Interdisciplinary Approaches to Financial Stability

CENTER ON FINANCE, LAW, AND POLICY
UNIVERSITY OF MICHIGAN

OFR OFFICE OF FINANCIAL RESEARCH

Panel 5: Measuring, Anticipating, and Testing Systemic Risk in Financial Systems
Friday, October 23, 2015 at 11:15 a.m.
Hutchins Hall 100

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The financial crisis of 2007-2009 has renewed our interest in understanding systemic risk, a risk broadly defined as a widespread failure of financial system that imposes large negative externality on the rest of the economy. Failure of a handful of very big financial institutions or correlated failure of a large number of relatively smaller institutions can both severely impair the financial system's ability to intermediate between savers and borrowers, which in turn can lead to large welfare losses by slowing down real economic activities. A vast empirical literature, spanning several episodes of financial crises across various countries, provides compelling evidence in support of this claim. Hence the case for managing and containing systemic risk is fairly straightforward. The real difficulty lies in measuring this risk and devising an incentive-compatible system to control it, a topic that our panel focuses on.

While we all have a general idea of what constitutes systemic risk, there is no widely accepted agreement on how to define it. This is not surprising given the lack of a fully developed general equilibrium theoretical model of systemic risk in the literature. Historically, academic work in this area was focused on banking and currency crises. This literature mainly focuses on the micro-foundations of crisis such as shocks to investors' preferences, informational frictions, and changes in aggregate liquidity needs of the entire economy. For example, one view from this old literature is that financial crises result from investor panics that are unrelated to

financial fundamentals (Kindleberger, 1978).[1] Diamond and Dybvig (1983) provide an elegant model of bank run that is driven by depositor panic and the resulting self-fulfilling prophecy.[2] Another view in the literature models banking crises as an inherent part of business cycle (Allen and Gale, 1998) and turns its focus on informational frictions and fundamental shocks to the economy.[3] Some recent papers focus on the destabilizing effects of margin-based trading by intermediaries who are subject to capital constraints and risk limits (e.g., see Brunnermeier and Pedersen, 2008).[4] Broadly, the theoretical literature has made tremendous progress in understanding "what might cause a financial crisis", but it doesn't take us all the way to a workable measure of systemic risk.

The task of extrapolating the insights from these models to a workable definition of systemic risk has become even more challenging in recent years due to two fundamental transformations over time. First, the boundary between different sub-sectors of the financial services industry has become blurred: banks, insurance companies, hedge funds, and other members of capital markets do not operate in isolation. Often they compete in similar risk segments, for examples hedge funds and insurance companies participate actively in mortgage linked credit risk through securitization vehicles. Further, through instruments such as insurance contracts and other derivatives products these institutions have become exposed to significant counter-party risk in recent decades. Second, markets around the world have become increasingly more interconnected in recent times: shocks in one part of the global economy can be felt relatively faster in the other. Given these intricacies of the global financial system, the search for a theoretically motivated measure of systemic risk that can be put to practice remains elusive.

Can we measure an economic construct that we do not fully understand theoretically? Perhaps. Perhaps we can do so by starting with empirical measures that have ``desirable'' properties that we would like to see in a good measure of systemic risk. But such an empirical approach needs a lot of data, to be precise a lot of data on events that can be classified as systemic. Fortunately, systemic failures are rare events, which is an unfortunate news for empirically motivated measures of this risk. Validating and establishing the usefulness of empirically motivated risk measures with limited data is a daunting task. Together, the lack of theoretical guidance and the sparse nature of systemic event leaves us in an uncomfortable situation: we have no choice but to make some ad-hoc assumptions in measuring systemic risk. Such an approach can sometimes lead to suboptimal regulatory policies and provide distorted

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[1] Kindleberger, Charles P. *Manias, Panics, and Crashes: A History of Financial Crises*. New York: Basic Books, 1978.

[2] Diamond, Douglas W., and Dybvig, Philip H., "Bank Runs, Deposit Insurance, and Liquidity," Journal of Political Economy, 1983, 91: 401-19.

[3] Allen, Franklin, and Gale, Douglas, "Optimal Financial Crises", Journal of Finance, 1998, 53:1245-84.

[4] Brunnermeier, M., and Pedersen, L.H., "Market Liquidity and Funding Liquidity", Review of Financial Studies, 2009, 22:2201-38.

incentives to financial institutions.[5] Even worse, there is always a possibility that we end up with a measure that doesn't really give us any early warning information for the next big event.

On the positive side, despite these limitations researchers and policymakers have made reasonable progress on this issue since the financial crisis of 2007-09. Even with some disagreement in defining what constitutes systemic risk, there are some common threads across definitions and across proposed measures of systemic risk. First, systemic risk is often associated with the instability of the entire financial system (as against a failure of few isolated institutions) and a resulting loss of *public confidence* in the system. Second, there is agreement that systemic risk creates large losses that spillover to the non-financial sectors of the economy, including firms and households. And finally, systemic risk is often associated with the interconnectedness of the financial system, which in turn links the survival of one institution dependent on the survival of others. Thus aggregate instability, large negative externality, and interconnectedness have all been suggested as key features of systemic risk. Beyond these features of systemic risk, how should we think about measuring and managing this risk in an economically sound framework? Some recent research papers have taken up this challenge. They typically combine insights from the practical world of risk management with economic theory to develop a workable model of systemic risk.

Acharya et al. (2010) propose a measure, called the systemic expected shortfall (SES), that is based on the idea that a bank's systemic risk depends on the extent of capital shortfall it has in very bad states of the world.[6] The authors provide a sound theoretical foundation to their measure, which effectively captures the propensity of a bank to be undercapitalized in the states of the world where the financial sector as a whole is undercapitalized. Thus SES measures the bank's expected losses during crisis. In one of the early attempts to measure systemic risk, Adrian and Brunnermeier (2011) take a related but different approach.[7] They propose a measure, called CoVaR, based on the value at risk (VaR) of the entire financial system conditional on institutions being under distress. An institution's contribution to systemic risk is then defined as the difference between CoVaR conditional on the institution being under distress and the CoVaR in the median state of the institution. Effectively, CoVaR provides a measure of the entire financial sector's losses as a function of the specific institution's losses. CoVaR and SES share a

[5] Value-at-Risk (VaR) provides an excellent example of such a distortion at firm-level risk management. Intuitively, VaR provides a measure of the downside risk of a portfolio in terms of the likelihood of bad outcomes. But it doesn't tell us how bad is the bad outcome. To be precise, the VaR isn't informative about the extent of losses once a portfolio hits the VaR limit. A risk monitoring system that is based on VaR constraints, therefore, can provide incentive to hide large tail risks. Only after the adoption of VaR for firm-level risk management, subsequent research showed that VaR has such an undesirable property and it is not a ``coherent" measure of risk in the sense of Artzner et al. (2002) (Artzner, P., Delbaen F., Eber J., and Heath David, “Coherent Measures of Risk”, 2001, 9: 203-28.).

[6] Acharya V., Pedersen, L.H., Philippon, T., Richardson, M., “Measuring Systemic Risk”, 2010, Unpublished working paper, New York University.

[7] Adrian, T., Brunnermeier, M., “CoVaR”, Unpublished working paper, Princeton University and Federal Reserve Bank of New York.

common feature in that they both focus on correlations in payoffs of an institution and the system as a whole in bad states of the world. CoVaR assesses the system's losses conditional on the institution's losses, whereas SES computes the institution's losses (and hence capital shortfall) conditional on system wide losses. Huang, Zhou, and Zhu (2011) propose the price of insurance premium required to cover distressed losses in the financial system as a measure of systemic risk.[8] All of these approaches face the challenge of measuring tail correlations with data that are predominantly coming from good times of the economy. The papers rely on some distributional assumptions on the asset returns to back out the tail correlations based on data obtained from normal times.

Another approach to the measurement of systemic risk relies on network models. Billio et al. (2012) tackle the issue of interconnectedness of the financial system using Granger-causality networks.[9] Their model tries to pin down the return correlation across different financial institutions over time: as the connectivity increases the system is likely to be more vulnerable to adverse shocks in any part of the economy. Such an approach gets us closer to the network connectivity aspect of systemic risk, however in contrast with the earlier approaches this model is not particularly focused on tail correlation. This line of investigation can benefit from borrowing insights from network models used in other fields such as epidemiology and computer science.

Going forward, it will be worthwhile to evaluate the performance of these models in terms of how well they perform in an out-of-sample setting (e.g., different periods and markets), and the speed with which they detect systemic events. It will be equally useful to understand the settings where these models work very well and where they fall short. Such an approach will allow us to combine these measures and extract information from them in an efficient manner to detect the buildup of systemic risk in the economy. Related, it will be useful to better understand how these measures of systemic risk correlate with fundamental economic constructs such as firm leverage, market liquidity, and economic losses.[10]

Any discussion of systemic risk measurement remains incomplete without a clear understanding of the incentives that lead to the buildup of systemic risk in the first place. This is especially important to ensure that regulations framed around the measures of systemic risk are prudent. Why do institutions become interconnected in the first place? Why do they become so large? Needless to say there are several economically sound rationales behind these decisions. An interconnected financial system can facilitate better risk sharing, and allow institutions to

[8] Huang, X., Zhou, H., Zhu H., "Systemic Risk Contribution", Unpublished working paper, Board of Governors of the Federal Reserve System.

[9] Billio M., Getmansky M., Lo A., Pelizzon L., "Econometric Measures of Connectedness and Systemic Risk in the Finance and Insurance Sectors", Journal of Financial Economics, 2012, 104: 535-559.

[10] For example, Brownlees and Engle (2015) take a step in this direction by linking their SRISK measure to drop in industrial production and employment rate. (Brownlees C., Engle R. F., SRISK: A Conditional Capital Shortfall Index for Systemic Risk Measurement, Unpublished working paper, New York University.)

manage their liquidity risk better. Thus an optimal non-zero degree of interconnectedness can be welfare maximizing. Similarly, larger institutions can obtain better economies of scale and scope, and pass on some of these benefits to the consumers. The real challenge lies in striking a good balance between these benefits of an interconnected system in good times and its externality costs in bad states.[11] Any use of systemic risk measure in managing the financial stability of the system must be mindful of this tradeoff.

A natural question arises: what use should we put our systemic risk measures to? One regulatory approach is to tie an institution's capital requirements to a sound measure of systemic risk such as its SES or CoVaR. Alternatively, institutions maybe required to contribute to a systemic insurance fund, akin to a deposit insurance fund, where the insurance premium depends on the level of systemic risk the institution imposes. These approaches must be mindful of the Lucas critique. The institution's risk-taking and risk-reporting behavior might change significantly once such a regulation comes into existence. Will such an approach lead to perverse incentive to underreport risks that are systemic in nature? For example, in a recent paper Begley, Purnanandam and Zheng (2015) show that banks are more likely to underreport their trading book VaR when they have lower capital and when the banking sector as a whole is capital starved.[12] A second approach to regulation can be market-driven. Institutions can be required to buy (and hence pay fair price for) insurance against systemic risk from a market participant. However, such a regulation must be mindful of the fact that the insurer of a systemic risk might itself not be solvent in the bad states of the world. Obviously, designing a regulatory framework for containing the buildup of systemic risk or containing its negative externality in the aftermath of a crisis is a non-trivial task. It is immediately clear that how we measure systemic risk has a profound impact on the effectiveness of these policies. We are currently developing risk measures based on market prices of these institutions from an environment where such regulations are not in place. Can we continue to measure the systemic risk in the same way after the regulations on systemic risk change? Even without this concern, we have to be mindful of the fact that market prices also reflect the likelihood of intervention by regulatory authorities in bad times. Ideally, risk measures based on market prices should not be contaminated by the market's expectation of the government support to the institution in bad times.

Let me summarize by stating three key challenges we face in this area. First, we need to make some more progress on the theoretical front so that we are able to get a measure of systemic risk that is economically sound. Second, we need advancement in testing the out-of-sample predictability of these measures. And finally, we need to focus on the incentives of the

[11] For example, Allen and Gale (2000) develop a model of financial contagion as an equilibrium phenomenon in which institutions with imperfectly correlated liquidity preference shocks hold interbank claims as an insurance against such shocks. Such an arrangement provides efficient risk sharing when there is no aggregate uncertainty. On the flip side, this arrangement is inherently fragile: small shock to the aggregate demand of liquidity can quickly result in a collapse of the entire system (Allen, F., Gale D. “Financial Contagion”, Journal of Political Economy, 2000, 108: 1-33).

[12] Begley T., Purnanandam A., Zheng K., “The Strategic Under-reporting of Bank Risk”, Unpublished working paper, University of Michigan and London Business School.

institutions *after* the adoption of systemic risk regulations to ensure that the regulations are not playing a catchup game with the buildup of risk in the economy.