

AFTERSHOCKS of the Financial Earthquake

BY JOHN WHITFIELD

When your scientific puzzle is someone else's catastrophe—as applies, for example, to seismologists studying earthquakes—the excitement of a new research opportunity must conflict with compassion for the sufferers. That's a conflict that many economists likely are feeling at present. As the credit crunch turns into a global recession, the emphasis is on disaster relief—rescuing the victims and repairing the damage. But besides influencing all our lives, the global financial system is also a source of questions and insights as rich and complex as the Earth's tectonic plates. And as with an earthquake, anyone surveying the wreckage is going to have a head full of what, how, and why.

The idea that mainstream economic theory does not do a great job of describing and predicting actual economic events will not be news to anyone who follows the Santa Fe Institute's output. Ever since the Institute was founded, its researchers have sought to find more accurate and realistic alternatives to the idea that the behavior of financial markets is driven by the smooth and optimal assimilation of new information, and that the people doing the buying and selling are working with perfect rationality to maximize their returns. It's a quest that has drawn in just about every theme of the Institute's work, including, but not limited to, fields such as networks (see Daniel Rockmore's piece in this issue), emergence, the dynamics of human behavior, and the interaction of history and determinacy.

Conventional economics at least has the advantage of being relatively simple. It's like looking under the streetlight for your car key, not because that's where you dropped it, but because that's where you can see. The problem is, financial markets aren't simple—quite the reverse. “The economy really is a complex system—all the pieces are built on each other,” says SFI Professor J. Doyne Farmer. But, he adds, conventional economics has rarely treated markets as such, with the result that their behavior is still extremely poorly understood.

Farmer has spent decades using ideas from physics and computer science to try and invent a flashlight that will illuminate areas untouched by mainstream economics. At the moment, he and his colleagues Stefan Thurner at the University of Vienna and John Geanakoplos at Yale—both SFI external professors—are working on simulations to analyze what many see as one of the key contributors to the crisis in the markets—debt, and its financial equivalent, leverage. That might be a dirty word right now, but it shouldn't be, says Farmer: “A lot of good things run on leverage—we really need it to make markets work,” as shown by the impact that the drastic drop in lending has had on the real economy. But these good things come at a price. “On the other hand, there's risk associated with leverage. As soon as it's there, you have problems.”

Leverage, as its name suggests, is an amplifier. By borrowing to invest, you increase your returns. But when things go wrong, you increase your losses.

The 1906 San Francisco earthquake continues to serve as a strong metaphor for the power of tectonic destruction.



THE CALIFORNIA HISTORY ROOM, CALIFORNIA STATE LIBRARY, SACRAMENTO, CA

And when one part of their portfolio declines, heavily leveraged investors are forced to liquidate other assets, driving those prices down, and creating a spiral of declining value that can spread through markets. In simulations, Farmer and his colleagues have found that adding leverage to a market changes the distribution of returns, creating what are known as heavy tails in the price movement. These reflect an increased probability of extreme events—that is, you become more likely to both hit the jackpot and lose your shirt.

What’s needed, says Farmer, is an actuarial understanding of the risks associated with leverage, which could be used to regulate the amount that investors are allowed to borrow—in a similar way that anyone taking out a personal loan is expected to offer evidence of their ability to repay it, and often to provide a down payment. That understanding is currently lacking. “Until we understand what the right amount of leverage is and how to regulate it, we’ll be repeating these mistakes,” he says.

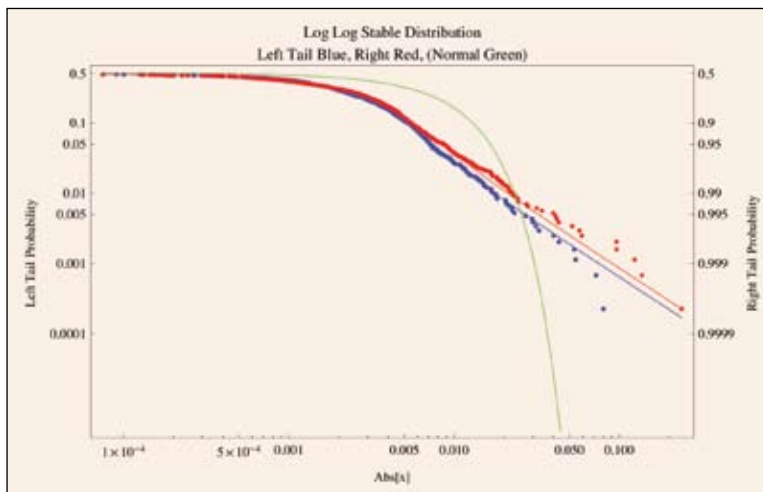
What Farmer and his colleagues do is often called “econophysics.” It uses vast data sets and sophisticated mathematical models to get a view of how history and environment affect the dynamics

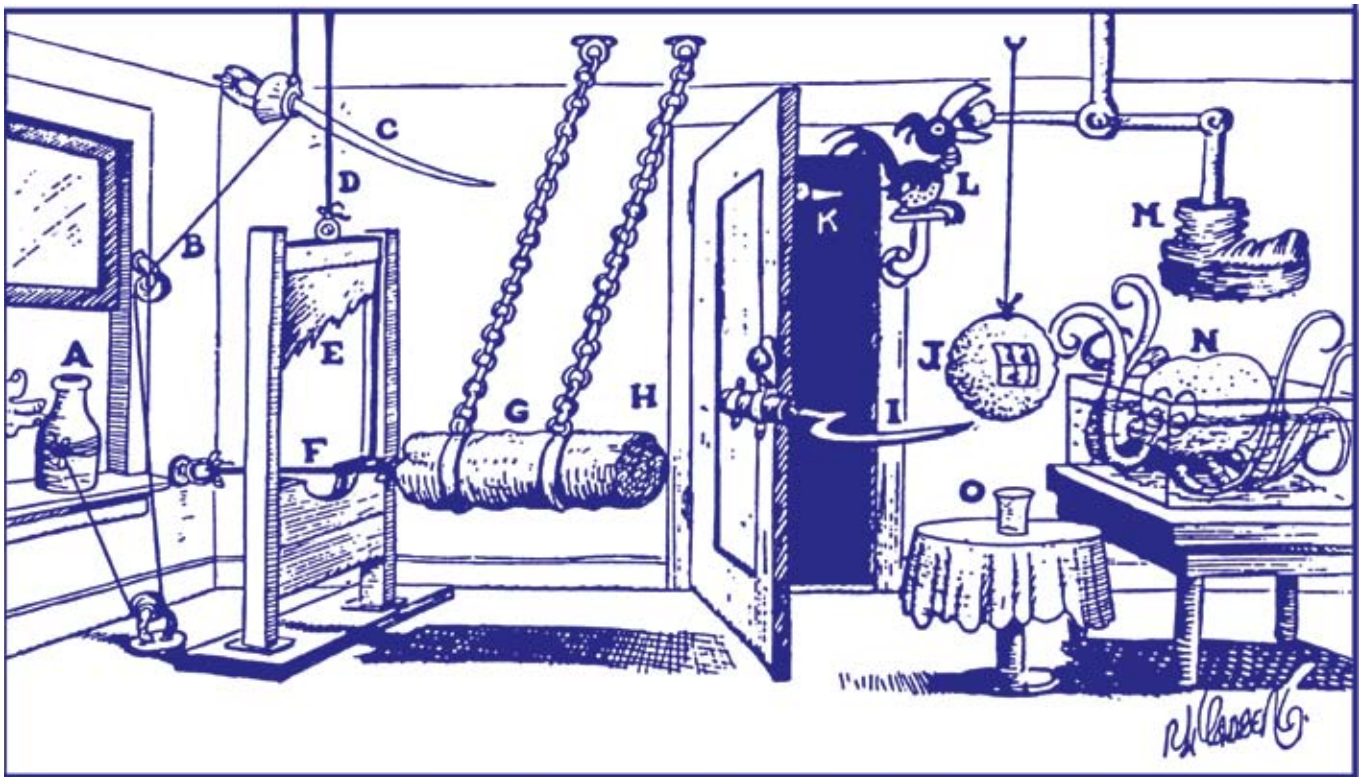
Adding leverage to a market changes the distribution of returns, creating “heavy tails” in the price movement, and so increasing the probability of large gains or losses.

PROFESSOR BUTTS STEPS INTO AN OPEN ELEVATOR SHAFT AND WHEN HE LANDS AT THE BOTTOM HE FINDS A SIMPLE ORANGE SQUEEZING MACHINE. MILK MAN TAKES EMPTY MILK BOTTLE(A) PULLING STRING(B) WHICH CAUSES SWORD(C) TO SEVER CORD(D) AND ALLOW GUILLOTINE BLADE (E) TO DROP AND CUT ROPE(F) WHICH RELEASES BATTERING RAM(G). RAM BUMPS AGAINST OPEN DOOR(H) CAUSE ING IT TO CLOSE. GRASS SICKLE(I) CUTS A SLICE OFF END OF ORANGE(J) AT THE SAME TIME SPIKE (K) STABS PRUNE HAWK (L) HE OPENS HIS MOUTH TO YELL IN AGONY, THEREBY RELEASING PRUNE AND ALLOWING DIVER'S BOOT (M) TO DROP AND STEP ON SLEEPING OCTOPUS(N). OCTOPUS AWAKENS IN A RAGE AND SEEING DIVER'S FACE WHICH IS PAINTED ON ORANGE, ATTACKS IT AND CRUSHES IT WITH TENTACLES, THEREBY CAUSING ALL THE JUICE IN THE ORANGE TO RUN INTO GLASS (O).
LATER ON YOU CAN USE THE LOG TO BUILD A LOG CABIN WHERE YOU CAN RAISE YOUR SON TO BE PRESIDENT LIKE ABRAHAM LINCOLN.

of markets. At the other end of the spectrum of unconventional economic ideas are behavioral and experimental economics. These take ideas from evolution and psychology to look at why individual behavior often deviates from conventional economic rationality, and the social consequences of such actions. SFI Professor Sam Bowles, using experimental and real-world evidence, has shown that economic incentives sometimes backfire, as they are a signal of distrust—it can be more effective to appeal to a person’s sense of duty and ethics than to try to bribe or fine them into activity.

Such experiments usually examine interactions between individuals, or in small groups. But you can apply the same ideas at a larger scale, says Duncan Foley, an SFI external professor based at the New School in New York. Foley has taken the ideas of behavioral economics and applied them to the interactions between banks. In the boom before the bust, he says, banks trusted one another in their dealings, because they believed that they held adequate reserves. This kept the interest rates for inter-bank lending low, and created an equilibrium state where banks lent freely to one another without collateral. “At the good





equilibrium, everyone takes it more and more for granted, and puts the balance sheet in a more and more leveraged position,” says Foley.

This increasing leverage, however, was like pressure building on a fault line. And it wasn’t the only source of pressure. Money from cash-rich nations such as China, Russia and Saudi Arabia poured into the United States, pushing the economy away from industry and towards financial services, triggering a consumption binge and inflating domestic asset prices. Even without sub-prime mortgage lending, a quake was inevitable, says Foley. “It’s a mistake to think that the system would have gone on indefinitely. If it hadn’t been mortgage-backed securities, it would have been credit card debt, or something else.”

In the past 18 months, says Foley, as it became clear that the banks did not have the cash to back up their promises, the trusting equilibrium of easy lending gave way to a much more expensive equilibrium, where trust has vanished, in a similar way that behavioral economics has found that a few cheats can undermine a large group of co-operators. “If any one institution refuses to deal with its counterparts on trust, it forces all the

others to devote capital to collateralization,” he says. Likewise, the real economy has shifted from an equilibrium where consumers spend and borrow, creating liquidity for others, to one where everyone holds onto their money, which threatens to keep the economy in its trough.

One difference between seismologists and economists, of course, is that the latter ultimately hope to prevent the disasters they study. And although the financial system is complex, some of the suggested fixes are quite simple. Both Farmer and Foley argue that a good first step would be to increase transparency, requiring investors to reveal the amount of leverage they have taken out, if not their actual positions. SFI Visiting Professor Ole Peters, who elsewhere in this issue explains how considerations of time can help optimize risk, has looked at this issue. He believes that many of the bonus schemes offered to fund managers, where the rewards for doing well were far greater than the penalties for failure, encouraged excessive risk-taking. One solution he suggests is to make the incentives in markets the same for traders and investors by requiring that traders invest in their own funds. “If you’re managing a fund and all your money is

invested in that fund, whatever is optimal for the fund is optimal for you,” he points out, adding that “perhaps the crucial step is to start using the concept of objective optimality.” This level of risk truly maximizes the return on an investment, not the level that seems like a good idea to a gung-ho fund manager angling for a massive reward.

Meanwhile, Foley suggests that the world financial system needs stronger controls on exchange rates. Something upon those lines was suggested by John Maynard Keynes at the 1944 Bretton Woods Conference, in which the allied nations made arrangements for global finances after World War II. But the United States was unwilling to give up the sovereignty that such controls would require—leading to the weaker World Bank and International Monetary Fund. This, says Foley, contributed to the problems of today, because it meant that the dollar became the de facto global currency and the United States found itself managing global demand, meaning that when its economy began to quake, the whole globe felt the aftershock.

Even with such a system, rebuilding isn't going to be easy. The markets may have moved into a new stable state: “It's a rather tough situation for policymakers to deal with,” says Foley. “The good equilibrium may no longer be there at all.” And even though many commentators and policymakers are calling for tighter regulation of financial markets, the appropriate stringency of regulation isn't at all clear. “If you regulate for the worst case, you over-regulate. But if you regulate for the normal case, you don't protect the system from collapse.”

Regardless of what fixes we attempt, we need new ways to monitor and understand the system, says Farmer. The simple models of conventional economics are not up to the job. “We've got no model that deals with, for example, the fact that the financial system affects the production sector of the economy, yet that's what's causing the recession,” he says. And taking complexity out of the markets isn't an option. Sophisticated financial instruments are here to stay, and can be a force for good. “We're not going to go back to banking in gold,” he says. The only thing we can do, he concludes, “is to recognize the complexity and tackle it head on.” ◀

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Let's say I offer you the following gamble: You roll a dice, and if you throw a six, I will give you one hundred times your total wealth. Anything else, and you have to give me all that you own, including your retirement savings and your favorite pair of socks. I should point out that I am fantastically rich, and you needn't worry about my ability to pay up, even in these challenging times. Should you do it?

The rational answer seems to be “yes”—the expected return on your investment is 1,583 1/3% in the time it takes to throw a dice. But what's your gut feeling? Perhaps you are quite happy with your present situation; maybe you own a house and a nice car and a private jet—would you be one hundred times happier if you

ON Time AND Risk

BY OLE PETERS

were one hundred times richer? And how much less happy would you be if you suddenly had nothing?

This example illustrates a common flaw in thinking about risky situations, one that can make us blind to excessive risks and which appears to have been a factor in the financial markets in recent years. As we will see, the calculation of the enormous expected return essentially assumes that you have dealings with parallel universes. Consequently, financial models can fall prey to the assumption that traders will regularly visit the parallel universe where everything comes up sixes. An analysis of risk and return that prohibits such eccentricities gives rather different answers. We will start with an outline of the classical treatment of risky problems, then offer an alternative, and finally discuss the practical consequences of both perspectives.

Daniel Bernoulli, the man who explained why helicopters fly a few hundred years after Leonardo da Vinci drew them and a few hundred years before they took to