of market

Who uses it for what purpose?
Sociology

Michael W. Macy and Robert Willer (2002). **From Factors to Actors: Computational Sociology and Agent-Based Modeling**. *Annual Review of Sociology* 28, 143–166

> *"In surveying recent applications [of ABM], we found that most congregated around two problems, (a) the self-organization of social structure and (b) the emergence of so- cial order."*
> *"ABMs are used to perform virtual experiments that test macrosociological theories by manipulating structural factors like network topology, social stratification, or spatial mobility."*

- From forecasts to thought experiments
- Differentiate against "equation-based", holisitic models which only represent the "deck of Colemans boat" in claiming and analyzing statistical relations between macrosocial variables.
- Example: Schelling's (1971) segregation model.

Who uses it for what purpose?
Political Science

L.E. Cederman (2001). **Agent-based modeling in political science**. *The Political Methodologist* 10 (1), 16–22

Joshua M. Epstein (1999). **Agent-based computational models and generative social science**. *Complexity* 4 (5), 41–60

- Make similar claims on studying emergent phenomena through generative models.
- ABM is used to model e.g.
  - Sudden outbreak of uprisings and revolutions.
  - Behavior of political parties.
  - Formation of preferences and ideological positions.

Summary

- **ABM vs. VBM:** Look more on the interaction of agents then the interaction of variables.
  - But: Individual-based variables are essetial in both.
- **Agent-based vs. equation-based:** It is not about equations between macroscopic variables but about the emergence of such relations.
  - But: Rule in the ABM algorith are equation. Macroscopic equations can be derived from agent-based models (e.g. Markov Chains); often faster, and deeper insight.
- **Agent-based vs. equation-based:** Not about equations of macroscopic variables but about emergence of their relations.
  - But: Rules in the ABM algorith are equation. Macroscopic equations can be derived (e.g. Markov Chains); often faster, and deeper insight.
- **Agent-based vs. game-theoretical:** It is typically not about perfect rationality over all future steps but about simple behavioral heuristics and the dynamics they trigger over time.
  - But: Myopic (not to forward-looking) rationality can well be a component of a dynamic model.

How do you do it? **6 steps**

1) **Agents and parameters**: Define agents, their dynamic variables and static parameters. Specifying them defines the **state** of the system.
2) **Behavior:** Define behavioral **rules** and **procedures** how agents change their state. Derive them from utility functions or from a psychological theory. States of other agents play a role. Randomness models uncertainty or influences not modeled.
3) **Initial constellation:** Fix an inital constellation: Typically, the number of agents (if not dynamic) and the initial values for their dynamic parameters.
4) **Simulation:** Implement a simulation as a computer program. Think about visualization and data storage. Programming environments: NetLogo, R, matlab, ...
5) **Macroscopic variables:** Define meaningful variables describing an emergent phenomenon.
6) **Mass simulationen** Check influence from static parameters on macro variables systematically.

Examples in NetLogo

- Schelling's (1971) segregation model
- Growth and redistribution (Lorenz 2013)
- Laver and Sergenti's (2011) model of party competition
- Clustering in ideological space (bounded confidence model) (see refs. in Lorenz 2014)

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