The Stability of Financial Networks

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In the light of recent and current economic uncertainties, the stability of the global financial system, or more precisely its systemic risk, has come under intense scrutiny as a question of the highest strategic importance, with potential impact measured in trillions of dollars. Andrew Haldane, Executive Director of Financial Stability at the Bank of England, in an important speech in 2009, has issued a clarion call to scientists of all disciplines to come together to use our understanding of other complex networks such as biological, engineered and social networks, to illuminate the nature of financial systems. This one-week intensive study period will attempt to address this call to arms by bringing together mathematically sophisticated researchers to apply the theory of random graphs to the question of systemic risk.

The Mathematical Problem Definition

This study group will focus on some of the very recent research that models financial networks as random graphs with nodes representing banks and their balance sheets, and edges representing a number of types of debtor-creditor relationships. The basic question to ask of the network is whether the system is susceptible to "domino effects" whereby certain types of externally applied shocks lead to a "cascade" of insolvencies. Some of these models are so deliberately simplified that they can only hope to reflect certain traits of the real world networks, but compensate by admitting analytical formulas. Properties of other more realistic models can only be understood through Monte Carlo simulation. Beginning with a detailed overview of real world networks, previous studies of their systemic risk, and some of the newest theoretical models, our overall goal will be to develop a comprehensive toolkit of computational algorithms that will include network simulation methods, analytic results for several models, plus statistical and graphical methods. With such a toolkit we can begin to have a detailed understanding of some of the basic features that we call systemic events.

A critical factor hampering the implementation of quantitative systemic risk methods is the availability of comprehensive databases in any developed economies: these are often either nonexistent, or completely unavailable to academics. Prior to the study period, we hope to obtain at least some historical data on the interbank links in a major financial network, either from the Brazilian banking network or another jurisdiction, and based on such a database we can investigate how several new mathematical modeling approaches may be applied. To develop a new theoretical understanding of this observed network, a first step will be to adopt a comparative statics approach, allowing us to see in these models which of the many parameters most affect various well known measures of systemic risk.

Many of the new theoretical systemic risk models are built in analogy to recently developed random graph models, such as the small world and scale free networks. Our application raises new questions for the general theory, and it will be of interest to attempt to pose and solve some of these as mathematical problems. One important aspect of the financial system is called the assortative property, and this has not yet been studied deeply by mathematicians. A number of mathematical problems have not been addressed in this context. For example, Monte Carlo simulation of assortative random graphs appears to be an unstudied problem. As well, the so-called cascade condition from random graph theory arises in systemic models too, but generalizations of this condition to assortative graphs appear to be new.

The study group will also consider further financial features are likely to have a large effect on systemic risk. For example, an unstudied problem is to determine the cascade condition in case the balance sheets are random. Other critical features not yet included in the current models are the liquidity hoarding and asset fire-sales that accompany and may easily magnify any financial crisis. We will consider how to model liquidity cascades as well as the impact of fire-sales of assets.

References

[Eisenberg and Noe(2001)] L. Eisenberg and T. H. Noe. Systemic risk in financial systems. *Management Science*, 47(2):236–249, 2001.

[Gai and Kapadia(2010)] P. Gai and S. Kapadia. Contagion in financial networks. *Proceedings of the Royal Society A*, 466(2120):2401–2423, 2010.

[Hurd and Gleeson(2011)] T. R. Hurd and J. P. Gleeson. A framework for analyzing contagion in banking networks. submitted paper to SIAM J on Fin. Math., October 2011.

[Upper(2011)] C. Upper. Simulation methods to assess the danger of contagion in interbank markets. *J. Financial Stability*, 2011.

[Watts(2002)] D. Watts. A simple model of global cascades on random networks. *PNAS*, 99 (9):5766–5771, 2002.