Why Can't We Have a Better Econophysics?

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Where I come from

- started in statistical mechanics (self-organization, cellular automata, information theory, etc.)
- migrated to statistics (inference for stochastic processes and nonlinear dynamics)
- no publications in economics, but a lot of time reading it, including econophysics
- projects underway

What is the problem?

- It's not that there isn't some good work in econophysics...
- or that there isn't a fundamentally good idea here...
- but there's a lot more that's weak ...
- ...and the weak stuff has some regularities and some lessons

Successes

- Phenomenology of financial markets
- organizational growth

Failures

- IMHO: Most everywhere else
- income distributions
- other power laws
- *explaining* regularities in financial markets
- minority games
- etc.

What's gone wrong?

- The fundamental intuition is right - economics *is* a many-body problem...
- but an impoverished notion of "bodies"
- along with weak data analysis

Bodies: Minority Game

- Prediction/decision rules modeled on spin glasses
- How humans (& other animals) predict has been extensively studied for ~50 years by experimental psychology, in game and non-game situations; pretty good models now
- these look *nothing at all* like MG rules
- no reason whatsoever to expect that results on those rules generalize or are universal

Income distributions

- Pareto (1890s): power-law tail; or maybe power-law with exponential cut-off
- Known since the 1950s that the bulk of the distribution is *not* Pareto but much more nearly log-normal
- But it's not exactly log-normal either
- not clear that there *is* a universal distributional form
- "Explanations" from random exchange of a conserved quantity of money (a la Boltzmann) go from false premises to false conclusions

Herding, fashions &c.

- Extensive - and very reasonable - modeling in economics going back to the early 1990s based on information contagion (Bikhchandani, Hirshleifer, Welch, Lohmann, etc.) - see Chamley, *Rational Herds*
- Even older models in sociology (Granovetter and earlier)
- modern theories of currency crises (and related financial crises)

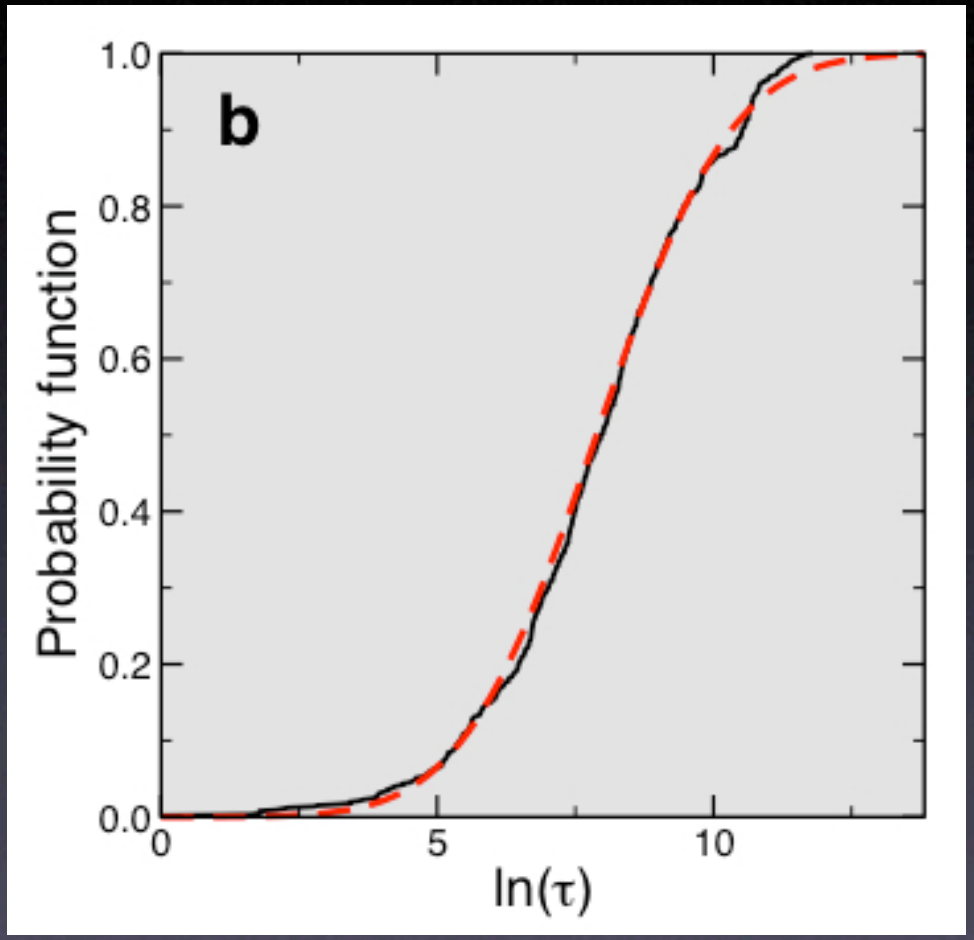
Lessons from Critical Phenomena

- Universality means quantitatively accurate results from even toy models (at least for certain quantities in certain limits)
- *Lessons learned I:* "details don't matter" (Per Bak, this room, ten years ago), with all the qualifications forgotten
- *Lessons learned II:* power laws are Way Cool
  - central limit theorem under long-range correlations/self-similarity

Statistical mechanics vs. statistics

- Statistical mechanics involves no statistics
- interpreting simulations is very different from data analysis
- division of labor within physics (theorists, experimentalists, phenomenologists)
  - theorists deal with *results*, not *data*
- result: (generally) smart people with no training in data analysis trying to do it and repeating old ideas

- statistics matters because it's about not fooling yourself
- es*pecially* with limited, noisy data and complicated relationships
- it's easy to get away with weak methods when you have huge amounts of clean data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Probability function
1.0
0.8
0.6
0.4
0.2
0.0
0
5
10
ln(τ)

Neoclassical economics

- Core: Selfish maximization of subjectively-expected utility under rational expectations in equilibrium
- Many successes; extensions to institutions, imperfect competition, etc.; but clearly false
- Like classical physics predicting matter is unstable
- There are limits where problems are easy to solve, other motives are weak, etc., and then neo-classical economics should work pretty well

Resources within physics

- There are things other than spin models, ideal gases, and random walks
- thermodynamics! (Foley and Smith)
- prices are gauge connections arbitrage opportunities are curvature (Ilinski)

Agenda 0

- Individual agents, with adaptive decision-making processes, who interact
- Large-scale phenomena, with variables aggregated from individuals
  - macro variables need to allow for more efficient prediction and causal abstraction
- Derive macro dynamics, at least approximately, from micro interactions

Agenda 1: Probabilistic Problems

- What are the large-scale consequences of *strong* interactions of things with internal degrees of freedom?
- What kinds of large-scale patterns are *generic*, so that details don't, in fact, matter? *Which* details?
- Approximation theory, convergence of stochastic processes, large deviations, Markovian coarse-grainings of Markov processes, making things work when N is much less than Avogadro's number...

Stat. mech. of adaptive agents

- Peyton Young, Dean Foster, etc.: sophisticated learning procedures + interactions leading to large-scale regularities (customary institutions), ergodicity, etc.

Urban growth

- Fujita, Venables & Krugman
- Explicit micro models, with imperfect competition, of spatial allocation and interaction
- Leads to cities, spatial structure, combined and uneven development, etc.
- Looks very much like classical pattern formation models

Agenda 2: Statistics

- How do we connect interesting stochastic process models to data?
  - *please* no more tweaked ARMA models
  - graphical model inference may be one route
  - indirect inference is another
- *Discriminating* between complex models
  - trouble if different micro processes have same macro limits
  - but then do we need to?

Bounds in industrial organization

- John Sutton
- Game-theoretic models of imperfect competition and firm growth
- Huge range of plausible models
- Derive *inequalities* which hold across all models
  - abstraction in Eric's sense
- Compare inequalities to data
- Explicit thermodynamic analogy (Carnot bound)

Agenda 3: Engineering

- Design institutions and interventions; do they work?
- Perhaps the only point on which Karl Marx agrees with Karl Popper...

Summary

- A real econophysics, deriving macroscopic phenomena from many-body processes, would be a wonderful thing
- We will need to expand our ideas about "bodies" and interactions
- We will need new methods of extracting large-scale regularities
- We will need new methods of data analysis
- Physicists *can* contribute, but not if they just push