Proposal for Chapter on Econophysics

Dean Rickles

There has quite recently emerged a new field living at the border of physics and economics, known as econophysics. The core of this new field is the treatment of the economy as an evolving complex adaptive system. This core idea needs little motivation; as Johnson et al. point out "it would be hard to find anyone who disagreed with the statement that a financial market is indeed a 'complex' system" (Financial Market Complexity OUP: 2003, p. 2). It seems clear that this is not limited merely to financial economic systems and readily transfers to 'multi-agent' systems of consumption and production in general—however, given the availability of very high-frequency data, financial markets do offer a much clearer 'window' into what economic complexity is like. How does this affect economics? In a recent textbook on econophysics, Challett et al. write that "econophysicists deny the very rules of the game on which mainstream academic research in economics is based" (Minority Games OUP: 2005, p. 14). In particular, the following central pillars of the standard theory are denied: rational expectations, the efficient market hypothesis, random walk behaviour of prices, equilibria, and so on. What results is a more 'empirical' approach to economics, based on techniques from non-linear dynamical systems theory, condensed matter physics, the theory of critical phenomena, and statistical mechanics.

The entrance of physicists to economics coincided with a perspectival shift amongst certain professional economists too. Brian Arthur, for example, also denied some of the foundational principles of mainstream economics, though for quite different reasons—primarily having to do with arguments designed to show that since economic agents really do have incomplete information about the market, and their information is not identical (i.e. they are heterogeneous), they must reason inductively about the future state of the economy, they must assess how others will act and what their expectations about the future will be (of course, the other agents will be doing the same thing). The result is, again, a conception of the economy as an evolving complex system. The physicists' tools (from the physics of disordered systems) were in place to describe and model this disordered jumble of traders, producers, technologies, and so on. In particular, sophisticated modeling techniques were able to generate close copies of real economic behaviour. The modeling involved (agent-based modeling) is a 'bottom-up' approach to (global) systemic properties: prices, volumes, etc..., are determined or generated by (local) interactions between traders, producers, and consumers. These global patterns then feedback into the agents' future behaviour and interactions, resulting in an interesting tangle of philosophical issues pertaining to emergence, reduction, supervenience, and inter-level (i.e.

‘local to global’ and ‘global to local’) causation.

I propose to give a philosophical review of this field in my contribution. There are many philosophically interesting issues that flow from this new work. A sample, that is likely to be covered in my contribution, is:

• Modeling issues. What is going on when models from the physical sciences (even from quantum field theory and gauge theory!) are applied to the social sciences? How do they work? Are the models functioning differently according to application? This ties in also to the question of what the observables of this form of economics are: prices, volumes? How is one to understand these? (They are time-dependent, so we should properly speak of ‘price (volume) at a time’. Moreover the time of measurement will not, in general, be regular, occurring instead at, e.g., 2 seconds then 5 seconds then 3 seconds... This is because price changes (ticks in the time series) are subject to the whims of agents—not to mention public holidays!)

• Laws in Econophysics? The previous topic leads on to another: If economies simply reflect what the agents are doing economically then, unless the agents are following laws, the economy will be anomolous (there will be no nice time-invariant properties that could feature in laws; no replicability). For complex systems like economies even the statistical properties are subject to change.

• Reduction and Emergence. One of the interesting aspects of physical complex systems is that their properties are typically multiply realizable by their microscopic configuration—for example, a specific temperature has many lower-level (lower-scale) realizers. This is often taken to mean that such properties are irreducible. Does this mean that economic properties are irreducible, since we are now treating the economy as a complex system? Moreover, was it the case that they were reducible according to the neoclassical economic theory? Agentbased modeling appears to be ambiguous on the question of whether economic properties are reducible or not. But we certainly have a supervenience thesis operating here: which one?

• Causation. The idea of econophysics is that agents’ (collective) behaviour generates economic properties, and these economic properties ‘back-react’ on the agents behaviour, and so on in a mutual cyclic embrace. This leads to what is a general conceptual issue in complex systems (and in non-linear dynamical physical systems in general): it is difficult to tell a causal story about how some outcome (effect) was caused, and what it was caused by. This is related to the problems of predictability in such systems.

• Understanding risk. The notion of risk in a complex system takes on a different meaning than is usual since such systems are often critical in certain regimes (for certain values of the control parameter). An interesting feature of this is that complex systems are supposed to be unpredictable, yet much of econophysics is devoted to finding ways to predict economic behaviour! This superficial inconsistency is ironed out in the use of power-laws to predict distributions of events, including risky extreme ones.

A tentative table of contents (with details) would be:

1. The emergence of econophysics: a very brief historical overview of how econophysics came to be, how it differs from the neoclassical approach, and how the link it forges between physics and economics differs from links between physics and economics of the past (i.e. the physiocrats).

2. The economy as an evolving complex system: the core ideas forming the basis of econophysics, including proposed definitions of the field. This will involve, inter alia, a description of the economy 'out of equilibrium', the critical nature of such a system, and the statistical description of it (power-laws, universality, etc...), path-dependence, and more.

3. What econophysics can do: here the motivations behind the econophysical perspective will be laid out and assessed (including the flaws in mainstream economic theory). We will question whether it is necessary (conceptually and practically) to shift to this new approach.

4. Problems and prospects: detailing the open problems faced by econophysics, and looking to future developments.

Rather than having some 'technical review' material at the beginning and some philosophical discussion at the end, I propose to integrate the technical and philosophical aspects *en route*.

Dr Dean Rickles
ACLM (piano), MA, PhD (History and Philosophy of Science)
Postdoctoral Fellow, Philosophy
University of Calgary, Canada