NEWS & VIEWS

C. GILLON/GETTY

FORUM Financial systems

Ecology and economics

A growing body of literature deals with the application of theories developed in other disciplines to financial institutions, to which a paper in this issue now adds. As outlined here, however, views differ as to its relevance. **See Perspective p.351**

THE PAPER IN BRIEF

- The paper[1] is entitled ‘Systemic risk in banking ecosystems’ and is co-written by an expert in banking and an expert in theoretical ecology and science policy.
- It was prompted by events underlying the international financial crisis that began in 2007.
- It focuses on the network dynamics of financial institutions and, in particular, on the influence of the pricing of ‘derivatives’.
- Derivatives are financial instruments that have become fiendishly complex, and that allow investment houses to hedge against, and bet on, price movements of commodities, bonds, shares and currencies without needing to hold the underlying asset.
- The authors apply models from ecology and epidemiology to explore, by a simplified ‘toy model’ analogy, how an initial bank failure can propagate through such institutions.
- They offer suggestions on how overall system stability can be achieved while ensuring that individual banks can maintain their necessary economic functions.

Proposing policy by analogy is risky

NEIL JOHNSON

A paper plane is a wonderful toy model with which to explain how real planes fly, and water flow is a great analogy for teaching about electrical flow through circuits. But without business-class seats, a paper plane can never be used to explain why two people pay vastly different prices for the same flight. Likewise, nobody unplugs a television to get a glass of water.

By cross-checking against our everyday experience and intuition, we can quickly see the limitations of such a toy model and analogy. However, when it comes to the complexities of the financial sector, our intuition (and arguably that of many financial experts) is so limited that rigorous statistical validation of any toy model or analogy is essential before policies are suggested. This is the potentially dangerous shortcoming of Haldane and May’s paper[1]. In models of complex systems and networks, tiny changes in the model’s assumptions — or changes in what it means to be a node, a link or ‘infectious’ — can inadvertently invert the emergent dynamics, for example by turning a stable output into an unstable one. Such changes can therefore amplify the inherent risk in any resulting policy suggestions.

There is already substantial consensus that policy-makers need to embrace financial-market risk within the framework of complex dynamic systems[2,3]. However, markets contain many heterogeneous objects, the interactions of which may change in any number of ways in the blink of an eye (or the click of a mouse). This new dynamic regime, in which the character of both the links and nodes can change on the same timescale[4,5], lies well beyond standard models of ecological food webs, disease spreading and networks. The resulting dynamic interplay can generate unexpectedly large market fluctuations — and it is these that invalidate the financial industry’s existing approach to the pricing of financial derivatives and the management of risk[2,3].

The financial model[6] borrowed by Haldane and May is an interesting, abstract, complex-systems toy model. However, even the model’s original creators[6] emphasized that “In order for these kind of models to be more realistic, some improvements certainly are needed”. They state that their focus was on “theoretical concepts” whose “relevance for real markets requires quantitative estimates of the parameters. Given the abstract nature of the model, this appears to be a non-trivial task.” They are absolutely right. Would you fly in a paper plane that had been scaled up to the size of a 747?

Policy-makers may never fully appreciate a model’s limitations, so policy suggestions are potentially dangerous unless accompanied by a quantified health warning of a model’s robustness and underlying assumptions, based on rigorous statistical testing against state-of-the-art financial data sets. Otherwise we simply increase risk, rather than reduce it.

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Network theory is sorely required

THOMAS LUX

Haldane and May[1] argue that models from ecosystem research can offer valid insight for understanding the financial sector. But is this too far-fetched an analogy? Can one really imagine the regulation of financial markets being based on their similarities to networks such as food webs? My answer, in a sense, is 'yes' — we should take these similarities seriously.

This is not to say that we should equate banks, and their depositors and hedge funds, with some type of schematic predator–prey model. It is rather the potential similarities between the structural, system-wide properties of these very different areas of study that we should be interested in. As Haldane and May point out, research in biology has arrived at quite clear-cut results on the determinants of the robustness and vulnerability of ecosystems.

By contrast, the modelling of 'representative agents' in economics has led to a delusive neglect of the effects of interaction between those agents. By focusing mainly on individual optimization of utility or profit, economics has lost the perception that "more is different"[7] — namely, that higher-level aggregates (for instance, the global financial system) can have properties that cannot be understood solely on the basis of their constituent units on a lower hierarchical level (the single bank or investor). Built upon this extreme form of reductionism, the established framework for bank regulation has been exclusively micro-oriented and has lacked any consideration of systemic risk factors.

As recent history has shown, system-wide effects are important. The default of Lehman Brothers in 2008 had the contagious effects of a 'super-spreader' disease, and the subsequent domino effect brought the entire financial system to the verge of collapse. Systemic, 'macro-prudential' regulation is now an issue on the political agenda, and the structure of the financial sector has to be scrutinized for its stabilizing and destabilizing feedbacks.

However, the micro-based banking literature has little to say on such issues. We know from the natural sciences that structurally similar connections between micro units might lead to similar system behaviour in very different areas. It seems essential, therefore, to take stock of the accumulated knowledge on network structures when studying systemic risk in the banking sector. The few available phenomenological studies of particular segments of the interbank market in the 'econophysics' literature have already identified network structures that are known to be vulnerable to shocks[8,9]. The near-collapse of the overnight interbank market at various stages of the recent crisis provides an empirical confirmation of how susceptible this particular structure is to disturbances.

Connections between financial institutions are, however, multi-faceted, and only part of this complex man-made system has been mapped in existing toy models. Going beyond toy models, an empirical assessment of how trading in complex derivatives affects the network topology of the banking sector, and how that interacts with other linking factors (such as interbank credit lines), is urgently required[10]. There is, of course, also a need to go beyond the first step of analogies, and relatively simple mechanical models, to examine the behavioural micro-foundations of how the agents involved choose their connections in this financial ecosystem. ■

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NEUROSCIENCE

Seeing into the future

The resting brain recapitulates activity patterns that occurred during a recent experience, possibly to aid long-term memory formation. Surprisingly, corresponding brain activity also occurs before an event happens. SEE LETTER P.397

EDVARD I. MOSER & MAY-BRITT MOSER

Traces of experience can be found in the activity of the sleeping brain. One region in which such traces are detected is the hippocampus, which is required for episodic memory in mammals. In rodents, for example, most hippocampal neurons fire selectively when the animal is in a particular location[1,2]. When these neurons — called place cells — are active during a particular experience, they also tend to be active during subsequent sleep[3,4]. The order of firing is also often preserved[5,6]. Such subsequent replay of brain activity also occurs in the awake state, when an animal rests between bouts of running[7,8]. The recurrence of experience-related firing is thought to contribute to the reorganization of synaptic connections between neurons during memory consolidation[4,9].

However, Dragoi and Tonegawa[10] write on page 397 of this issue that hippocampal reactivation is not merely a reflection of prior experience. They initially recorded sequences of firing in place cells when mice that had been running on one arm of an L-shaped track were resting at food locations near the ends of that arm. As expected, place-cell firing sequences were replayed during pauses at the food locations. The authors then opened the other track's arm to allow the animals to run across the entire L. Surprisingly, they found that when the mice were resting before gaining access to the second arm, some of the firing sequences in their brain matched those subsequently recorded on the new arm. They refer to this predictive activity as preplay (Fig. 1).

One might argue that, on exposure of the animal to the extended segments, preplay merely reflects replay of activity associated with the familiar first part of the maze, the shape of which was similar to that of the new part. But mice with no prior experience on any track also showed preplay. Together, these observations suggest that, in a new environment, activity sequences involving a specific assembly of cells are selected from already-existing sequences in the network.

So why have other investigators using similar experimental procedures not detected preplay? After all, in the most common design, the firing sequences that occur during a behaviour are compared with resting sequences both before and after the behaviour — just as in the present study. Dragoi and Tonegawa[10] propose that their method of comparing spike sequences