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Economics focus

Agents of change

Conventional economic models failed to foresee the financial crisis. Could agent-based modelling do better?

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MAINSTREAM economics has always had its dissidents. But the discipline's failure to predict the financial crisis has made the ground especially fertile for a rethink.

Critics tend to agree on what is wrong with current macroeconomic forecasting. A hearing of the House of Representatives Committee of Science and Technology on July 20th targeted the "dynamic stochastic general equilibrium" (DSGE) models used by the Federal Reserve and other central banks. The hearing aimed to "question the wisdom of relying for national economic policy on a single, specific model when alternatives are available." The Institute for New Economic Thinking in New York, which had its inaugural conference in April, has attacked many of the assumptions, including efficient financial markets and rational expectations, on which these models are predicated. These assumptions were clearly too simplistic. But there is less agreement on what should replace the old ways.

One of the most promising options was the topic of a workshop in Virginia at the end of June. The workshop was funded by America's National Science Foundation and attended by a diverse bunch that included economists from the Fed and the Bank of England, policy advisers and computer scientists. They were there to explore the potential of "agent-based models" (ABMs) of the economy to help learn the lessons of this crisis and, perhaps, to develop an early-warning system for the next one.

Agent-based modelling does not assume that the economy can achieve a settled equilibrium. No order or design is imposed on the economy from the top down. Unlike many models, ABMs are not populated with "representative agents": identical traders, firms or households whose individual behaviour mirrors the economy as a whole. Rather, an ABM uses a bottom-up approach which assigns particular behavioural rules to each agent. For example, some may believe that prices reflect fundamentals whereas others may rely on empirical observations of past price trends.

Crucially, agents' behaviour may be determined (and altered) by direct interactions between them, whereas in conventional models interaction happens only indirectly through pricing. This feature of ABMs enables, for example, the copycat behaviour that leads to "herding" among investors. The agents may learn from experience or switch their strategies according to majority opinion. They can aggregate into institutional structures such as banks and firms. These things are very hard, sometimes impossible, to build into conventional models. But in an agent-based model you simply run a computer simulation to see what emerges, free from any

top-down assumptions.

Although DSGE models are also based on microeconomic foundations, they accept the traditional view that there exists some ideal equilibrium towards which all prices are drawn. That this is often approximately true is why DSGE models perform well enough in a business-as-usual economy. They do badly in a crisis, however, because their "dynamic stochastic" element only amounts to minor fluctuations around a state of equilibrium, and there is no equilibrium during crashes.

ABMs, in contrast, make no assumptions about the existence of efficient markets or general equilibrium. The markets that they generate are more like a turbulent river or the weather system, subject to constant storms and seizures of all sizes. Big fluctuations and even crashes are an inherent feature. That is because ABMs contain feedback mechanisms that can amplify small effects, such as the herding and panic that generate bubbles and crashes. In mathematical terms the models are "non-linear", meaning that effects need not be proportional to their causes.

These non-linearities were clearly on show in the credit crunch. At the workshop Andrew Lo of the Massachusetts Institute of Technology presented a model of the American housing market, inspired by ABM approaches, which showed how a fateful conjunction of rising house prices, falling interest rates and easy access to refinancing created an awesome burden of debt. John Geanakoplos of Yale University explained how the debt cycle in remortgaging—high amounts of leverage during booms, low amounts during recessions—can act like an out-of-control pendulum to create instability. Sujit Kapadia of the Bank of England is trying to model the web of interdependencies created by the use of complex derivatives. These "network-based vulnerabilities" are just the kind of thing that ABMs are good at capturing.

Model behaviour

Another big lesson of the crisis is the role of interactions between different sectors of the economy—housing and finance, say. Although conventional models can incorporate these, ABMs may be better tailored to modelling specific sectors. The organisers of the Virginia workshop—Doyne Farmer of the Santa Fe Institute and Robert Axtell of George Mason University—wanted to explore the feasibility of constructing an immense ABM of the entire global economy by "wiring" many such modules together.

What might be required for such an enterprise? One vision is a real-time simulation, fed by masses of data, that would operate rather like the traffic-forecasting models now used in Dallas and in the North Rhine-Westphalia region of Germany. But it might be more realistic and useful to employ a suite of such models, in the manner of global climate simulations, which project various possible futures. In either case, the models would need much more data on the activities of individuals, banks and companies.

Such data-gathering raises privacy fears but is essential. Seismologists may not be able to forecast earthquakes precisely but it would be deplorable if they were to resign themselves to modelling just the regular, gradual movements of tectonic plates. Instead they have developed ways of mapping the evolution of stress patterns, identifying areas at risk and refining heuristics for hazard assessment. Why not do the same for the economy?

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