

# In financial ecosystems, big banks trample economic habitats and spread fiscal disease

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(Phys.org)—Like the impact of an elephant herd grazing on grassland, multinational banks shape the financial environment to an extent that far outweighs their small number. And like a contagious person on a transnational flight, when these giant, interconnected banks succumb to financial ills, they are uniquely positioned to infect wide swaths of the financial system.

Researchers from Princeton University, the Bank of England and the University of Oxford applied methods inspired by ecosystem stability and contagion models to banking meltdowns and found that large national and international [banks](#) wield an influence and potentially [destructive power](#) that far exceeds their actual size.

When a large bank—defined as having various holdings and extensive connections—falters widespread financial loss and a virulent drop in confidence can quickly consume a financial system, the researchers report in the journal the [Proceedings of the National Academy of Sciences](#) (*PNAS*). Systems like those in the United States in which a few banks hold most of the assets amplify these effects.

As a result, the capital that current regulations require large banks to maintain should not be based solely on its own risk, but also on the institution's systemic importance, the researchers suggest. This would mean that large banks maintain capital that not only surpasses that of smaller regional and local banks, but also is proportionally larger than the bank's slice of the financial pie. Additionally, requiring such hefty

reserves could discourage banks from becoming "too big to fail," the researchers write.

Lead author and Princeton mathematical [epidemiologist](#) Nimalan Arinaminpathy explained that the paper represents part of an effort to examine how tumult such as the 2007-08 [global financial crisis](#) can spread throughout a [banking system](#). Prior to the crisis, regulators typically judged banks on their individual health rather than their potential threat to the overall network, he said.

"In terms of regulation, there was really very little attention to how the financial system worked as a whole," said Arinaminpathy, who is a postdoctoral research associate in Princeton's Department of Ecology and Evolutionary Biology.

"When looking only at individual institutions, big is beautiful because larger banks can more easily diversify their assets," Arinaminpathy said. "But a system-level perspective reveals that when a big bank goes down its impact is much bigger than its size regardless of diversity. We wanted a modeling framework to explore how big that effect could be and how to lessen its intensity."

In addition, said second author Sujit Kapadia, a Bank of England financial-policy adviser, the models demonstrate how a lack of confidence perpetuates a financial crisis. That fear manifests as "liquidity hoarding," wherein banks stop lending to one another. Unlike a virus, financial contagion only spreads more quickly and widely when banks "quarantine" themselves by freezing loans and cutting business ties. That, in turn, feeds distress, which further fuels withdrawal from the system. This power of fear to promote failure was evident following the collapse of Lehman Brothers Holdings Inc. in 2008, which was a major driver of the global crisis, Kapadia said.

"After Lehman Brothers failed in 2008, confidence disappeared from the system rather suddenly and the system just fell off a precipice," Kapadia said. "The speed and sharpness of that collapse in confidence was more than might have been expected before the crisis, and is one of the reasons we tried to build confidence effects into this framework."

The researchers' conclusion that larger banks should maintain capital relevant to their importance could actually promote innovation in the industry by favoring smaller, more agile banks, explained George Sugihara, a theoretical biologist at the Scripps Institution of Oceanography at the University of California-San Diego. Sugihara, a published proponent of similar approaches to regulating large banks, is familiar with the *PNAS* paper, but had no role in it.

"This would basically create a systemic-risk tax for larger more highly connected institutions and work to the advantage of smaller financial institutions," Sugihara said. "It is there in the small banks and thrifts that many publicly useful financial innovations arise."

The models the researchers created illustrate that such a policy is not only crucial, Sugihara said, but also potentially far-reaching and relatively simple to implement in comparison to existing, more complex regulations.

"This particular integration of network dynamics with confidence effects makes this model unique, and potentially both minimal and comprehensive," Sugihara said. "It calls attention to a general class of problem that has a long tradition in ecology but is only recently being taken seriously in central banking—namely, the importance of evaluating risk by viewing banking as a 'whole' system."

## **Of elephants and illnesses**

The researchers simulated a banking system inspired by models of ecosystems first developed in the 1970s by the *PNAS* paper's third author, Robert May, a professor of zoology at Oxford, a Princeton visiting professor in ecology and evolutionary biology, and former chief scientific adviser to the UK government. In ecology, these frameworks cast a holistic eye on how the interactions between different species can shape the stability of an ecosystem. In epidemiology, the consideration is the various avenues through which a virus is introduced and spread through a population.

Banking systems now need similar scrutiny, May explained, because regulations have since the late 1980s typically focused on minimizing risk for individual banks at the expense of the wider financial world. Large institutions have been free to expand their activities, May said. At the same time, those big institutions were permitted before the crisis to maintain financial reserves proportionately less than those held by small banks on the reasoning that the sheer size of a larger bank's holdings would be more resilient to economic tumult.

"The need to analyze financial systems—as distinct from the operation of individual banks, one-by-one—is making itself increasingly obvious," May said. "Individual banks have tended to become more diverse in their activities, but the system as a whole has become less diverse. In short, there is a tension between what might be best for each individual bank and what might be best for the system as a whole."

If the financial world were an ecosystem, large banks would be like a "keystone species," Arinaminpathy said. These species' importance extends beyond their biomass, or the collective weight of resident individuals, he said. For instance, a typical elephant herd can weigh several hundred tons, but the effect it has on the grasslands on which the animals graze has a cascading impact on other species that exceeds their physical presence.

"For large banks, we're not just looking at their individual size but the role they play in the financial network as a whole," Arinaminpathy said.

When it comes to the spread of financial disease, large banks can act as a "super spreader," a sick individual that can spread a contagion widely, Arinaminpathy said. An example is the contagious person whose infection spreads easily in the tight confines of a long flight. Likewise, multinational banks have numerous close financial ties that speed transmission. But while isolation can stem a biological virus, financial "contagions" feed on anxiety.

"An important distinction from biological disease is that financial contagions become more virulent and transmissible the more anxious people become," Arinaminpathy said. "We capture the well-observed phenomenon that a loss of confidence creates a cycle of financial and psychological insecurity. The worse confidence gets, the more severe those financial shocks get."

## **Bank sick day**

The researchers' financial models contained 200 banks and three "contagion channels" that introduce illness into the system—liquidity hoarding, the spread of defaults and a collapse in asset value (such as mortgages). Though these avenues of financial crisis have been examined individually, Kapadia said, he and his co-authors are the first to demonstrate how they interact with one another and with system wide confidence.

The central model contained eight large banks and 192 smaller banks, all with equal capital and cash. The researchers selected a random bank for sudden failure and measured how that affected the entire bank system through each of the three contagion channels. It was in this model that financial trouble in one bank could create a tide of uncertainty that

caused widespread distress in the system. Yet, catastrophe could be averted more often if large banks have backup capital commensurate with their size.

Notably, in these simulations, when a large bank collapsed the probability of the system collapsing as a result exceeded 16 percent. There was no such risk when a small bank failed. The impact was highly localized and the probability that more than three additional banks would falter was less than 2 percent.

"The models aren't set up to make quantitative estimates, but rather to show that if they fail, larger banks will have a more-than-proportionate impact on the financial system than smaller banks," Kapadia said.

"Twice the bank size doesn't mean twice the impact from bank failure. Instead, the financial network acting together with confidence effects can be a strong amplifier, so that you get more than twice the impact."

A banking system akin to that in the United States wherein a few banks control most assets worsened these effects. The researchers created a more concentrated model using data from the American financial sector indicating that 1.4 percent of U.S. banks controlled 79 percent of banking system assets in the first quarter of 2011. In their simulation, three banks out of 200 were large, but each was 250-times the size of a smaller bank. In such a model system the failure of a single large bank was even more catastrophic, while the system is virtually unaffected by small banks until they all fail.

Another scenario factored in diversification by allowing big banks to hold twice as many types of assets as small banks. The researchers found that large banks with a variety of holdings can survive hard times longer, but once they eventually suffer failure, the implications for the system can be more widespread than in the other models.

Although diversification is lauded as a stopgap to crisis, Arinaminpathy said, he and his co-authors found that it also could heighten vulnerability by increasing the exposure to risk on numerous fronts.

"Diversification does protect a financial institution somewhat, but once several assets sour, banks now have many avenues for transmitting and contracting contagions," he said. "So looking at things on a systemic level, variety can be a bad thing once a bank fails and the outcome can be just as destructive, if not more."

The researchers plan to build on their work with models that more closely resemble real banking systems, as well as explore indicators of what makes a bank systemically important and how risk builds up in a system over time, Arinaminpathy and Kapadia said.

"The essential point of this paper," Arinaminpathy said, "is that the financial network works together with confidence effects to amplify the importance of larger banks to a scale beyond their size, and that these effects could be key when thinking about how we might better regulate the system in the future."

**More information:** The paper "Size and complexity in model financial systems" was published Nov. 6 in the *Proceedings of the National Academy of Sciences*. [www.pnas.org/content/109/45/18338.abstract](http://www.pnas.org/content/109/45/18338.abstract)

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