Massive Agent Models

Rob Axtell
George Mason/Computational Social Science/Computational Public Policy Lab/Center for Social Complexity
Northwestern/NICO

FULL-SCALE Ma ive Agent Models

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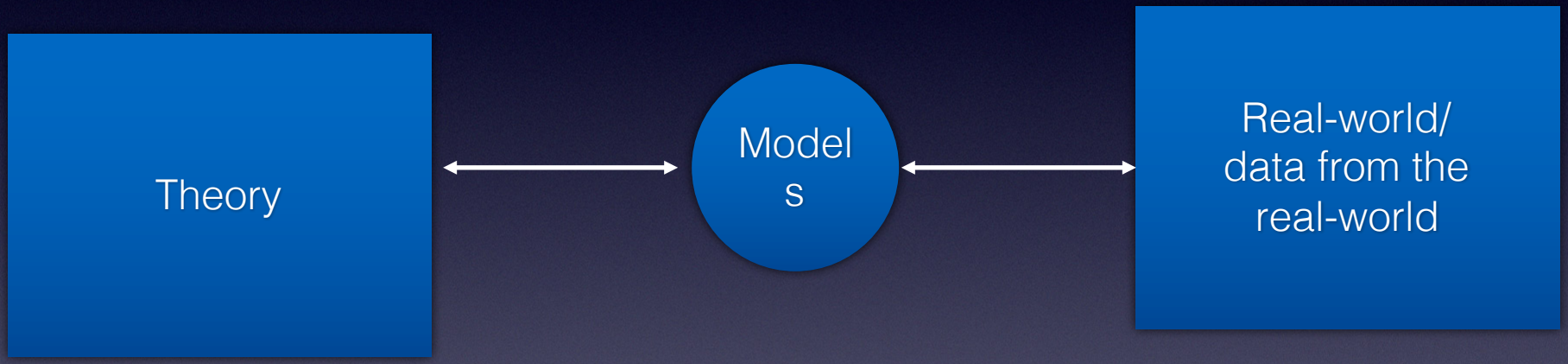
Philosophy of Social Science: Models Mediate



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 => 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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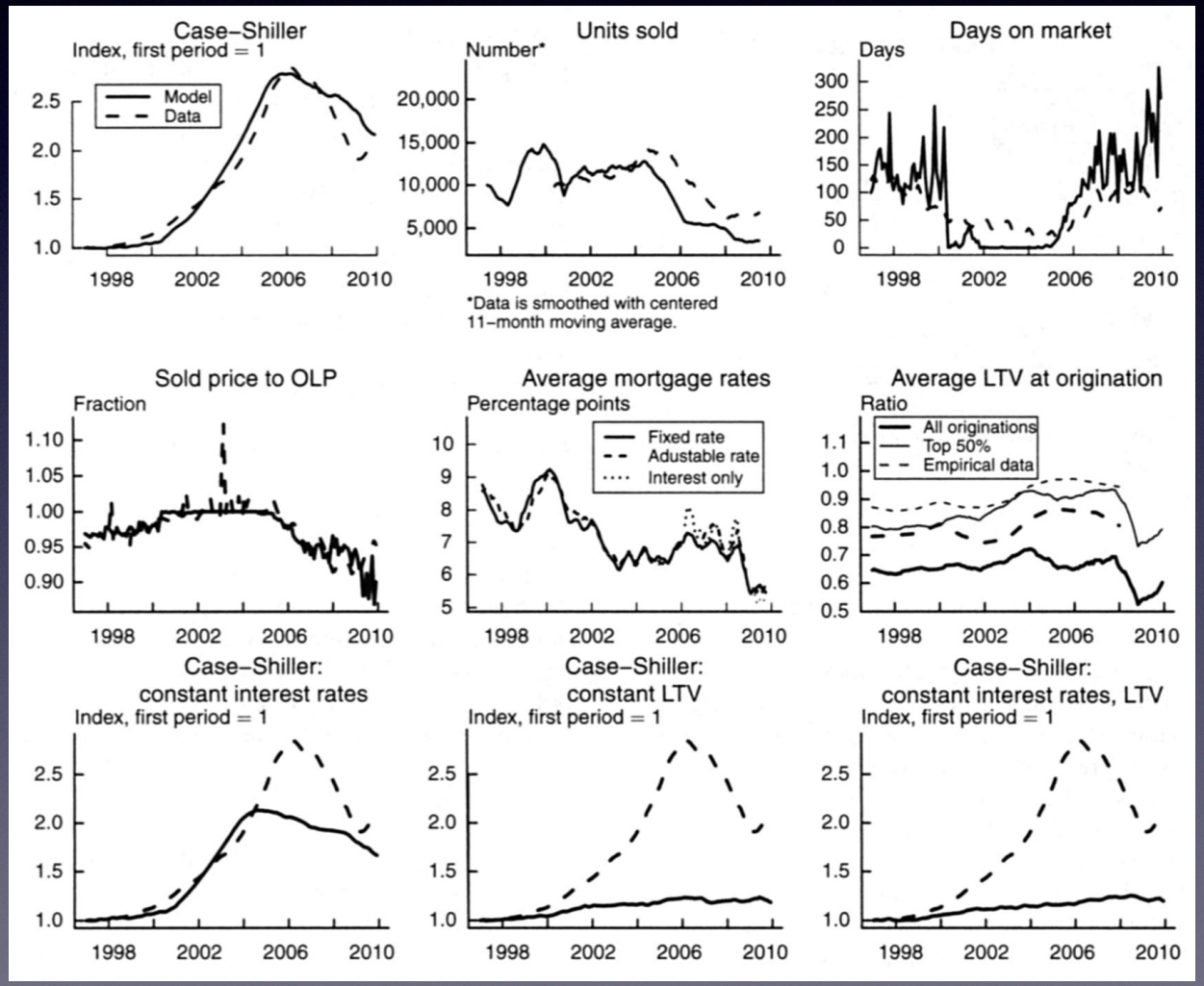
Full-Scale Housing Bubble Model: Washington, DC

- 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



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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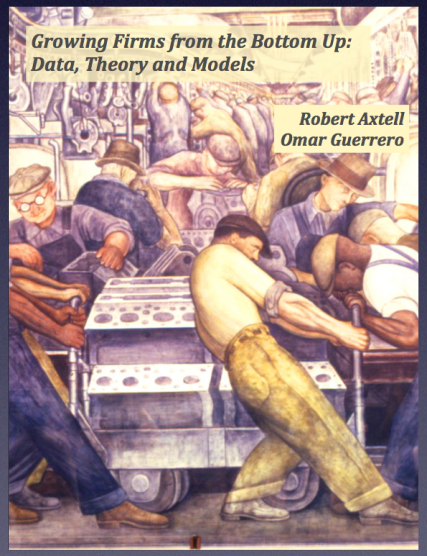
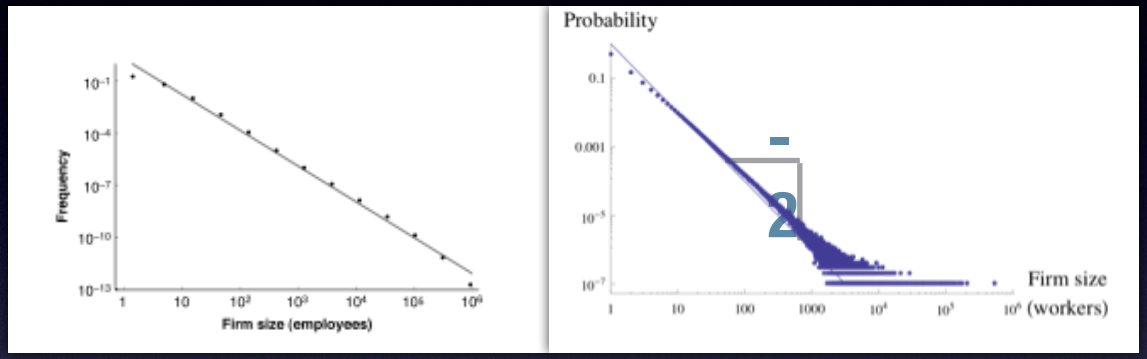


Firms: Results



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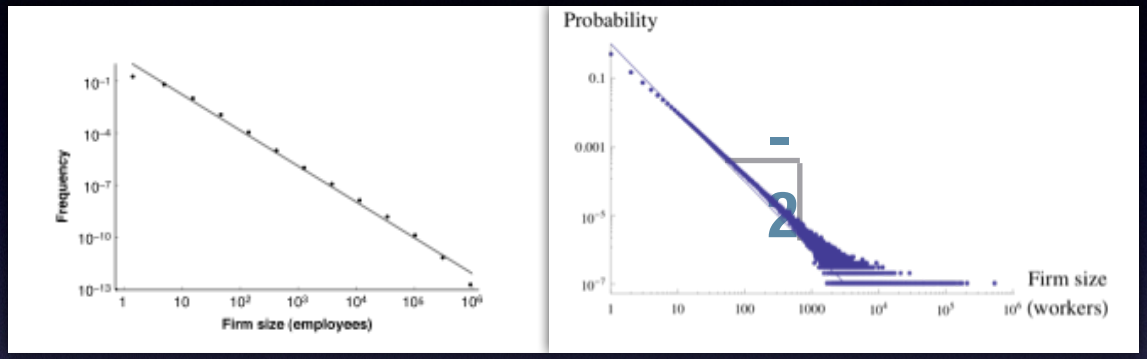

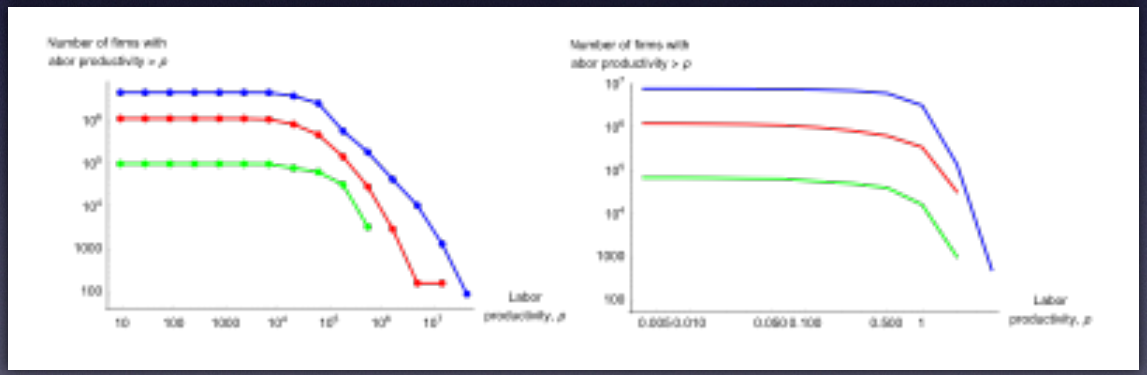

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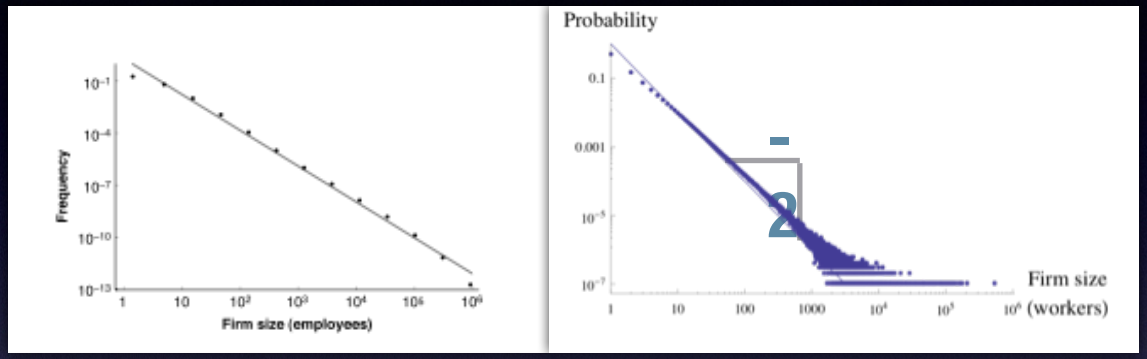

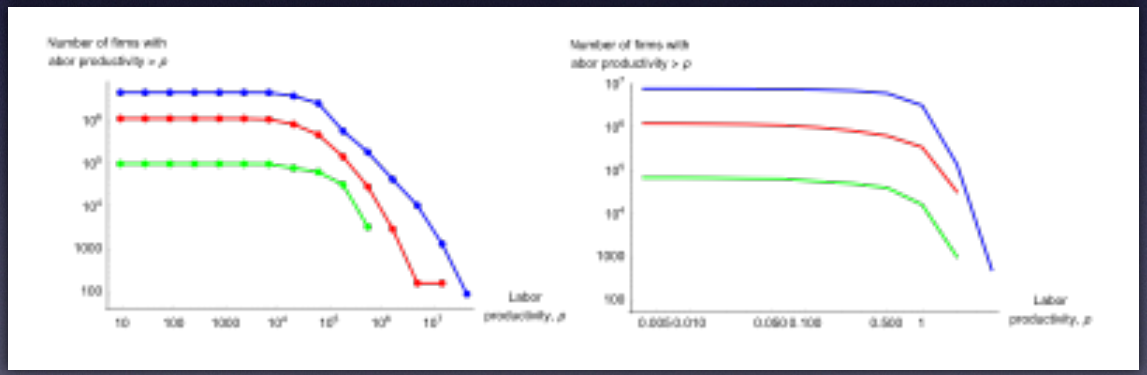

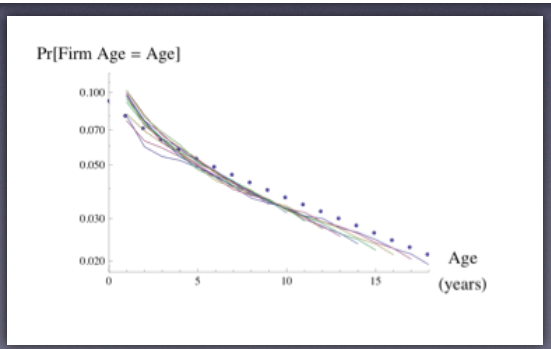

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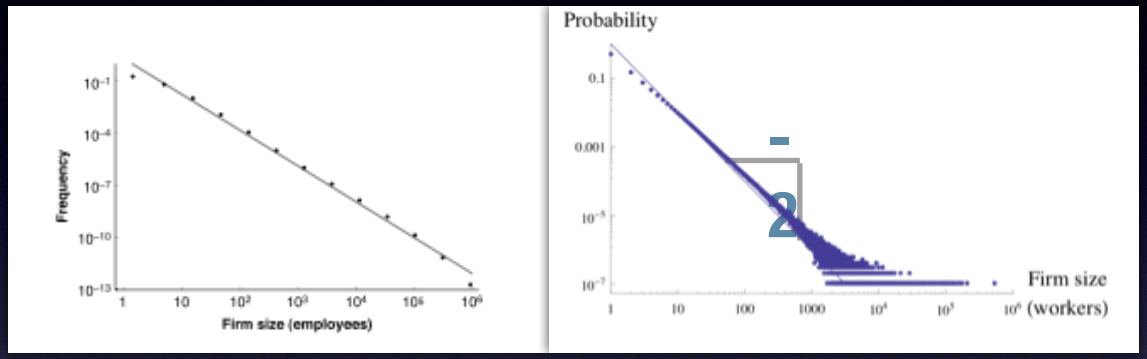

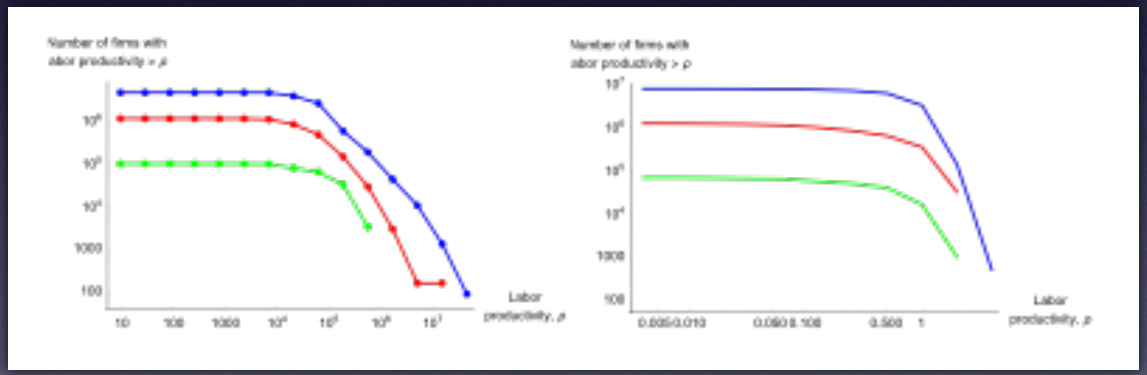

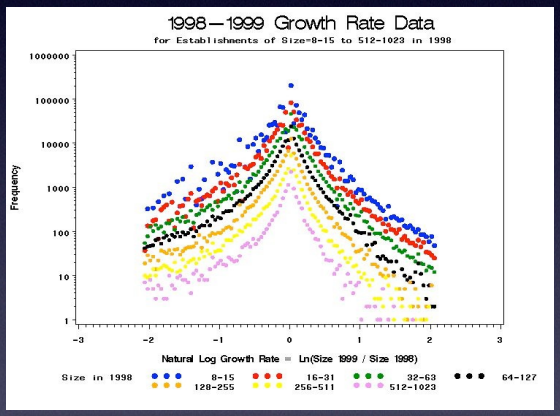

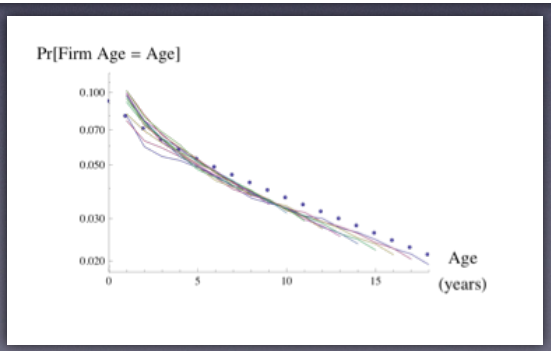

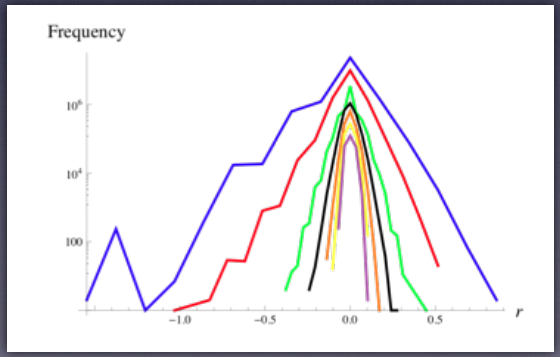

Rationale for Full-Scale

- *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"

Economic conception	Simple	Complex
Quantity of agents	representative (one, few)	many (possibly full-scale)
Diversity of agents	homogeneous	heterogeneous (or types)
Agent goals, objectives	static, scalar-valued utility	evolving, other-regarding
Agent behavior	rational, maximizing, brittle	purposive, adaptive, biased
Learning	individual, fictitious play	empirically-grounded, social
Information	centralized, maybe uncertain	distributed, tacit
Interaction topology	equal probability, well-mixed	social networks
Markets	WMAD, single price vector	decentralized, local prices
Firms and institutions	absent or unitary actors	multi-agent groups
Governance	benevolent social planner	self-governance, emergent
Temporal structure	static, impulse tests, 1-shot	dynamic, full transient paths
Source of dynamism	exogenous, outside economy	endogenous to the economy
Solution concepts	equilibrium at agent level	macro steady-state (stationarity)
Multi-level character	neglected, dual fallacies	intrinsic, macro-level emerges
Methodology	deductive, mathematical	abductive, computational
Ontology	representative agent, *max U*	ecology of interacting agents
Policy stance	designed from the top down	evolved from the bottom up

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=> not COTS

Need a Basic Research Program on Agents

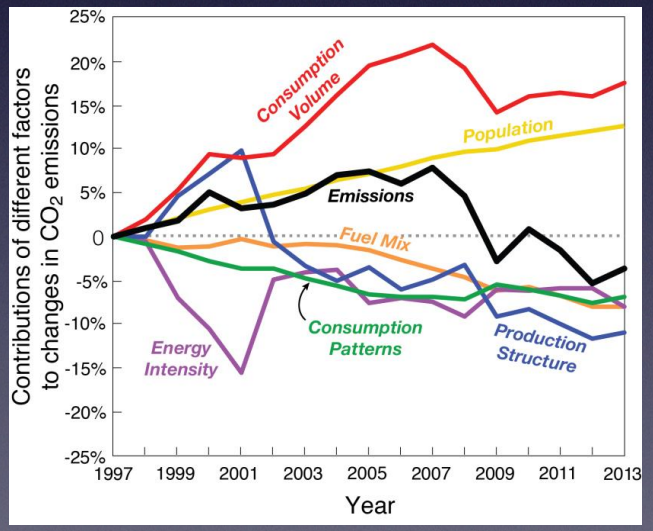
- Behavior: from experiments to software agents
- Parallel execution: from difficulty to easy
- Estimation of agent models
- Proposals:
  - $10M research center
  - $100M National Institute for Finance
  - $1B FuturICT

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

Working papers

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

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 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

Working papers

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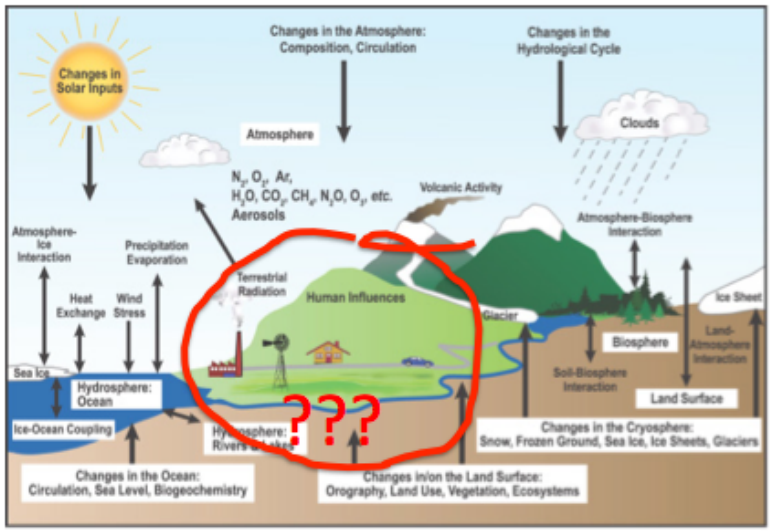
Next Generation Economy, Energy and Climate Modeling

Eric D.Beinhocker, J. Doyne Farmer, Cameron Hepburn

Prepared for the Global Commission on Economy and Climate
11 October 2013



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 we use GCMs?
  - Would we invert the funding pyramid?