

Modeling and the Sciences of Life

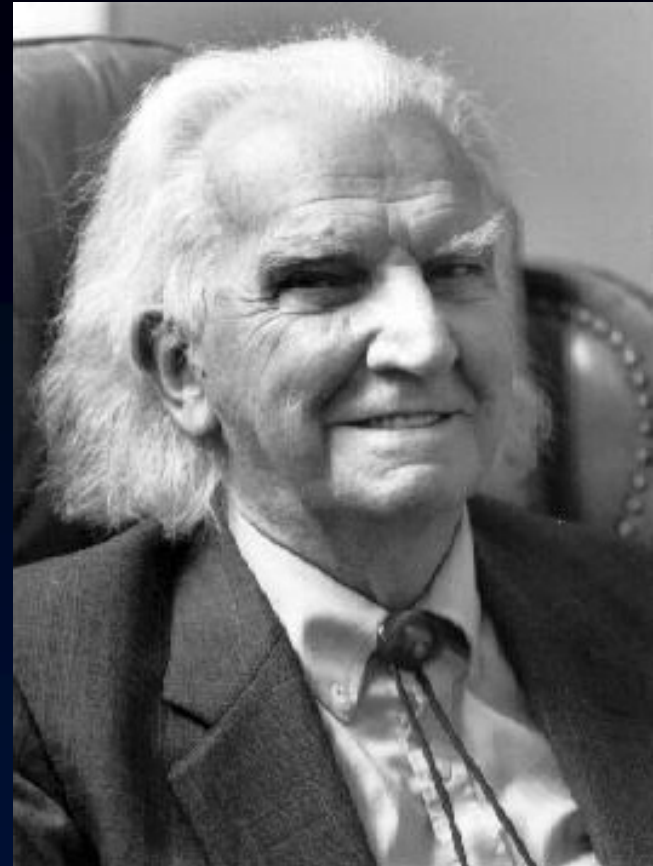
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Kenneth E. Boulding
(1910 - 1993)



Agent-based Modeling

*Why should we bother,
and what is possible?*

David Colander's remark

“For 50 years economics has climbed a mountain only to discover, arriving above the clouds, that a bigger and better peak lay beyond.”

The economic and social world...

... is massively parallel, heterogeneous in its actors, locally interactive, and always reacting anew

So are agent based models

At the heart of agent-based modeling is the question: how will agents react?

- Usually, simple rules. Can we go beyond these and make agents “intelligent”?
- Can we have them create things-- strategies, organizations, institutions, laws?

Back to beginnings, 1987 ...

John H. Holland
(1929 -)



Making agents smart

- Santa Fe Institute's artificial stock market (1988)
- We taught “artificial agents” to recognize patterns, learn which ones worked, and invest using these, adapt as the market changed
- Result: Realistic market behavior

One notch up ...

- Not just agents creating actions, but more complicated structures

How does this thinking apply to
health care markets?

Econ 101: Yes dear Milton, it's true that free markets are efficient, providing ...

1. They are subject to diminishing returns on the margin
2. They are open to entry and exit
3. All producers and consumers are profit maximizers, and can do all the calculations that this requires
4. Everyone has full information about costs, products, qualities, of all players and products, etc.
5. There are large numbers of producers and consumers
6. Everyone has access to all markets and products
7. No producer is large
8. There is no price fixing
9. There are no free riders
10. There is full insurance as to outcomes
11. Products are infinitely divisible
12. All products and services are fungible
13. There are no externalities
14. All inter-temporal markets exist
15. There is a fair legal system with free access to all
16. All employees are vigilant
17. Producers and consumers act in their long term interests
18. Everyone faces incentives that reflect these conditions
19. The tooth fairy exists

The health-care system, a complex web of incentives

1. For patients to take up more treatment than required
2. For patients to misrepresent to insurance companies
3. For patients to take less care of themselves if insured
4. For patients to insure only when they need to
5. For physicians and hospitals to carry out unnecessary procedures
6. For physicians to practice defensive medicine
7. For hospitals to treat only the recoverable
8. For physicians and hospitals to charge what they think they can get
9. For hospitals to buy expensive equipment
10. For insurance companies to cherry pick patients
11. For insurance companies to withhold full payment from physicians
12. For insurance companies to withhold or drop coverage from patients

Simultaneously, a move to creating and testing many system architectures

Agent based modeling can help us understand how this interconnected system of incentives will react under different system architectures, information disclosure, management, changes in technology

Can also help us foresee reactions in advance

“Thousands of consumers are gaming Massachusetts’ 2006 health insurance law by buying insurance when they need to cover pricey medical care, such as fertility treatments and knee surgery, and then swiftly dropping coverage ...”

– *Reason*

What will be the effect
of innovation?

In the economy, innovation happens

... not so much with coming of new individual technologies,

but as the economy encounters new bodies of technology

The medical field is encountering ...

two huge bodies of technology:

- computation
- genomics

This encounter brings new combinations

- Digital + X-Ray = CT scanning
- Digital (internet) + records = Shared records
- Digital + genetic + sampling = Diagnostic arrays
- Genomics + medical testing = Protein control

This huge encounter

... will change the system, the information available, and the incentives, e.g. in insurance

We need to play it out, understand it-- but in possible structural novelty, not just quantitative differences

In particular, useful to study how
system can be gamed

A slow shift in technique, comparable to that of 1660s

The model of science is shifting from physics to
biology

“The process of carrying out mathematics deserts the
white board and moves permanently to
computers.” -- James Bailey

“One of the great opportunities for the next few decades is the development of a mathematics which is suitable to social systems, which the sort of 18th century mathematics we use is not.”

-- K. Boulding



What agent-based modeling can do

When we set up **systems**

=> they create **incentives**

=> people **react to** these, exploit system

=> a **pattern results** that differs from the “expected” one

ABMs can help us study this