Massive Agent Models

Rob Axtell
George Mason/Computational Social Science/Computational Public Policy Lab/Center for Social Complexity Northwestern/NICO
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Northwestern / NICO
Philosophy of Social Science: Models Mediate

Positive models: how the social system works
Normative models: how to make it work better
Archetypical Agent Story #1: Water Management in N. NM

- Distinct user types: Native rights, farmers, ranchers, industry, consumers, recreation...
- 1,000,000 line FORTRAN code run daily to control flows in the Colorado + Rio Grande rivers
- **Normative goal**: Water access for *people*
- How much of the code was behavioral/social
- 1 number: elasticity of demand!!!!!
Archetypical Agent Story #2: Fishery Management

**Old way: top down**
- Exogenous biology (fish)
- Aggregate fishing fleet
- Optimal control of harvest
- Stock assessment $\Rightarrow$ TAC
- Pathological outcomes:
  - Harvest as fast as possible
  - Global decline in harvests

**New way: bottom up**
- Endogenous biology
- Individual fishers (data)
- Individual tradable quotas
- Outcomes:
  - Emergent strategies: FTL
  - Sophisticated mgmt of choke species
  - Stabilization of harvests
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Full-Scale Housing Bubble Model: Washington, DC

- Integrate the data on every:
  - household (Census, IRS)
  - house/housing unit (county tax records)
  - mortgage (CoreLogic)
  - real estate transaction (MLS)

- Create model for 2M people in Baltimore-Washington metro area for 1995-2010
Aggregate Results

- Case-Shiller Index, first period = 1
- Units sold
- Days on market
- Sold price to OLP
- Average mortgage rates
- Average LTV at origination

*Data is smoothed with centered 11-month moving average.
Full-Scale Model of the U.S. Private Sector

- Data on ALL business firms (IRS)
  - ~30 million firms total
  - ~6 million firms with employees
  - ~100K firms enter, exit each month
- ~120 million employees
  - ~10 million in flux each month
- DSGE models used by Fed: 1 firm!
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Rationale for Full-Scale

- *Fluctuations* are proportional to system size $^{1/2}$
- Not at full scale: either fluctuations are not right or reparameterize to get fluctuations right but then other aspects not likely to be right

- Social systems are hard to *aggregate*

- Social systems are *stiff*: at time $t$ the only way to get to time $T > t$ is to march through $(t+T)/2$
Rationale for Agents

- **Heterogeneity**: Beyond ‘representative’ agents
- **Bounded rationality**: Beyond *homo economicus*
- **Social networks**: Beyond ‘perfect mixing’
- **Nonequilibrium**: Beyond Walrasian and Nash eq (e.g., agent-level flux yet aggregate stationarity)
- **Space**: Beyond isotropy assumptions
Herbert Simon: “Social sciences are the *hard* sciences”

<table>
<thead>
<tr>
<th>Economic conception</th>
<th>Simple</th>
<th>Complex</th>
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</thead>
<tbody>
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<td>Quantity of agents</td>
<td>representative (one, few)</td>
<td>many (possibly full-scale)</td>
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=> not COTS
Need a Basic Research Program on Agents

- Behavior: from experiments to software agents
- Parallel execution: from difficulty to easy
- Estimation of agent models
- Proposals:
  - $10M research center
  - $100M National Institute for Finance
  - $1B FuturlICT
Going Forward...

- Representative agents deeply problematical
Going Forward...

- Representative agents deeply problematical
- Certain first-order effects dominate *most* others:
  - Economic conditions
  - Technological progress
  - Real estate values enormous
- Human adaptation endogenous: Lucas critique
Pathologies of 'Integrated Assessments' of Climate Change:
Representative Agents vs Heterogeneous Populations,
Rational Response vs Behavioral Adaptation,
Homogeneous and Static Beliefs vs Diverse and Dynamic Perceptions,
Technological Stationarity in a Non-Stationary World,
Average Effects vs Extremes, and
Neglect of Poorly Understood Scientific Issues

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Krasnow Institute for Advanced Study
George Mason University
Fairfax, Virginia 22030 USA

Version 0.5: 10 April 2014

Abstract
Conventional analyses of the social and economic impacts of climate change are
often framed in terms of so-called integrated assessments. A cursory review of the
methodology underlying such work clearly demonstrates them to be unsatisfactory
on a variety of grounds. In this paper we first critique the use of such models and
then suggest ways their current limitations can be relaxed.

I. Introduction: Integrated Assessments of the Net Costs of Climate Change
For more than 20 years it has been the norm for economists and policy analysts
to sum up the costs and benefits of climate change, as they determine them, and
render summary, normative assessments of how best to ameliorate the impending
**Pathologies of Integrated**: Representative Agents vs Heterogeneous Rational Response vs Behavioral Homogeneous and Static Technological Static Average Effects Neglect of Power

Rob Axtell®
Department of Computational Social Science Krasnow Institute for Advanced Study George Mason University Fairfax, Virginia 22030 USA

Version 0.5: 10 April 2014

**Abstract**
Conventional analyses of the economy are often framed in terms of so-called “representative agents” methodology underlying such analyses. This paper examines how the economic system is framed on a variety of grounds. In this way, it then suggests ways their current framing can be improved.

1. Introduction: Integrated Accounting
For more than 20 years it has been necessary to sum up the costs and benefits of human actions in a manner that renders summary, normative assessments more feasible for decision-making. The idea that human economic actions are integrated is central to this framework. Interactions among economic, social, and environmental systems are at the heart of this approach.

**Next Generation Economy, Energy and Climate Modeling**

Eric D. Beinhocker, J. Doyne Farmer, Cameron Hepburn
Prepared for the Global Commission on Economy and Climate
11 October 2013

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[Diagram of the global economy and climate system, with a focus on human influences.]
Summary

- **Problem**: conventional social science models (e.g., CGE, DSGE, SD) not up to the task

- **Good news**: Agents are a way forward (e.g., in the 1980s there was no solution)

- **Bad news**:
  - No COTS, a basic research program is needed
  - No basic research program is in the cards
  - Solutions may be years in the making
Rerun the Tape?

- Imagine starting over on climate + social science:
  - Would we use IAMs with a few rep. agents? DICE?
  - Would we ask for/better micro-data?
  - Would we make behavior a primary focus?
- Start from human dimensions (impact/effects):
  - Would we use GCMs?
  - Would we invert the funding pyramid?