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

• especially with limited, noisy data and complicated relationships

• it’s easy to get away with weak methods when you have huge amounts of clean data
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