

What is agent-based modeling? What are the opportunities and challenges?

OECD

April 15, 2019

J. Doyne Farmer

Institute for New Economic Thinking at the Oxford Martin School
Baillie Gifford Professor, Mathematical Institute, University of Oxford

External professor, Santa Fe Institute



Two competing theories of human behavior

- *Constrained rationality (“as if”)*
 - *Rational expectations with friction*
- *Bounded rationality (verisimilitude)*
 - Heuristics + myopic reasoning

Require completely different methodologies!

How are DSGE models solved?

- Define economic context, utility functions
- Derive first order conditions
- Find solution that maximizes utility
- Key technologies are solving equations and finding fixed points

Standard macro is based on old technology

- National accounting: mid-20th century
- Official macro models: small scale computing
 - most computing time is spent on optimization
- 21st century technologies:
 - Big Data
 - large scale computing

Complex systems approach takes behavioral economics seriously

- Embraces bounded rationality
- Agents follow heuristics, myopic reasoning
- Update heuristics that currently work well
- Well supported in behavioral experiments
 - see e.g. work of Cars Hommes
- Nonequilibrium
 - may or may not converge to equilibrium

Simulation

- ABM = simulation of decision makers
- Simulation: Mimic one system by another
- Dynamical system
 - each agent make decisions
 - determine economic consequences of decisions
 - each agent makes decisions ...
- Simulation of bounded rationality is feasible
 - not true for constrained rationality

Economic simulation

- Each household and firm can be different
 - can do nonlinearities, complex interactions
 - endogenous dynamics often emerges
- Challenges
 - how do agents make decisions?
 - granular data to calibrate at microlevel
 - understanding model results
 - developing software for simulation
 - making large scale simulations run fast

Emergent behavior

- Emergent behavior: Qualitatively different than that of individual components.
- Nonlinear behavior: Whole not equal to the sum of its parts
- Must model at fine scale
- Emergence depends on nonlinearity
 - e.g. endogenous dynamics

What does this imply about equilibrium?

- Work with Marco Pangallo, Tobias Galla, Torsten Heinrich, James Sanders
- Exhaustively studied normal form games using empirically valid learning algorithms
- Equilibrium is unlikely when games are complicated and competitive
 - more than 2 players
 - more than a few possible actions

Complexity economics is young

500 person-years vs. 50,000 person years

- Need to develop new methods
 - estimation of free parameters
 - estimation of initial conditions
 - parallelism
- Standard software libraries
- Better data sets

Complexity economics requires different toolkit

- Bounded rationality => simulation
 - decisions of agents require less computation
- Requires a different skill set
 - large scale software engineering
 - interdisciplinary
- Requires very different data
 - need detailed micro data for calibration

Economics can be done without assuming equilibrium!

- No utility functions
- No rational agents
- No perfect maximizers

Applies to all branches of economics

In this session:

- Financial networks (systemic risk)
- Macroeconomics
- Insurance industry
- Labor (networks of unemployment)
- Money creation
- Technology innovation