Modeling and Measuring Systemic Risk*

Markus Brunnermeier, Lars Peter Hansen, Anil Kashyap,
Arvind Krishnamurthy, Andrew W. Lo

October 15, 2010

Abstract

An important challenge worthy of NSF support is to quantify systemic financial risk. There are at least three major components to this challenge: modeling, measurement, and data accessibility. Progress on this challenge will require extending existing research in many directions and will require collaboration between economists, statisticians, decision theorists, sociologists, psychologists, and neuroscientists.

Proposal

An important challenge worthy of NSF support is to quantify systemic financial risk.

The recent financial crisis has focused widespread attention on systemic risk in the global financial system. It is neither feasible nor desirable to eliminate all aggregate risk. Investment in risky ventures can be socially productive even when this risk cannot be diversified away. Calls for regulation based on concerns of systemic risk are premised on concerns that the potential excess risk-taking within the financial system will lead to government bailouts when losses mount. Designing appropriate policy interventions that do not create perverse incentives for the private sector is important. However, any meaningful discussion and implementation of such policy requires better measurements and better models of the interaction of the role of financial markets in the macroeconomy that motivate or justify these measures. Key questions include: What components of aggregate risk exposure of the private sector are problematic for a society? How might we measure these in meaningful ways, and what data can be used to support these measurements? What guidance do models provide on the best way for regulators and private agents to manage systemic risk?

Prior to the crisis, financial regulation around the world largely consisted of a patchwork arrangement with a bevy of regulators overseeing various institutions and markets in isolation. No single regulator was responsible for looking across the global financial system and identifying vulnerabilities that might be building up from the complex interactions of actors throughout the economy. As Federal Reserve Chairman Ben Bernanke put it, “We must have a strategy that regulates the financial system as a whole, in a holistic way, not just its individual components."[1]

The global regulatory response to the crisis has followed Bernanke's dictum, creating various agencies and committees that are charged with monitoring and controlling these risks. In the United States, a substantial portion of the Dodd-Frank Wall Street Reform and Consumer Protection Act details how systemic risk should be regulated. But fulfilling this object will be extremely challenging. Currently, we lack not only an operational definition of systemic risk, but also the data needed to measure it. Without the potential for measurement, the term "systemic risk" is mere jargon that could support the continued use of discretionary regulatory policy applied to financial institutions and lead to ad-hoc policies that are inconsistent and fraught with unintended consequences. The transparency and rationality of regulatory policy would be greatly enhanced by the thoughtful modeling and reliable measurement of systemic risk. Policy concerns along these fronts have been articulated by many, including by Former Fed Chairman Paul Volcker in a September 24th speech at the Federal Reserve Bank of Chicago. Unless we are able to measure systemic risk objectively, quantitatively, and regularly, it is impossible to determine the appropriate trade-off between such risk and its rewards and, from a policy perspective and social welfare objective, how best to contain it. This is the current grand challenge that faces us today.

In the last decade there has been a substantial literature that explores dynamic stochastic equilibrium models estimated by formal econometric methods. These models have gained considerable prominence in research departments of central banks and have improved our understanding of price stability. In contrast, there is a much smaller literature on equilibrium models that include a role for financial market frictions and can speak meaningfully to financial stability. There is a sharp contrast between our understanding of price stability and our understanding of financial stability and systemic risk, where the gaps in our knowledge are much more pronounced.

There are at least three major components to the challenge of monitoring these risks: modeling, measurement, and data accessibility. Meaningful measurement requires a clear definition of systemic risk and thoughtful modeling of this construct. But modeling in this area is still primitive. We argue that systemic risk is a major social problem because of the potential for significant spillover from the financial sector to the real economy, yet existing models that identify externalities in the financial system with macroeconomic consequences are highly stylized and fall short of generating formal guidance for statistical measurement.

---

[1] See Ben S. Bernanke, "Financial Reform to Address Systemic Risk" at the Council on Foreign Relations, Washington, D.C., March 10, 2009

Thanks to basic macroeconomics models from decades past which motivated national income accounting measures, we can quantify the state of the economy in many ways. For instance, we know GDP growth (1.7% for 2010Q2), how non-farm payrolls have changed (–95,000 in September 2010), the level unemployment (9.6% as of September 2010), the number of housing starts (598,000 in August 2010), and the rate of inflation in consumer prices (0.3% relative to the previous month in August 2010). We can measure the current risk of the U.S. stock market through the implied volatility of the S&P 500 index (19.88% as of October 14, 2010). And we can measure the relative value of the U.S. dollar compared with other currencies (76.666 as of October 14, 2010).

What is the current level of systemic risk in the global financial system? We cannot manage what we do not measure.

Some research does exist that builds on measures of risk exposures of stochastic cash flows in asset pricing models, characterizing risk and return relations using statistical methods. This research has a long history, including discussions of volatility fluctuations and tail risk, but is not tailored to the regulatory challenges going forward. The required models for measuring systemic risk will need to have quantitative ambitions of sufficient scope to confront real externalities that are induced by financial market behavior. To support this new research agenda, additional data must be collected, and the newly created Office of Financial Research offers one promising avenue to meet this challenge. Also, the Census Department currently supports empirical investigations with confidential data, and it may be necessary to draw on their experience.

Given the complexity of the financial system, it is unlikely that a single measure of systemic risk will suffice. We anticipate that the variety of inputs ranging from leverage and liquidity to codependence, concentration, and connectedness will all be revealing. Moving beyond stand-alone inputs to a joint study will be difficult but is necessary if this task is to be achieved. The increased complexity and connectedness of financial markets is a relatively new phenomenon that requires a fundamental shift in our linear mode of thinking with respect to risk measurement. Small perturbations in one part of the financial system can now have surprisingly large effects on other, seemingly unrelated, parts of that system. These effects have been popularized as so-called "Black Swan" events—outliers that are impossible to predict—but they have more prosaic origins: they are the result of new connections between sectors and events that did not exist a decade ago, thanks to financial innovation and technological progress. A more integrated approach to studying these challenges will lead to enhanced understanding of their economic interactions and statistical relationships. This will push modeling in new directions and reveal new challenges for measurement.

Existing research from a variety of areas may be useful catalysts for this new research agenda, but they require significant modification, extension, and integration. For instance, one intriguing approach to modeling the interaction of financial firms is to view the financial industry as a network. Network models have been used in a variety of scientific disciplines, including economics and other social sciences. When applied to financial markets, they capture direct spillover effects such as counterparty credit risk. The study of systemic risk requires also the study of indirect spillovers that occur through prices that clear markets because in a crisis situation, these indirect effects might be even more potent. Nevertheless, a network structure, with the appropriate enrichments, promises to provide one way of understanding better the systemic consequences of the failure of key components to a financial network. To push this approach in quantitative directions will require building on prior research from other fields that features quantitative modeling and empirical calibration.

How individuals, firms and other entities respond to uncertainty in complex environments remains a challenge in economics and other social sciences. Concerns about ambiguity and, more generally, the challenge of learning and assigning probabilities in complex environments motivates the study of alternatives to the simple risk aversion model that has been a workhorse in economics. There are a variety of advances in decision theory, probability theory, and the cognitive neurosciences that give some guidance for how people do and should confront uncertainty. There is scope for productive exchange with closely related literatures from sociology, psychology, and neuroscience. Converting these various insights into operational quantitative models are only in the early stages of development, but they offer promise in helping us understand better the challenges of measuring systemic uncertainty.

Research on mechanism design and incentives in the presence of private information has been a demonstratively successful research program. This program, however, has been more qualitative than quantitative in nature. In the crisis, policy-makers have had to fall back on qualitative models of systemic failure, such as the well-known Diamond-Dybvig model of bank runs. While these models have provided useful insights, policy could have been better calibrated if regulators could have relied on more sophisticated representations of the financial system. Going forward, insights from corporate finance and asset pricing, including research on asset prices that confront financial market frictions, the nature and dynamics of liquidity, and corporate governance structures related to risk management are critical to building rational and practical models of systemic risk. Mechanical models of market frictions run the danger of failing to provide reliable guides to behavior in response to changes in the underlying governmental regulations of financial firms

As mentioned previously, there is an extensive literature on measuring risk-return relations using statistical methods. Along some dimensions, this literature is now quite advanced. It features time variation in volatilities, typically measured using high frequency data. There are interesting extensions that confront tail risk using so-called Levy processes as alternatives to the mixture of normal models that has been analyzed extensively. This line of inquiry may provide some valuable inputs going forward, but the systemic risk research challenge will require that this statistical literature be pushed in new directions, away from the problem of characterizing risk-return patterns and providing inputs into pricing formulas for derivative claims, towards identifying and characterizing the systemically important components of existing financial enterprises. New measures of risk or uncertainty will need to confront and quantify spillover effects that should be the target of regulation. High-frequency risk measures that are now commonly employed in the private sector and in academic research will have to be supplemented by low-frequency quantity information that measures the magnitude of imbalances that can trigger so called “systemic events”.

Finally, systemic risk presents at attractive and intellectually stimulating area of inquiry that will attract young researchers. In summary, this is an exciting research challenge that can build upon a variety of previously disparate literatures to provide valuable insights, with major challenges going forward that involve collaboration among several disciplines in the SBE Directorate and beyond.