



Conference Summary: Measuring Systemic Risk

Dec. 15 and 16, 2010

I. Overview: Defining the Need

Conference organizers and hosts set the agenda for discussion with remarks that outlined the need for useful definitions and measures of systemic risk. These risks are not new; there is a long history of bank runs and financial crises dating back to Roman times. Some—but not all—failures in financial institutions result in negative externalities that ripple through the financial system and the economy as a whole. An accurate evaluation of these risks is important for several reasons:

- We cannot manage what we cannot measure. Lord Kelvin’s dictum applies: “...when you can measure something, ... express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of the meager and unsatisfactory kind.”
- Risks that are viewed as systemic spawn public policy intended to manage them. Different models and characterizations of systemic risk lead to differing, possibly contradictory policy responses that may have unintended consequences.
- The demand is immediate: the Office of Financial Research (OFR), established by the Dodd-Frank Act (DFA), is not yet fully established administratively but is already formulating policy and is facing deadlines to supply data required to implement DFA. OFR is designed to include the academic community, and seeks input on creative and effective ways to use available data to make these immediate decisions.

The systemic risk research agenda should seek quantification that supports informed discussion of system-wide risks to the economy at large. This entails fueling analysis with rich new data sets and evidence. Attempts at measurement must avoid:

- Approaches without a solid theoretical backing. See Koopmans’ critique of Burns and Mitchell’s attempts to measure business cycles.
- Vague characterizations of systemic risk, which allow greater regulatory discretion. As Volcker noted, when policy is left to the judgment of individual regulators, they will be relentlessly lobbied, leading to the politicization of policy.
- Absence of replication. Data confidentiality could inhibit confirmation of measurements

- Preordained support, even if inadvertent, of a policy or position, such as “too big to fail”.
- Overemphasis on quick answers. Fast action is needed, but correct identification of systemic disturbances is essential to guide effective policy responses.

Characterizing Systemic Risk

Before we can measure systemic risk, we need to define or characterize it. Large price movements themselves do not constitute systemic risk. For example, on April 14, 2000, the U.S. stock market fell by 6.5 %, representing a loss of \$1.04 trillion. This was not systemic; few people even remember this event. Systemic risk is not about losses alone; it is about how we respond collectively to losses. As with crises and disasters in other industries, shocks in the financial sector cause pain, which generates reactions aimed at avoiding further pain. This conference aims to face the discomfort resulting from the financial crisis, so that we learn the correct lessons and respond most effectively.

General properties that are usually associated with systemic risk include:

- Negative externalities. Financial economists have long believed that the failure of certain large, interconnected financial institutions could have spillover effects on the financial system as a whole. Since the costs of failure do not fall exclusively on the failing institution, there is an incentive for firms to take excessive risk and to invest less in risk management than is socially optimal.
- Breakdown of key parts of the financial system (e.g., the collapse of the asset-backed commercial paper market in 2008–2009).
- Large multiplier on shocks. In the 2008 crisis, why did a \$2 trillion subprime loss generate a \$20 trillion hit to the household balance sheet?
- Shared belief in an erroneous risk measurement, and herd behavior following such beliefs (e.g., housing prices will only go up).
- Asset price bubbles. Such bubbles are not well defined and extremely hard to detect in real time. Important facets to consider include:
 - Is there a fundamental technological change that justifies the increase in asset price?
 - Is the boom in the asset market primarily financed by debt?

If the answers are “no” and “yes”, it is more likely that a bubble is present.

Definitions of Systemic Risk

Various definitions of systemic risk (not mutually exclusive) were put forward throughout the conference:

- The risk of disruption to a financial entity (typically involving large losses in the financial sector) with spillovers to the real economy. If the entity's role is easily replaced, it is less systemic.
- Risk of a crisis that stresses key intermediation markets and leads to their breakdown, which impacts the broader economy and requires government intervention.
- Imbalances that build up during an asset price bubble, materializing in a crisis; this involves huge contagion and spillovers, both direct (contractual linkages and direct flows between institutions) and indirect (runs, fire sales, liquidity spirals, credit crunches). Indirect spillovers tend to be more important than direct spillovers.
- Adverse general equilibrium amplification and persistence.
- The network perspective: Risk that critical nodes of a financial network cease to function as designed, disrupting linkages.
- Financial contracts with externalities.

II. Network Analysis

Systemic risk is often associated with interconnectedness, although the precise way in which increased connections between financial institutions may lead to increased systemic risk is not entirely clear. An overarching theme is that systemic risk is a function of the system itself, arising endogenously from linkages between institutions. Given the importance of interconnectedness, it can be useful to seek insight into the nature and measurement of systemic risk by modeling a financial system as a network. The application of network analysis to finance goes back at least two decades and has provided a powerful tool for modeling financial problems and assessing risk.

In one network model presented, banks check the creditworthiness of one another and form connections in anticipation of trading. Banks with unacceptably high credit risk collapse (or, equivalently, they find no trading partners). Generally, it is beneficial to have more connections in a network in order to optimize opportunities, find a trading partner, and diversify risk. This model reveals:

- Individual nodes in a network can collapse both in good and bad times.
- The collapse of one bank increases the probability of the collapse of a connected bank.
- The rate at which this probability increases is a function of the proximity of the two banks within the network.

- Thus, there can be cascading collapses, and for the same network structure, these increase as the probability of shocks increases.
- With a wider network and more connections, risk is diversified and it is less likely for any node to collapse; in bad times, there are fewer nodes to connect to, so there is less diversification.
- However, fewer connections could restrict a cascading collapse to only a cluster of nodes, limiting the propagation of financial distress. This is true with idiosyncratic shocks, but if the collapse is systemic, there is less protection.

Network theory contributes useful concepts drawn from other disciplines such as public health, ecology, or sociology to help assess risk. For instance, epidemiological models for the spread of disease can inform how we might model financial contagion. Similarly, the “tipping point” theory of how an idea can spread among connected individuals can contribute to our understanding of risks in the financial system. In the tipping point model,

- A network has k nodes; an individual within that network has $k-1$ individuals they might talk with.
- A person who hears an idea spreads it with independent probability r to each of his friends. The expected number who hear it is $r(k-1)$. A well-connected person can spread an idea to many others.
- R = average number of people to whom a given individual spreads the idea, expressed as a function of (r, k) .
- If $R < 1$, the idea dies out; if $R > 1$, the idea takes off exponentially.

The tipping point example shows how complex and dynamic networks, through contagion and nonlinearities, can generate huge impacts from small shocks. Also, similar shocks can have different impacts in different networks.

Network analysis of financial systems has also drawn from the theory of physical networks such as rail and airline routes and hubs. Financial networks are much more difficult to model because they are so dynamic, involving multiple decision-makers that are all interacting, collaborating, and competing. A simple example is an economy of multiple Markowitz portfolio optimizers with market clearing. Introduction of intermediaries further complicates the network. For instance, analyzing balance sheets as networks must take into account not just the sources and uses of funds but also the behavior of intermediaries and the strength of those relationships.

We are living in a world of fragile networks, whether in transportation, infrastructure, or finance, but we can track players, costs, distress, and risk to identify the most important nodes and links

in networks. We can also use network analysis not only to analyze these vulnerabilities, but also to quantify strengths and synergies. For example, this analysis can show when mergers might succeed or fail.

Financial networks evolve endogenously, and we need to model how they evolve through time. For example, the introduction of credit default swap (CDS) markets shifts credit exposures within financial networks. Does this evolve towards more or less stability?

A recent study of asset commonality, debt maturity, and systemic risk found that clustered financial institutions tend to hold the same portfolios. In unclustered networks, banks hold the assets of two adjacent banks, but none of the banks in this network have identical portfolios, which reduces systemic risk. Hence the network structure is important. Other new work in this area attempts to:

- Study the degree of interconnectedness between financial institutions.
- Develop econometric measures of systemic risk to capture linkages and vulnerabilities of the entire financial system.
- Identify systemically important institutions.
- Capture the build-up of systemic risk prior to a crisis.

These efforts construct systemic risk measures based on increasing commonality among banks. Linear and nonlinear Granger causality tests are also used to analyze linkages between banks, insurers, hedge funds, and broker/dealers. Using Granger causality networks to graph interconnections shows that the density of financial networks increased steadily up until the Long Term Capital Management collapse in 1998. Subsequently, nodes collapsed, the networks thinned out, and then grew to high density again by 2007–2008.

This research has identified some early warning signs of systemic risk based on the number and type of connections in the network and the closeness of those connections. These risk measures can be used to predict actual losses. Another area of research explores causal relationships between networked financial institutions. Reinforcing feedback loops between nodes generate growth and decline, while balancing feedback loops generate stability.

Studying these dynamics has shown that delays and lags in responses matter. An example is the margin spiral outlined by Brunnermeier and Pedersen. They found that margin spirals are reinforcing, because more illiquidity generates bigger haircuts, which in turn generates additional illiquidity. Loss spirals are also reinforcing: as prices drop, collateral is devalued, and firms must shrink balance sheet by selling assets, pushing prices even lower.

The critical question is whether the overall system is reinforcing or balancing. Where are the tipping points that move the system from overall balancing to overall reinforcing? As systems tip from stability to instability, networks evolve, perhaps due to individual decisions. For instance, was Lehman Brothers a critical node? When did Lehman become a critical node?

Network theory has been applied in practice to analyze financial systems for central banks. Proprietary software tools have been developed for this use, and an open-source tool will be available for use by the end of the year. Financial networks cannot be observed as easily as physical networks; their structure must be derived from analyzing aggregate transaction data. A financial network produces an overwhelming amount of data, in inconsistent formats. We need to standardize transaction data and develop tools to automatically process and validate it. Also, we need to decide what constitutes a link or node by asking:

- Are nodes economic units? Legal units? Branches? Groups? (e.g., DeutscheBank has different names and entities all over Europe.)
- What comprises a link in the network? Liquidity flows? Infrastructure connections? Indirect linkages? (e.g., How are overnight loans identified and matched up across institutions?)
- Should the structure of the network be inferred from direct connections (contractual obligations, cash flows), or should it incorporate indirect connections (e.g., if Bank X fails, it may be more likely that there is a run on Bank Y, even though Bank X and Bank Y have no direct linkages)?

The network view suggests some public policy implications. It is important to:

- Collect data on interconnected banks (and other institutions that have similar functions) and identify the network structure.
- Assess the risk to a bank from more distant neighbors in the network.
- Identify central nodes whose collapse can significantly impact the network. Trade network theory offers ways of measuring the importance of specific nodes based on features other than size.
- Develop the ability to measure the fragility of nodes and to rank nodes by fragility.
- Develop useful measurements. Macroprudential oversight is being put into place right now; in the U.K., a Financial Policy Committee has been established. Regulators need to examine aggregate and cyclical risks as well as network risk in order to determine how to handle systemically important institutions. Accurately measuring systemic risk is essential to these tasks.

- Apply our growing understanding of network dynamics to intentionally design robust networks.

Discussion

Q: What is the role of central counterparties (CCPs) in financial network risk?

- Generally, CCPs make networks safer. They create one key node, so essentially the network model will be more concentrated.
- Basel III addressed the risk of CCP.
- There are different methodologies for how CCPs can be organized, and network analysis can offer insights about how best to structure them.

Q: Network models have been useful in showing us structure, but it's critical to understand more about how endogenous lines of communications are formed and what happens when one node in the network fails. How do we evaluate communications, reliability, and credibility in the network? How do we think about standardizing this endogeneity?

- There is no doubt that networks, and the precise nature of the connections, are highly endogenous, so simply mapping the network is unlikely to yield sufficient statistics for managing systemic risk. Ultimately, we need to understand the economic nature of the links between nodes to fully capture the equilibrium implications of the network. A first step toward that ambitious goal is to construct static snapshots of the network over time so we can begin collecting data that will ultimately be required to estimate more fully articulated dynamic equilibrium models of the system. For example, bilateral creditor/obligor relationships are very sensitive to counterparty creditworthiness and general market conditions—both of which can change abruptly and in response to the actions of either counterparty—and are therefore rife with endogeneities. But even if we cannot fully model those endogeneities, it is still a valuable exercise to collect data on the network topology so as to understand the potential changes through which endogenous aftershocks are likely to be transmitted.

Q. Rather than focusing on what happens to networks when a systemic disaster occurs, shouldn't we be thinking further ahead about how to structure optimal networks and prevent crisis?

- Yes, looking forward is critical; key nodes should be identified in advance, just as we prevent the spread of disease by vaccinating key individuals first.
- When something goes wrong, that is when the network becomes important.
- There are three means of improving our assessment of network risk:

1. Correlation analysis; this approach is straightforward.
 2. Ask firms directly for relationships, risks, and liabilities; this may not produce reliable data, but it has the benefit of forcing institutions to collect data and do the risk analysis they should be doing for their own benefit.
 3. Identify the counterparties; this is labor-intensive and carries the danger of doing a partial analysis.
- One way to get a handle on the dynamic nature of networks is to look at existing networks under different conditions, shocks, and delays, which will tell us something about optimal structure.
- Q.** If we had network maps of the financial system in 2008 prior to Lehman's collapse, would anything have changed? Would the Fed have taken a different course?
- Perhaps a network map would have revealed the scale of AIG's centrality earlier on. (Some maintained that as early as 2005, network analysis showed that AIG was important. Its interconnectedness was apparent.) According to some, a social network analysis of the roles played by belief systems and trust issues would have been particularly useful. Others felt that an analysis of beliefs would have been less valuable, since risk is cyclical and all players respond to cyclical factors in similar ways to achieve similar goals.
 - There would have been more clarity about spillovers from the Lehman bankruptcy.
 - Deutsche Bank built a network model on the fly in the face of the crisis. Doing so was difficult, but it apparently helped Deutsche Bank optimize its response to the crisis.
- Q.** If networks reveal time-varying externalities that leave the public covering losses, should we tax interconnectedness?
- Q.** Does network analysis pose a danger in that it may push us away from looking at prices? Example: Money market funds are subject to runs because they are priced incorrectly. That risk may not be revealed by examining interconnectedness.

III. The Shadow Banking System

The function of a banking system is to transform long-term, risky, illiquid assets into short-term, safe, liquid liabilities. As long as there is demand for such short-term liquid liabilities, the financial system will operate a banking system. If the traditional banking system fails to meet this demand at a low cost, or if the regulatory burden on the traditional banking system is too high, a shadow banking system will emerge.

The traditional banking system is highly regulated. The shadow banking system seeks to achieve similar functions without this regulatory burden. It will mutate and evolve to respond to developments, but it will not go away. This mutation process itself is a source of risk. The growth of the shadow banking system is a signal that bank regulations are not working, because shadow banking evolves to end-run such regulations.

- A critique: It is misleading to say that the shadow banking system “transforms” risky long-term securities into low-risk short-term liabilities. The risk does not go away. Risk is transferred, not transformed.
- The shadow banking system is characterized by the relatively unregulated use of short-term debt to finance long-term assets. A financial crisis is always a crisis of short-term debt. The government could try to clamp down on short-term debt, but new money market mutual fund (MMMF) rules would just increase demand for it. Anyone funding long-term assets with short-term debt is contributing to systemic risk by effectively holding a put option. Several responses were offered to this point:
 - There is demand for short-term debt and incentive to transform risky assets into short-term, lower-risk form; the market will satisfy this demand, rightly or wrongly.
 - The shadow banking system allows a security to be held at lower capital costs, with an implicit government backstop. The government should impose stronger capital requirements.
 - Many structured investment vehicles were credit-enhanced by sponsoring banks. What would these banks’ capital positions have looked like if they had to recognize this credit enhancement?

The Crisis in the Shadow Banking System

The collapse of the shadow banking system in the recent crisis occurred in slow motion.

- Fall 2007: First, the asset-backed commercial paper (ABCP) market collapsed. ABCP was a major source of funding for the shadow banking system. The repo market took up the slack. Overnight spreads hit 100 basis points, which was clear evidence of liquidity problems.
- Pre-Bear Sterns: Primary dealers borrowed overnight and lent term, holding mortgage-backed security (MBS) assets that the shadow banking system was having trouble with.
- Post-Bear, pre-Lehman Bros. collapse: The repo market was fragile; the Fed stepped in to backstop the shadow banking system with the Primary Dealer Credit Facility and the Term Auction Facility.

- Post-Lehman: The crisis and response were internationalized, as the Fed lent to the Eurozone via swap lines.

Regulatory Response Implications

- Regulations put into place quickly after the ABCP decline should significantly limit capital arbitrage; however, there are already attempts to work around those rules and it will be interesting to observe regulators' response.
- Efforts are in motion to make the tri-party repo market more stable and to devise alternatives to the daily unwinding of positions.
- The future of government-sponsored enterprises (GSEs), including the Federal Home Loan Banks, is uncertain. GSEs will require more capital, which leads to significantly smaller balance sheets, higher costs of credit, and more volatility.
- Term ABSs grew quickly since 2000. Going forward, new rules will limit leverage and better align incentives between originators and investors. We will see more competition among rating agencies and more information provided to the public. However, this may not prevent serious risk management errors like those that occurred in the 1990s.
- The regulatory tool we needed but lacked was a risk retention requirement. Investors were able to make deals for instruments that looked like riskless debt without putting any money into the deals.

Policy Considerations for the Future

The Fed must be concerned with capital market liquidity. It is not just the “lender of last resort”, but also the “dealer of last resort.” Also, the critical role of ratings agencies must be better addressed. The Dodd-Frank Act removes any official reference to ratings in federal capital requirements, but this will not be effective. Markets are eager for a simple, credible measure of risk. Several other issues for the future were mentioned:

- MMMFs must be incentivized to take seriously their credit risk. (The non-2a7 universe could be a new source of systemic risk.)
- The shadow banking system will not change quickly. Top-down solutions are unlikely to work because markets evolve organically. The best we can manage is to take small steps to move towards a more stable equilibrium.
- Safe harbors in bankruptcy offer great stopgap measures. They must be implemented as adaptive systems that do not have cliffs in eligibility.

- Securitization was a failure of risk management, particularly in the mortgage market. The wrong tools were used; CDOs were applied to risk management problems in cases where they were not suited to the task. A better approach might be to use hedging as an alternative risk mitigator to achieve diversification. Unfortunately, markets are incomplete, and lack the needed hedging tools. Can the public sector provide suitable tools? For example, perhaps the government could complete markets with “HIPS”, a version of TIPS offering protection from inflation in housing prices.
- There would be value in moving hedging from the OTC market to exchange-traded cleared instruments. The hedge accounting requirements in FAS 133 offer an incentive to create complex derivatives tailored to meet needs. Relaxing this rule could encourage use of instruments already traded on exchanges. However, exchange-traded derivatives generate huge cash exposure.
- The goal should be the most parsimonious tinkering of the rules we can get by with. Enforcing existing rules and modernizing them would go a long way in preventing the concentration risk that contributed to crisis.

Discussion:

Q. After 20 years of macro-stability, it’s not surprising that a flexible shadow banking system developed. The question is, do we want to extend a safety net and all the accompanying regulation to this system?

- Safety nets can be problematic and must be implemented with care. Establishing backstops that persist creates unintended consequences and rent-seeking behavior.
- A common view is that we need to stop signaling bailouts, so firms will not depend on that possibility. In fact, despite signals that Lehman would be allowed to fail, the consequences were so alarming that now there is a 100% probability that any other firm or institution will be rescued.
- An opposing view argued that given the political reaction to the federal responses in 2008, there is no chance of another Troubled Asset Relief Program. Regulators have very little flexibility.
- A key question is, what is the appropriate scope of institutions? Safety nets like the FDIC and the discount window exist because bank runs and failures are expensive. Instead of widening safety nets, we need to understand exactly which activities are occurring within institutions (e.g., why are aircraft leases done by financial institutions?).

IV. Sovereign Risk

The discussion of sovereign risk and its relationship to systemic risk measurement began with a number of questions for consideration:

- What's next with the Euro? Restructuring of Euro-denominated debt? Euro inflation?
- What's next for the U.S. and its state and local fiscal problems?
- When a country gets bailed out, who gets the money? Why do they need a bailout?
 - How does the origin of the problem differ for different countries/institutions? Greece borrowed and spent; Ireland guaranteed debt of banks that borrowed from Europeans (not primarily Irish) to invest in the U.S. Spain's problems stemmed from contingent liabilities, bailing out banks that lent domestically, and credit guarantees.
- What actually happens when a sovereign defaults? What can be seized? What is the cost of a default to the sovereign?
- Is sovereign debt systemic? If so, why? Vague references to contagion are not helpful.
- Banks assigned nearly zero capital to sovereign debt assets. Why treat sovereign debt as quasi-risk free?
- Why do people think sovereign defaults would lead to a catastrophic decline in the Euro? Is this true or would it make the Euro stronger?
- Deeper economic questions:
 - Why is so much sovereign debt short-term? Expectations about a decline in bond prices 10 years from now are creating a crisis today because so much debt is short-term.
 - Is the Eurozone a monetary union or a fiscal union? If a fiscal union, uniform bank regulations/capital requirements must be applied across the member countries.
- In the recession, we saw a flight to quality to U.S. debt. What is so special about U.S. debt?
- Should sovereigns issue something like "government equity" or "government state-conditional debt," with a payout that declines when the government faces a fiscal crisis?

The Sovereign Debt Picture

The financial crisis that began in 2007 coincided with increased sovereign debt across all advanced economies. By 2010, U.S. government debt was 1.5 times higher than in 2007, and Japan led all other countries in gross debt. These growing fiscal imbalances led to contagion in other vulnerable countries. In government bond markets, there was little difference in spreads across countries before 2010. Now there is huge differentiation. Government sector CoVaR is now rising, suggesting that sovereign risk is becoming a bigger potential source of systemic risk. Within the EU, peer monitoring failed to respond to growing imbalances in many countries for a variety of reasons. The strong role of misreported data in Greece, which arguably triggered a more general sovereign crisis in the EU, demonstrates the importance of accurate statistics.

A model for assessing fiscal sustainability was presented that considered the following:

- Fiscal factors:
 - Level of debt, including fiscal limits. Research by Trabandt and Uhlig suggested that there is some level of debt beyond which problems occur, but that level seems to be country-specific. Reinhart and Rogoff suggest a fiscal limit of around 90% debt/GDP. Other research shows that the management of public debt, including size, structure (maturity), composition (holders), and liquidity, is very important.
 - Fiscal flows, including granular analysis of government spending and revenue. Long-term net liabilities such as pensions and social security must be measured. Political risk and institutional quality are important factors.
- The macro-financial environment, including GDP and its composition, competitiveness, external position, and financial conditions such as interest rates.
- Stock-flow adjustments: contingent liabilities in the financial and nonfinancial private sector.

Interaction Between Financial and Sovereign Risk

A key question to consider is, “What is the perimeter of the public sector?” When financial crises weaken private institutions, it is understood that, de jure or de facto, the government will step in. Thus, the government in effect has a contingent liability for this private debt. We need to compute the magnitude of this liability.

- There is information to compute this liability in accounting data, market equity data, and market debt data (including CDS spreads). We should use all three.

- An approach called Systemic Contingent Claims Analysis calculates the multivariate density of banking system expected losses and government contingent liabilities:
 - Overall European contingent liability (95% tail risk) peaked after Bear Stearns at around \$3 trillion.
 - Using Systemic CCA on European economies reveals losses as a percentage of GDP estimated at 25% for Ireland, 6% for Greece, and 23% for Portugal.

Measuring systemic sovereign risk involves comparing the risk of two countries defaulting in a given time period. Factors that increase the joint default risk are systemic risks. We cannot observe these probabilities, but markets give us prices of these probabilities. There are three possible sources of these correlations:

- Countries have joint default risk because of correlated fundamentals.
- Countries have linkages on the asset side (e.g., German banks owning Spanish assets).
- “Plumbing” problems, related to market shocks.

Recent research examined correlations of CDS spreads across 26 developed and emerging markets, and found them very high (73% in 2007–2010). These were much higher than stock market correlations. This suggests that the correlations are not driven by correlated fundamentals. The most important factor driving these correlations is the linkage to U.S. markets. Sovereign CDS spreads are more highly correlated with the U.S. market than with the nation’s own stock market. This is evidence of the “plumbing” problems.

Interestingly, U.S. sovereign CDS spreads are also strongly related to U.S. financial markets, but less so than other sovereign nations. When we look at the U.S. as a currency union, the average correlation of CDS spreads across states is 66%, less than across global sovereigns. Comparing manufacturing states in the U.S. to Japan and emerging markets shows a negative relationship, suggesting that this seems to be driven by trade flows. There is no evidence of contagion from the state to federal level.

European Bailouts

The Greek default problem came as a surprise and led to bank bailouts in Europe. This induced a huge moral hazard problem. Why did the European authorities provide bailouts? Greece is not systemically important, comprising only 4% of Eurozone debt. Why would the failure of Greek sovereign debt lead to a European bank meltdown? Fear of contagion is sometimes put forth as a motive. Why is this?

- If Germany does not bail out Greece, perhaps this signals that they will not bail out important countries like Spain and Italy. Germany cannot bail out all of Europe; any notion that it could is ludicrous and would lead to taxpayer revolt.
- An argument can be made that European sovereign debt is particularly important because it is used as collateral for repos. If these sovereigns reach junk status, they would become invalid as repo collateral. The opposite seems to be happening, as the ECB is being generous with the poor quality of collateral it is accepting from southern European nations.
- The sovereign bailout may be a smokescreen to bail out the banks. If so, is it better to bail out banks directly and avoid the sovereign moral hazard?
- Another explanation is political: Bailouts are rooted in fears of European disintegration.

Discussion

- Does the unified currency in Europe exacerbate systemic risk, since the affected country cannot devalue? This eliminates one policy lever, but other levers—tax policy, structural policies, and regulatory policy—remain.
- There are different and difficult issues of transparency when measuring debt problems. Issues in Greece seemed to appear overnight, yet were no real surprise. The assumption was that there was a problem; the question was when the actual size of the problem would be revealed. In Ireland, the total amount of bank loans was about three to four times the Irish GDP, which was an obvious problem. By contrast, it is harder to measure the fiscal status of American states. New York State has not issued general obligation bonds in seven years and therefore has not been rated. Its debt is backed with revenue-producing assets, which are difficult to analyze. A further complication is that much of the U.S.'s state obligations are in pension liabilities, which are difficult to quantify.
- Irish banks borrowed from Germans and invested in the U.S., basically functioning as offshore banks for European investors, much like banks registered for convenience in the Cayman Islands. Why were they rescued by the Irish government? Would such Cayman Islands banks expect the government there to bail them out in the event of trouble?
- If a large nation defaults, the reputational damage to subsequent defaulters is greatly diminished.

V. The Housing Sector

The rapid increase in housing prices in the first half of the decade was a large positive shock to household wealth, which suggests a correlated adjustment in the economy. If the relative price of housing decreases, the impact via the wealth effect is unclear. Because housing is financed via mortgages, the bigger impact of the decline is through the financing vehicle.

Household debt also rose dramatically in advance of the financial crisis. This sort of increased indebtedness makes people better off in the short run, but could be problematic when shocks cause constraints to bind. Likewise, there was a dramatic rise in mortgage securitization (largely government-induced). This increased diversification—a positive result—and introduced additional renegotiation frictions. In addition, declining interest rates led to rapid refinancing, which in turn reduced household equity.

Another important issue is the impact of government regulation and government housing programs: Do these distort consumer and investor behavior for political goals? There is considerable debate over the impact of implicit government guarantees on the pricing of default and collateral risk.

Measuring Housing Sector Risk

Conventional wisdom holds that it was hard to assess the risk of mortgage-backed securities because modeling household behavior is difficult, the securities were too complex, and issuers hid relevant data. In reality, housing-related instruments are not too complex to understand. Just as the tax code is complicated but taxes can be readily calculated with software like TurboTax, modeling mortgage risk is relatively straightforward and excellent data is available. Investors could figure out what they were buying.

Before the crisis, Lehman Brothers published a study¹ on the impact of different house price appreciation (HPA) scenarios. The numbers for a disaster scenario of 5% depreciation per year for three years implied a 17% loss to mortgage holders, with roughly a third of home loans defaulting. These numbers were remarkably prescient. Actual annualized HPA was -10% per year from the fourth quarter of 2005 through the fourth quarter of 2008. That produced a 12.32% loss-to-date, with forecast losses of 21% to 24%. Although Lehman's loss projections were on the correct order of magnitude, their probability of a housing price meltdown occurring was only 5%—far too low. Projections clearly showed that if prices went down, all BBB-rated securities would be wiped out. The famed ABACUS deal was made up almost entirely of BBB tranches, yet investors bought such securities because they thought prices would continue to rise.

The difficulty, then, is forecasting sustainable HPA. In 2001-2002, housing prices seemed above fundamentals and pessimists forecasted flat or negative HPA. For three subsequent years these

¹ "HEL Bond Profile Across HPA scenarios"

pessimists were proved wrong and their credibility was destroyed. Economic theory does not give us a method to quantify a sustainability threshold of HPA. Suggested indicators like the housing price to rent ratio or unusually low interest rates would not have accurately predicted the path of HPA in the early part of this decade.

We understood the mortgage risk; what we did not understand was the financial institutions. Despite concerns over the “originate to distribute” model, it turned out that players were not using one; they were originating and holding rather than distributing the risk.

Household Leverage

Household debt-to-income (D/Y) has been rising since 1950, but increased more dramatically starting in 2001. From 2001 to 2006, the increase in D/Y exceeded that of the previous 40 years. The household debt-to-asset ratio also shot up to historical highs, reaching about 65%—a shocking level. Some macroeconomic consequences of these debt levels are revealed by Amir Sufi’s study of county-level data, sorted by the change in D/Y (denoted “ $\Delta(D/Y)$ ”) between 2002 and 2006. The top decile $\Delta(D/Y)$ counties were in California and Florida—areas where real estate demand is strong and supply is inelastic. The smallest debt increases were in Tennessee, Kentucky, and some areas in Illinois. The results show:

- Mortgage default rates were much higher (13–14%) in high $\Delta(D/Y)$ counties.
- High $\Delta(D/Y)$ areas saw major drops of 40–45% in house prices; declines were modest in low $\Delta(D/Y)$ counties.
- Residential investment measured by construction permit activity remained nearly level in low $\Delta(D/Y)$ counties but collapsed for high $\Delta(D/Y)$ counties, where construction has remained low since the recession officially ended.
- Durable goods purchases were impacted. There was a 40% to 60% drop in auto sales in high $\Delta(D/Y)$ areas beginning in 2006–2007 which persists to this day. In contrast, low $\Delta(D/Y)$ areas experienced only a temporary decline in durables purchases. A recovery in auto sales began in 2009 and sales now top 2005 levels.
- Employment is harder to link concretely to household debt and other factors may be in play, but again, low household debt areas saw smaller jumps in unemployment and a faster recovery than high $\Delta(D/Y)$ counties.

When talking about measuring systemic risk, it is important to look at leverage in financial markets, but it’s much easier to see what’s going on in the real economy. Why weren’t high levels of household debt seen as a huge problem? Part of the answer might be that too much attention was paid to debt represented by one- and two-year ARM mortgages, which appeared manageable, rather than the whole long-term debt burden.

Pricing Systemic Risk in Mortgages

In recent years, 90% of U.S. mortgages carried some type of government guarantees. Those guarantees are thought to have led to excessive risk-taking by government-sponsored entities in the housing market. The Dodd-Frank Act addresses this, and there are proposals calling for making the guarantees explicit in the secondary mortgage market in order to avoid “sudden stops” in the housing finance system. Some advocate explicit guarantees only for catastrophic losses. Others call for a completely private mortgage market, but even that approach could be interpreted as providing an implicit government guarantee.

There is considerable discussion of a system in which the government guarantees mortgage risk and builds the risk into the price. However, it is unclear how to price risk fairly, and people will make decisions based on the price signal.

- Some policymakers feel that it is the government’s role to manage risk. In this view, added fees should cover only the expected costs of the guarantee, and there is little recognition that the risk to the taxpayer should be priced.
- Fannie and Freddie priced guarantees using a weighted average cost of capital methodology, with debt priced as risk-free. But in practice capital is much more costly, and guarantees increase capital needs.
- One study using a standard options-based valuation approach with data from 2005 and earlier produced these empirical estimates:
 - The fair premium for a mortgage guarantee was 20 to 30 basis points, implying a lot of systematic risk. This is a “small but politically difficult” premium.
 - If the premium were set equal to the expected cost of the guarantee (no risk pricing), the premium would be ≈ 0 , since there were very few defaults in the pre-2006 data.
 - If Fannie/Freddie assets were assumed to have 10% less value, the premium jumps to 81 basis points.

Refinancing Risks

One way to look at mortgage risk is as a call option embedded in interest rates (the refinance option) and a put option in home prices (the default option). When interest rates decline, we see large waves of refinancing. Cash-out refinancing creates some additional risk by resetting the put-option strike. Cash-out refinancing totaled \$200 billion per quarter in 2001 through 2008 and accounts for most of the increase in outstanding mortgages on the books today. This leads to a ratchet effect: When housing prices increase with flat or decreasing interest rates, owners refinance and take equity out, but when prices then decline, there is no symmetric requirement

that the homeowner *put equity back in* to avoid an increase in loan-to-value (LTV) ratios. Thus, fluctuations in house prices tend to ratchet LTV up, increasing potential systemic risk.

In other words, rising home prices, falling interest rates, and easy financing synchronizes leverage across time and geography, greatly increasing systemic risk. A simulation using price and interest rate data from the past nine years showed:

- If no equity were extracted, \$4 trillion in new mortgages would have been required, and the value of the (implicit) government mortgage guarantee would have been \$280 billion.
- In actuality, \$11 trillion in new mortgages was issued, implying massive equity extraction. The resulting value of the government guarantee was \$1.5 trillion.

The problem here is that, unlike a hedge fund collateralizing a loan with its prime broker, a homeowner cannot sell a piece of a house to adjust leverage and cannot issue new equity. Possible solutions include:

- Changing mortgage structure so lenders do not bear this risk. That could include mortgages that convert to an equity position in the home when the national housing price index declines, or making all mortgages have recourse and maintain better lending standards.
- Better analytics and enforcement of capital requirements. Historically, banks did not respond to the ratchet LTV effect by increasing capital.

Discussion

Questions arose about the availability of housing asset data, with some arguing that it is hard to obtain or not available in a useful format that reveals important linkages. Some pointed out that this data is mostly found in lengthy prospectuses; to extract the data in a usable, machine-readable form or purchase it from private vendors is expensive. The OFR could potentially produce and publish these data, such as cash-flow waterfalls for each instrument. To what extent should this information be thought of as a public good? To what extent must sophisticated investors bear the cost of seeking out the data to analyze their own risk?

Some financial institutions assumed that everything they knew was available to regulators. An important question is *who* has access to data; it is important for it to be available broadly to people with different interests and agendas. A case in point is the odd eighths problem in the NASDAQ. It was not detected by regulators or industry; only analysis of the available data by researchers pursuing a specific question revealed the issue. OFR should provide the broadest access as possible.

Several policy issues and avenues for research were raised:

- In 2006, household debt equaled 44% of total nonfarm debt, as compared with government debt (23% of total). This suggests a demand side to the situation; if the world wanted dollar-denominated fixed-income securities, it came from the household sector.
- The notion has been put forth that government policies encouraging home ownership caused the crisis. However, the government has been doing this for decades, and if it caused a problem, we would have seen a housing bubble in the 1940s when the GI bill introduced no-interest loans.
- From 2000 to 2004 there were a series of government mandates towards increasing affordable housing. Can the expansion of the GSEs into low income housing (in particular, their increased portfolio positions in subprime MBSs) be convincingly associated with the subprime housing boom? Does government involvement in housing finance increase or decrease systemic risk?
- The key problem is policies that induce incorrect valuation of assets. Example: Fannie and Freddie were simply responding to policy that attempted to hide the cost of affordable housing. If the government wished to support such housing, a direct open subsidy would have been preferable.

VI. Risk Analytics

Systemic risk measures gauge covariation of an individual institution's distress with financial sector distress. Examples include:

- CoVaR = VaR of the financial system conditional on the VaR of a particular institution; this measures large losses to all stakeholders.
- Systemic Expected Shortfall (SES); this measures large losses to equity holders.
- Distressed Insurance Premium (DIP); this measures large losses to debt holders.
- Contingent Claims Analysis (CCA).

The idea is that two institutions may have the same individual risk, but one is more highly correlated with the financial system as a whole, due to direct network connections, fire sales, runs, and so forth. The risks of these two institutions have different welfare implications.

Desirable features of systemic risk measures:

- They must help understand the tails. We want to condition on negative events, so we need a long time series. Systemic risk looks at tail correlations, and is not the same as systematic risk, which is at play in normal times.
 - But is all tail risk systemic? Don't we need to identify the source of tail risk? Don't we need to model externalities? These are valid concerns that need to be addressed, but even in the short term there is high demand by the government for usable measures of systemic risk.
- Measures should link to institutional characteristics and activities associated with the theory of systemic risk, such as firm size, leverage, and maturity mismatch. Some activities such as securitization are more systemic than others.
- Implications for regulation should be countercyclical. In economic booms, measured risk is low, but we need to be concerned about measuring risk into the future. For example, in 2005 the Volatility Index was at an all-time low, but CoVaR-measured tail risks were huge.

In the future, systemic risk measurement should move toward incorporating:

- Institutional features, such as credit lines and implicit guarantees.
- Market structure and events, such as the flash crash, and the drying-up of liquidity in the tri-party repo market just before the Bear Stearns collapse.
- Additional data, such as tick data and stress tests.

For the Federal Reserve, operationalizing systemic risk measurement is a real and present daily challenge. The Dodd-Frank Act imposes specific near-term demands on regulators for risk measures. For example, the Financial Stability Oversight Council (FSOC) is tasked with designating systemically important nonbank financial institutions (SIFIs). This designation will trigger supervision. The council needs agreement on concrete tangible measures to support this designation process.

“Systemically important” means that disruption of this entity’s activity has important and measurable spillover effects on the broader economy. Another factor associated with systemic importance is that the institution has a business model or linkages that are hard to replicate quickly if it fails. The Financial Stability Board (FSB) calls for higher loss capacity for SIFIs.

Three commonly-used measures of systemic risk—CoVar, systemic expected shortfall (SES), and distress insurance premium (DIP)—are highly correlated. When these three measures are plotted for institutions using data through November 2010, they point to the same set of

institutions as systemic risks and correspond well with the SCAP 2009 “stress tests” results. However, all three measures are highly correlated with size; larger institutions look risky. (Perhaps this validates, in a crude way, the notion of “too big to fail”.) After controlling for institution size, the three measures differ substantially.

Risk topography and liquidity mismatches

Measures of systemic risk often use data from flow of funds, call reports, and SEC filings. All of these focus on cash flow, which does not reveal the risks stemming from derivatives. It is important to collect a broader set of data on risk sensitivities. One way to do this is to obtain massive data sets and get technology enterprises to apply algorithms to analyze it. However, this approach does not account for investor behavior. Instead, an alternative is to use a two-step “Risk Topography” approach that incorporates the projected behavior of thousands of experienced risk managers:

- Step 1: Each significant financial institution reports how their firm’s value and liquidity responds to orthogonalized stress factors, and how the institutions’ decisions would react to such factors. In response to a 5%, 10%, or 15% change in value, would they sell off assets? Withdraw credit?
- Step 2: The response data from step 1 will be incorporated into a general equilibrium analysis.

Risk topography reveals mutually inconsistent plans. For example, if all firms respond to a particular negative shock with fire sales of similar types of assets, who will be the buyers? How will prices have to respond to induce a class of buyers to emerge? Some questioned the ability to correctly interpret the partial equilibrium responses elicited in Step 1.

Another potentially helpful measure is the Liquidity Mismatch Index (LMI). This looks at the interaction between market liquidity (ability to sell assets easily to raise cash without major price concessions) and funding liquidity (the ability to roll over short-term debt). In a crisis, creditors raise haircuts, reducing funding liquidity as the need for margin funding increases. This induces firms to sell assets to reduce funding needs, potentially exacerbating market liquidity problems.

Practical Implementation

Within the financial industry, there is a stronger push for stress testing than for correlation risk models. Rating agencies looking at structured products like MBSs are focusing on analysis at a more micro level, with loan-level data rather than aggregate data, and they look at responses to observable macro factors rather than latent factors.

A key question for measurement is, what is the correct level to aggregate data for measurement models? The level of granularity should align with the objective of the model. Implications for default correlations between loans depend greatly on the macroeconomic environment. Different

models applied to the same assets can produce wildly different results or predict opposite behaviors. Where possible, it is useful to do analysis at the individual loan level. And because it is difficult to reach agreement upon an analytical approach and the pace of adoption is slow, it may be best to start with simple risk measurements and work toward more sophisticated methods.

The Role of Hedge Funds and Institutional Investors

Systemic risks are highly nonlinear, and require micro-data from all major participants in the market, including pension funds, insurance companies, hedge funds, and proprietary trading desks. Incomplete information can yield a false sense of security.

From the industry perspective, viewing the data as a network structure is a useful approach. However, in a crisis these networks are highly volatile, as players drop out and traders sever ties with weak partners. During the height of the crisis, there were daily phone calls to determine who was still trading with whom, and no one knows how close the system came to massive, multilateral withdrawals from trading. It was noted that if one more institution failed after Lehman, five more would have probably failed within days, because all had holdings vulnerable to runs and fire sales.

A representative of a fund-of-funds reported that it examines the position of each hedge fund at least monthly or even daily. Even so, risks are difficult to measure because exposures and portfolios change so rapidly. Keeping tabs on these institutions is a labor-intensive enterprise. And interpreting hedge fund positions can be difficult; it may be hard to tell if the holding is an outright position or part of a hedge.

Appropriate disclosure levels are a matter of debate, and more uncertain under the unknown parameters of Dodd-Frank. To protect proprietary information and prevent predatory actions, there is a practical limit to financial firms can be asked to disclose. Looser Freedom of Information Act (FOIA) limitations under Dodd-Frank are a concern.

Discussion

Potential issues with the Risk Topography approach were mentioned:

- For highly concentrated banks, there is a relationship between the regulators and the regulated that banks can manipulate strategically. In the Risk Topography approach of collecting information from risk managers, banks may have an incentive to inflate their response. Built-in cross-checks on data can contain this.

Differing views were expressed on the availability of the data required to measure risk:

- During the crisis, the SEC said that they did not have the data used by the ratings agencies. The ratings agencies said that the government was too cheap to buy the data.

In fact, the SEC did have credit rating data. What was missing was data on the exposures of entities. This is a complex analysis problem. It takes thousands of employees just to look at a large firm's transactions and positions. It was suggested that the data, once extracted, should be made available on an open source basis, perhaps by the new Office of Financial Research (OFR).

- 70% of MBSs made loan level data available, but it is very expensive to compile the data in a way that supports strong conclusions. Institutions generally will not provide data in a linkable fashion without a high level of trust. Firms are reluctant to do so.
- Simply asking the top 20 prime brokers at leading institutions might produce all the needed data without asking thousands of hedge funds for data individually.
- This is complicated by the fact that most hedge funds have multiple prime brokers, often with one or more offshore, so data is intentionally out of view.

VII. Implementation Challenges

Implementation is a large, important topic, and something we need to get right. If the recent crisis has taught us anything, it's that risk to our system can come from almost any quarter. We must be able to look in every corner and across the horizon for dangers. During the crisis, our system was not able to do this. Financial systems are evolving rapidly and this evolution is endogenous. Our intuition about what can go wrong is driven by experience from the past, even as the past rapidly becomes less useful as a guide to what might go wrong in the future. As one panelist noted, "We worry about 20 things that won't happen, and then the 21st blows up."

Challenges for the Office of Financial Research

- The Dodd-Frank Act established the Office of Financial Research (OFR), an independent agency within the Treasury, to address inadequacies in data and analysis. OFR's mission is to standardize data, shape it into useful forms, and share it. It will conduct, coordinate, and sponsor a vibrant research agenda that aims to produce risk models, risk assessments, and early warning systems. Expertise brought to bear on this daunting task will include not just that of economists and statisticians but also network analysis and behavioralists.
- OFR was structured to safeguard independence from politics, with an independent budget process and a director who serves a six-year term, not at the pleasure of the President. Its annual reports to Congress are not subjected to anyone else for prior review and approval.
- OFR has no regulatory authority, so there is no pressure for its analytics to be tied to immediate needs for action, nor will it be reluctant to point out existing regulatory gaps and failures.

- Concerns about attracting talented staff with the right expertise have been addressed with salaries higher than the standard government pay scales, and the availability of unique data that will attract innovative researchers. However, most innovative researchers will still reside within the universities, so the need for outreach and creative collaborations with academia is critical.

The first steps for OFR are establishing reference data and determining achievable risk metrics. For models, the office should look to the kind of multidisciplinary, multi-focused approaches used to address large-scale problems such as climate change and disaster response. OFR faces several key scientific challenges, because tail events are rare and little data is available. Analyzing rare tail events requires strong models and valid assumptions.

OFR is building an active research community to address these challenges. It will not happen with the efforts of “six guys in Treasury”; academic researchers and industry experts must help.

Current risk systems do not:

- Predict failure cascades.
- Determine counterparty losses; it would be heroically difficult to do so, because we do not know the linkages.
- Predict the probability of an institution failing.
- Account for linkages.

Data Confidentiality

Measuring systemic risk relies on large quantities of specific data gathered from disparate sources. Ensuring confidentiality is more and more difficult. For example, even when the Census anonymizes data, when these data are combined with other data that is freely available on the internet and sophisticated analytical tools, users can break confidentiality. With financial data, it is easy to take an educated guess on the identities of major financial players.

Data collection and analysis is extremely costly. Increased access and use improve the cost/benefit ratio, but wider sharing can reduce respondent trust, which lowers response rates and can compromise data quality. On the other hand, when external researchers can use and critique micro-data, they help improve the quality of both the data and the analysis.

Research shows that firms strategically disclose information in external reports through aggregation of information. One way to increase participation in data collection efforts is to give something back by providing firms with data aggregated in a much more useful form than what they submitted. However, it is important to note that when you ask enterprises for information

they do not already collect for their own purposes, you will get poor data. It is always best to seek data they already produce.

On issues of access and confidentiality, the OFR should not reinvent the wheel, but should turn to the Census and other state, federal, and international agencies that are already conferring on these matters. These cross-agency discussions have revealed several key challenges:

- Defining optimal data delivery mode.
- Protecting confidentiality.
- International data sharing as standards and laws differ across borders.
- “Meta data” standards and documentation.

Creating an International Reference Data Utility

The creation of the OFR to plug data gaps is a historical achievement because the lack of coordinated and standardized data remains staggering.

- We have “vertical transparency” in the form of prospectuses, which offer full details on a single instrument or entity. (BaFin collects 600,000 printed prospectuses per year, which are stored on paper.)
- We need “horizontal transparency”—system knowledge anchored to an infrastructure offering reliable, standardized reference data on all relevant instruments and entities. The ECB’s experience with the Centralized Securities Database, the largest system of its kind in the world, would benefit from such a registry of reference data sets on all relevant instruments and legal entities. When a prospectus is issued, each player extracts information from it using its own method with no common language.
- Commercial data sets are error-prone and use proprietary formats; the financial industry consistently fails to set data standards (due to built-in barriers, such as “first adopter risk,” for instance).
- U.S. financial stability depends on international instruments and international counterparties, so international data standards must be built into OFR methodology. The U.S. is ahead of Europe in this effort, but Europe can and should build on OFR’s work.
- We need an international Reference Data Utility—“one solution for the world”—with two reference registries:
 1. A registry of instruments with unique identifiers, key attributes, interrelations, and classifications.

2. A registry of legal entities, with unique identifiers, attributes, interrelations, classifications, *and* electronic contact addresses.
- It is critical to address how to reconcile such a global utility with various national laws. .
A broad design concept was proposed

The Regulatory Viewpoint

The emphasis of the Securities and Exchange Commission has always been on *transparency* and *disclosure*, including disclosure of specific events, compensation (because incentives influence risks taken), and pension liabilities. Disclosure is a pillar of Basel III. To gain compliance, regulators must work to reduce the threat perception and seek the input and viewpoints of the regulated.

To extend disclosure and improve quality, some ideas have surfaced:

- Disclose shadow NAVs for money market mutual funds. These shadow NAVs give the true market value of the MMMF's portfolio to four decimal places. This is just the first phase of money market reform.
- Provide downloadable data on cash waterfalls for ABSs. Free data will lower the cost of due diligence and reduce dependency on rating agencies.
- Under Dodd-Frank, hedge fund advisors must register with the SEC, making the SEC the conduit of information on hedge fund safety. What information should be reported? What should be publicized?

It is important to realize the extent to which data and disclosure regulations are set up in response to a particular incident. They may solve one problem while creating others. While the establishment of OFR is a most welcome and essential step, measuring and managing systemic risk will continue to be a challenge. The very act of mapping systemic risks will change what the risks are, and innovation will continue. Success in this endeavor is the crisis that does not happen.

Industry Lessons Learned

From the perspective of a self-regulating agency formed by financial markets, several lessons emerged from the financial crisis:

- Risk management of complex CDOs “sat between market risk departments and credit risk groups” in large financial organizations; neither fully embraced the risk management role.

- One reason the originate-and-distribute model turned into originate-and-hold was that markets froze after the first Bear Stearns hedge funds went down. It was not possible to unload the risk.
- Information was available to do the due diligence work, but investors were either too lazy or too incompetent to do the work, so they relied on ratings agencies.
- Not enough attention was paid to AAA tranches as they became illiquid.
- VaR and other risk management models failed to capture risks because historical correlations broke down.
- Stress testing scenarios did not capture the complete collapse of liquidity.
- The regulatory system was overmatched at every level: origination, securitization, and sales. Regulation was fragmented, with multiple players at each level and no one surveying the entire market. It will help to have the FSOC tasked specifically to do so.

Some beneficial changes have been observed since the crisis. Banks are now proactively upgrading their valuation methodologies. Within firms, silos are breaking down and there are better information flows, and more consistent valuation across them. Risk management models have changed liquidity assumptions (e.g., assuming liquidation periods greater than 10 days). For illiquid positions where it is hard to get market prices, firms now take such positions out of the VaR calculations and hold capital against such positions separately. Other positive changes include:

- More severe stress tests.
- Increased dialogue between treasury and risk controllers and among agencies internationally.
- Continuous re-evaluation of products (e.g., auction rate securities). Are these products functioning as anticipated?
- More transparency and better processes to elevate issues and exceptions to top management.
- Re-evaluation of sales practices and disclosures to customers.

Discussion

Q. How will the OFR attract the right set of smart, innovative, diverse people to make the organization work?

- The availability of new data will make it intellectually attractive for energetic researchers to work there.
- It will be multidisciplinary; in many agencies there is a single career path, but at OFR there will be opportunities to collaborate with colleagues from diverse fields.
- There is considerable attraction to public service; federal agencies are already attracting staff from Wall Street and academia. However, that may be a short-term attraction and not enough to overcome the advantages of working in a university community.
- A fellowship and visiting scholar program will help attract talent.
- There is a lifestyle consideration: promising young scholars want to live in a vibrant campus community, not a sedate Virginia suburb. It may be useful to follow the Google/Microsoft model of hiring young researchers part-time and letting them work remotely.
- It would be a mistake to build a 7,000-person bureaucracy to study systemic risk. Researchers would be stale within two years. Universities are home to researchers with long histories and also young eager people who want to change things. One good approach might be the DARPA model of providing grants to researchers.

Q. Is it realistic that the OFR can focus on data collection and monitoring and avoid policy and regulation? If risk is seen to be building up, it is necessary to be able to do something. What is the policy instrument? Where in the U.S. system as a whole will that policy action be taken?

Q. On confidentiality, the Census Bureau model is interesting but has limitations. Significant access constraints mean that the data is not highly used in research, particularly in economics. Contracts may offer a better model for handling confidentiality issues.

In fact the Census Bureau is looking into a contract model. It is difficult to mask corporate data especially with large or unique companies; this will be an issue the OFR must face.

Q. Is the financial crisis a tail event? If so, do we think data is going to help us prevent the next crisis? Will we ever have the data or models to predict the next one?

- This is a tail event—the system breaking down. There is a hurricane analogy here; in 1908 if you would have asked people how to model and predict hurricanes, they would have said it is hopelessly complex. This looks similarly complex now, but there is reason for optimism. This conference was really quite special in that a whole panel was devoted to network science; and that a speaker from the NSTB discussed the human elements of cooperative problem solving. “I believe profoundly that with the right research brought to the table, we can advance the science of finance just as we have with the science of human life and cosmology.”