A little more conversation

Economics historically has surprisingly strong links to physics. Early economic theories devised by the likes of William Jevons and Leon Walras — both physicists by training — involved explicit analogies with notions of mechanical or thermodynamic equilibrium, then at the forefront of physics. Today, in contrast, we see in economics and physics two fields divided by tall academic walls and utterly contrasting scientific paradigms.

There has, of course, been an explosion of recent interest by physicists in economic phenomena, especially through statistical physics and computational modelling: efforts to understand the mathematical character of market fluctuations, the distribution of business forms by size and rate of growth, and so on. A real convergence of the economics and physics cultures still seems remote, and persisting differences demonstrate just how durable distinct scientific cultures can be. Yet there are encouraging signs of increasing conversation between the two fields.

One thing that strikes many physicists as odd about today's economic theory is its persisting reliance on clearly unreasonable assumptions about human behaviour — notions of perfect rationality, for example, or narrow self-interest. Although economic research has become far more empirically minded, the agents that populate most economic theories remain caricatures of human reality.

It's not clear, however, that this should be problematic. Indeed, physicists also rely almost exclusively on similarly abstracted models. We use the Ising model, for example, to understand collective magnetic order in real materials, even though we know that a model of two-valued classical spins with only nearest neighbour interactions is an absolute parody of reality: magnetic forces don't act only between nearest neighbours, they vary in strength due to inhomogeneities and defects, and often the relevant physics isn't even classical.

This is OK, we all agree, because it works. In the case of magnetism, of course, we have the theory of critical phenomena that justifies why it works, at least close to the critical point, and why all those left-out details don't really matter. In many other cases, we don't have general reasons, a priori, for believing we can dispatch with details and get away with it, yet empirically it seems we can. It works in economics too.

In 1970, to take one famous example, economist George Akerlof penned a delightful paper entitled *A Market for Lemons*. In his toy model, Akerlof supposed that used cars are either good or defective (the latter known as 'lemons'), and that potential buyers have no way to know or find out whether a car is a lemon. His simple model included only the most rudimentary picture of human decision-making, and suggested that the buyer, to be safe, would have to factor that unknown risk into the price he offers. Moreover, because people owning good cars know they won't get good value for them, they won't put them on the market. This sets off a diabolical spiral,

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as buyers then have even more reason to suppose that used cars must be lemons, and will offer even less for them. Out of the model emerges an explanation for an otherwise puzzling observation: that new cars lose a good fraction of their value as soon as they're driven off the dealer's lot.

So there's clearly nothing wrong with economic theory using highly simplified models. More justified, it seems to me, are criticisms of the traditional economic approach to the dynamics of collective economic systems. Economic phenomena clearly arise through the activity and interaction of many agents, such as people, firms and so on. These agents act on myriad strategies, often copy and learn from one another, and in many other ways respond to what they see others doing. Yet in economics the most common trick is to suppose that interactions between economic agents can in fact be ignored, and that behaviour of a heterogeneous collection of agents can be approximated by that of one 'representative agent' reflecting average behaviour over the population.

There's no doubt this technique is useful analytically — as is the mean-field approximation in physics, to which it is closely linked — but it can also lead to serious error. In particular, it tends to ignore or discount strong correlations among the behaviour of many economic agents that can lead to large collective fluctuations and transient phenomena that may be more important than the average behaviour. The current economic crisis, to take one rather dramatic example, has been driven by tight correlations and causal links between different economic factors; phenomena of this kind can barely be investigated at all on the basis of representative-agent models.

In this respect, physicists have been active — working increasingly alongside economists — in helping to pioneer the development of agent-based models that mimic markets by simulating the behaviour of individuals, banks, hedge funds, governments and so on. Akin to molecular dynamics simulations, these models do not at the outset discount the possibility of strong correlations, but let the dynamics emerge naturally from the actions of interacting participants. This approach offers economic theorists the same kind of tool that computational modelling does for physicists studying supernovae or complex fluid flows; namely, a means for gaining intuitive insight into systems that would otherwise be overwhelmingly complex, on the basis of which it may be possible to build simpler models later.

Such agent-based models are highlighted in a paper by physicist Doyne Farmer and economist John Geanakoplos, in which they describe a 'conversation' they've had over the past eight years about economics, its foundations and its relationship with physics (arXiv:0803.2996v1; 2008). Farmer and Geanakoplos offer a balanced and informative overview — for scientists from both sides of the fence — of what is good and bad about traditional economic techniques. Although starting with the usual baggage that comes from indoctrination in any scientific field, they have managed to see their way past it. If so far only a small minority of economists has embraced physics-based approaches, this may slowly be changing. Furthering that change requires more listening from both sides.

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