Risk analysis for a complex world

November 18 2014

Developing adaptable systems for finance and international relations could help reduce the risk of major systemic collapses such as the 2008 financial crisis, according to a new analysis.

The increasing complexity and interconnection of socioeconomic and environmental systems leaves them more vulnerable to seemingly small risks that can spiral out of control, according to the new study, published in the journal *Proceedings of the National Academy of Sciences*.

The study examines risks are perceived as extremely unlikely or small, but because of interconnections or changes in systems, can lead to major collapses or crises. These risks, which the researchers term "femtorisks," can include individuals such as terrorists, dissidents, or rogue traders, or

factors like climate change, technologies, or globalization.

"A femtorisk is a seemingly small-scale event that can trigger, often through complex chains of events, consequences at much higher levels of organization," says Princeton University professor and IIASA Distinguished Visiting Fellow Simon Levin, who adopted the term (originally suggested by co-organizer Joshua Ramo) together with an international group of experts during a 2011 IIASA conference on risk modeling in complex adaptive systems.

Levin explains, "A complex adaptive system is a system made up of individual agents that interact locally, with consequences at much higher levels of organization, which feed back in turn to affect individual behaviors. The individual agents can be anything from cells and molecules, to birds in a flock, to traders in a market, to each and every one of us in the global environment."

The complexity of such systems makes it difficult or even impossible to model the outcomes of specific changes or risks, particularly very small or seemingly insignificant ones. The study examines several examples of such femtorisks that set off major crises, including the credit default swaps that led to the 2008 financial crisis, the recent protests in the Middle East and Ukraine that led to the broad upheavals in both regions' political systems, and the warming temperatures in the Arctic that have led to massive international interest in the region for mining and economic development.

Risk management for an unpredictable world

In light of such unpredictable risks, the researchers say, the most resilient management systems are those that can adapt to sudden threats that have not been explicitly foreseen. In particular, the researchers suggest a model drawing on biological systems such as the vertebrate

immune system, which have evolved to respond to unpredictable threats and adapt to new situations.

"In practice it is generally impossible to identify which of these risks will end up being the important ones," says Levin. "That is why flexible and adaptive governance is essential."

The general principles of such management include: effective surveillance, generalized and immediate initial responses, learning and adaptive responses, and memory, say the researchers. Levin says, "We need to design systems to automatically limit the potential for catastrophic contagious spread of damage, and to complement that with effective and flexible adaptive responses."

More information: Frank AJ, Collins MG, Levin SA, Lo AW, Ramo J, Dieckmann U, Kremenyuk V, Kryazhimskiy A, Linnerooth-Bayer J, Ramalingam B, Stapleton Roy J, Saari DG, Thurner S, von Winterfeldt D. 2014. Dealing with femtorisks in international relations. *Proceedings of the National Academy of Sciences*. DOI: 10.1073/pnas.1400229111

Provided by International Institute for Applied Systems Analysis