WHAT BIOLOGY CAN TEACH US ABOUT BANKING

BY LORD ROBERT MAY, Baron May of Oxford

The behavior of nonlinear dynamical systems has been the unifying theme of my own nonlinear academic trajectory. Beginning as an undergraduate chemical engineer, I ended up with a PhD in theoretical physics, and roughly 10 years later transmogrified into a professor of biology at Princeton University. I believe the ways in which system risks can arise, and propagate, in different settings is best seen from many different perspectives. And it is increasingly clear that such a view of complex adaptive systems is critical to our future well-being, as we are indeed engulfed in complex, and often coupled, systems, from our environment to our social networks and our financial systems.

In my own subject of ecology, SFI has been a major player in understanding systemic risk, particularly in studies of the nonrandom network structures whereby real-world ecosystems reconcile complexity (many species interacting with each other) with persistence in naturally fluctuating environments. Given the additional shocks being imposed on ecological systems by human activities—overexploitation, habitat destruction, alien introductions, all compounded by climate change—such understanding is increasingly important. It is especially so as we strive to maintain a multitude of ecosystem services, not counted in conventional assessment of gross domestic product, but upon which we depend. In this general area, SFI professors such as Jennifer Dunne, Mercedes Pascual, and others are among the best in the business.

This is only one of several major areas where SFI's "clean sheet of paper" approach to complicated problems has been important. It is my belief, however, that the recent—and continuing—worries about the performance of financial markets present SFI with its greatest-yet challenge and concomitant opportunity.

Figure 1 provides a striking illustration of the truly extraordinary growth in the amount of leveraged money swishing around within the UK banking system in recent years, arguably associated in part with the growth of computing power and contrasting greatly with the previous century's stability. Other countries show similar patterns. Much of this growth derives from increasingly complex financial instruments, which purport to reconcile greater returns with diminished risks.

In 2006 the US National Academy of Sciences (NAS) and the Federal Reserve Bank of New York (FRBNY) put together a prescient study, based on the observation that, while such complex "derivatives" and credit-default swaps seemed attractive at the level of individual financial institutions (henceforth brigaded as "banks"), essentially no one was considering the possible implications for the system as a whole. In addition to bankers and other economists, this NAS/FRBNY study drew in researchers from areas where some "read-across" seemed likely: ecology, infectious disease transmission, and the electricity grid.

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Subsequent to the financial crisis that began in 2008, this issue of systemic risk has moved center stage. In the UK, studies of mathematical metaphors or "toy models" of banking systems have buttressed the intuition of central bankers, suggesting, for example, that all banks should revert

LEFT: **HOUSE OF CARDS** BY PEG DENNEY, COURTESY EILEEN BRAZIEL FINE ARTS

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to the somewhat higher capital reserves (or other liquidity) that they had previously held. These studies also suggest that big banks should hold relatively bigger such reserves than small banks (contrary to the trends of the nineties and noughties); there are lessons to be learned about the disproportionate influence of big banks from relatively recent work on "superspreaders" of infectious diseases.

Additionally, the stabilizing advantages of modular organization in complex systems, seen both empirically and theoretically in ecosystems, suggests a return to greater separation between retail and investment banking activities, along the lines of the US Glass-Steagall Act enacted in 1933. This legislation followed the recognition that a major factor in the Great Depression was banks leveraging casino activity with depositors' money. (Glass-Steagall was repealed at the high tide of free-market extremism that flourished toward the 20th century's end.) These measures, and broadly similar ones being aired in the US, not only march with the dynamical properties of sensible models of banking systems, but also are intuitively reasonable.

The recommendations of the UK's Independent Banking Commission, reported on September 12, 2011, are broadly along the above lines: in particular, higher capital reserves and retail banking activities to be structurally separated (by a strong but flexible "ring-fence") from wholesale and investment activity. Many bankers, however, argue against these recommendations and simply wish to get back on the roller coaster.

All these problems are compounded by the fact that there can be a conflict between what is best for any one bank viewed in isolation, and what is best for the system. This paradox is exemplified by the following toy model (Figure 2): Consider N banks and N distinct, uncorrelated asset classes, each of which has some very small probability, p, of having its value decline to the extent that a bank holding solely that asset would fail. At one extreme, assume each bank holds the entirety of one of the N assets: the probability for any one bank to fail is now p, whereas that for the system is a vastly smaller p^N. At the opposite extreme, assume all banks are identical, each holding 1/N of every one of the N assets: The probability for any one bank to fail is now much smaller than p, but all banks now being identically constituted, if one fails, all fail, and this probability is much bigger than p^N (being of the general order $e^N p^N$). The former pattern minimizes diversification of individual banks but maximizes diversity of the system, whereas the latter does the opposite. Previous international banking

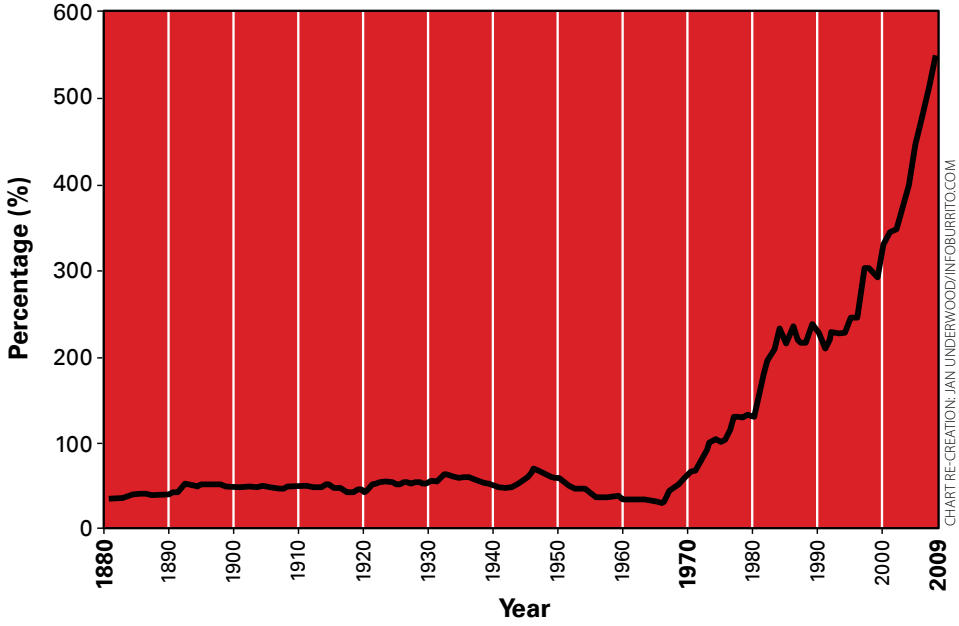

Figure 1: This graph illustrates UK bank assets expressed as a percentage of GDP, over the past century. The fast increase may be due to the amount of leveraged money circulating within the system.

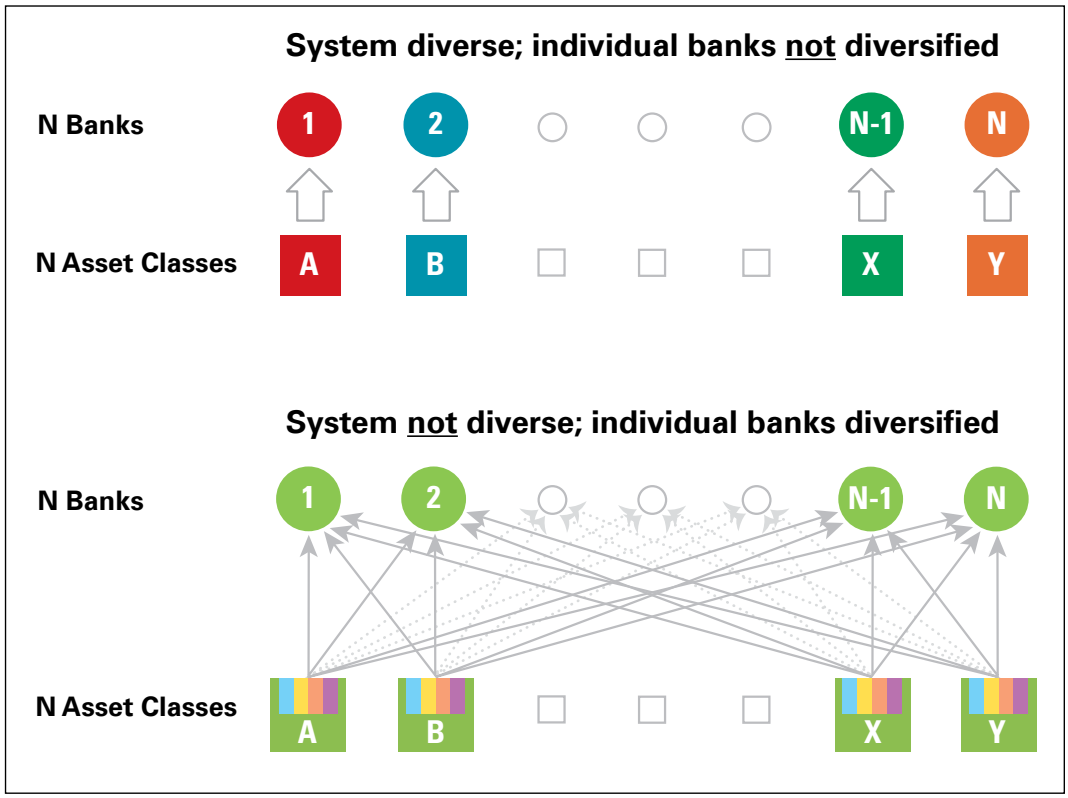

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Figure 2: The top arrangement minimizes diversification of individual banks but maximizes diversity of the system, whereas the bottom arrangement does the opposite.

regulatory meetings, known as Basel I and II, had focused on individual banks and essentially disregarded the system as a whole. Such promotion of individual diversification, without corresponding attention to systemic risk, thus arguably contributed to our present problems.

My view is that considerations of systemic risk are very important, and that greater understanding of how to minimize the likely costs of problems cascading through the system is needed. But I also believe it to be of even greater importance to have more sophisticated and reliable mechanisms for rating complex financial instruments. In retrospect, it is hard to believe anyone could have been so bewitched by illusionary mathematical elaboration of faulty assumptions as to rate collections of Triple B house mortgages as Triple A. There are both technical and social questions here: Not only was the mathematics underpinning the evaluation of complex derivatives (Arbitrage Pricing Theory) grossly unsound, but excessively diligent credit ratings agencies are unlikely to survive in a privatized system. How best to resolve this problem?

Underlying the problems of systemic risk and of proper evaluation of individual financial instruments is a deeper and even more difficult question, recently posed by Harvard's distinguished economist Benjamin Friedman. Beginning with the observation that the role of financial markets in a free-enterprise economy is the efficient allocation of investment capital, he went on to ask, "How much is it costing us to operate this financial system?" His answer: "A lot." Quantifying this assessment he observed that, in the US 30 years ago the cost of running the financial system was 10 percent of all the profits earned in America. This rose to 20–25 percent 15 years ago, and just before the crisis hit, "running the financial system took one-third of all profits earned on investment capital."

I thus conclude by suggesting one important and appropriate task for the sciences of complexity, and for SFI. Take up Benjamin Friedman's challenge: "The time has come for a serious evaluation of the costs and benefits of running our financial system." ◀

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