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Economic Policy Making with Agent-Based Modeling and Serious Games

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The Definition of Agent-Based Modeling (ABM)

- Computational study of processes modeled as **dynamic systems of interacting agents** according to certain behavioral principles and rules of the environment
- **Agents =** Individual, social, biological and/or physical entities
- "How collective behavior *emerges* from individual interactions"

ABM's characteristics

- Organizations are heterogeneous and complex systems and organizational action is a result of interactions among adaptive humans or firms
- Computational laboratories to explore various institutional arrangements, various potential paths of development so as to assist and guide e.g., firms, policy makers etc. in their particular decision context

The use of ABM's

- Increased understanding of systems through controlled computational experiments.
- In hierarchical models, vector-based representations are annoying
- Objects structures simplify the model

ABM is an alternative to

- **Empirical Statistical Models**: Fitted to past data. These successfully forecast a few quarters ahead as long as things stay more or less the same, but fail in the face of great change.
- **Dynamic Stochastic General Equilibrium Models**: Assume a perfect world, and by their very nature rule out crises of the type we are experiencing now

ABM Concepts

- Feedback loops, evolutionary processes, collective dynamics, learning (individual and social), non-linear dynamics, punctuated equilibria, adaptive behavior, complex networks, out-of-equilibrium dynamics, criticality, scaling, etc.
- **Emergence:** Bottom-up aggregate behavior that cannot be inferred by decomposing the system into its individual parts.

ABM Exemplary Research Questions

- Why social networks enhance or mitigate social stratification (sociology)
- Why herding behavior amplifies the movement of stock prices (economics)
- Why a flourishing civilization suddenly collapses (anthropology and archaeology).
- Why urban segregation emerges even within well-mixed populations (human geography)

An Example: Schelling Racial Segregation Game

- An interesting and important puzzle:
- After 1964 housing discrimination was illegal in the US
- Since 1950 racial prejudice has declined
- Yet neighborhoods remain highly segregated
- Schelling (1978) hypothesized that segregation:

  - does not need to be imposed (top-down)
  - does not reflect preferences (bottom-up)
  -self-organizes through dynamic interaction

An Example: Schelling Racial Segregation Game

- **Rules of the game:** Stay if **more than one third** of your neighbors are “kin” otherwise move to random “tolerable” vacant location if possible https://www.youtube.com/watch?v=dnffIS2EJ30
- **Key finding:** City can “tip” into high segregation even if citizens have only mild preferences for living with agents of their own type!
- Schelling was a co-recipient of the 2005 Nobel Prize in Economics. He is considered a “father” of ABM.

Another Example: Transforming the Dutch Linear Plastic Packaging System Towards a Circular Economy: Challenges, Opportunities, and Implications

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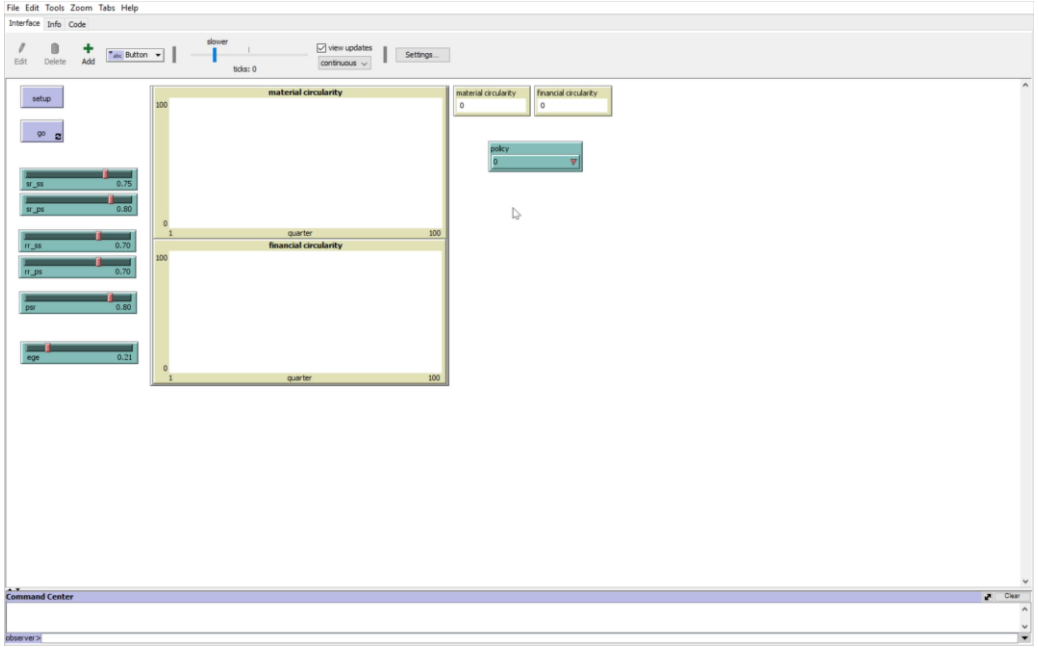

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The goals of ABM's

- **Empirical:** Why have particular large-scale regularities evolved and persisted, even when there is little top-down control? (E.g., trade networks, mutual cooperation based on reciprocity, and social norms). ABM researchers seek causal explanations grounded in the repeated interactions of agents operating in specified environments. In particular, they ask whether particular types of observed global regularities can be reliably generated from particular types of agent-based models.
- **Methodological:** How best to provide ABM researchers with the methods and tools they need to undertake the rigorous study of social systems through controlled computational experiments? ABM researchers are exploring a variety of ways to address this objective ranging from careful consideration of methodological principles to the practical development of programming and visualization tools.

The goals of ABM's

- **Heuristic:** How can greater insight be attained about the fundamental causal mechanisms in social systems? Even if the assumptions used to model a social system are simple, the consequences can be far from obvious if the system is composed of many interacting agents. The large-scale effects of interacting agents are often surprising because it can be hard to anticipate the full consequences of even simple forms of interaction.
- **Normative**: How can agent-based models be used as laboratories for the discovery of good designs? ABM researchers pursuing this objective are interested in evaluating whether designs proposed for social policies, institutions, or processes will result in socially desirable system performance over time. (E.g., auction systems, voting rules, and law enforcement).

ABM in Policy Making

- An understanding of the policy domain rather than the numbers it generates
- Models should be designed at an appropriate level of abstraction
- Although appropriate data for calibration and validation may sometimes be in short supply, modelling is often still valuable
- Modelling collaboratively and involving a range of stakeholders from the outset increases the likelihood that the model will be used and will be fit for purpose
- Effective communication between modellers and stakeholders
- Modelling for public policy involves ethical issues that need careful consideration

New opportunities for ABM

- Ideologies, premature computational technologies, data scarcity
- Agent-level rationality and general equilibrium
- A large-scale agent-computing model of the housing bubble in Washington DC. by Geanakoplos et al. (2012). They took advantage of the granularity of a large dataset from financial and real estate companies. By specifying highly detailed causal mechanisms, their model was able to emerge the bubble from bottom-up and became a pioneering tool to provide counterfactual estimates for different policy interventions.
- Governments and policymakers are more critical about traditional methods and open to new alternatives (E.g., Haldane & Turrell (2017) from Bank of England).
- Growth of big data and new methods in data science

Examples of ABM in Policy Making

- **EURACE** aimed to model entire economies at the level of each household and firm, in order to provide a policymaking tool (Deissenberg et al., 2008)
- **CRISIS** (http://www.crisis-economics.eu/) motivated by the global financial crisis of 2008 and attempted to provide tools that would help to foresee similar events in the future
- **Policy Priority Inference (PPI, The Alan Turing Institute):** Developing computational and network methods to advise governments on the policy priorities needed to reach socioeconomic development goals (https://www.turing.ac.uk/research/research-projects/policy-priority-inference).

ABM Platforms

- High-level programming languages like **Java** and **Python**
- **Netlogo** (https://ccl.northwestern.edu/netlogo/)
- **LSD** (http://www.labsimdev.org/Joomla_1-3/)

Some ABM Webpages

- Complexity Explorer Santa Fe institute (https://www.complexityexplorer.org/) :A course on "Introduction to Agent-Based Modeling"
- On-Line Guide for Newcomers to Agent-Based Modeling in the Social Sciences by Robert Axelrod and Leigh Tesfatsion (http://www2.econ.iastate.edu/tesfatsi/abmread.htm)

Suggested Readings on ABM in Modeling

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- Dawid, H., Harting, P., van der Hoog, S., & Neugar, M. (2019). Macroeconomics with heterogeneous agent models: Fostering transparency, reproducibility and replication. *Journal of Evolutionary Economics*, 29, 467–538.
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Suggested Readings on ABM in Modeling

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