Challenges for Macro Financial Modeling
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Good morning. I want to thank Lars, Andrew and the organizers for inviting me to speak this morning. I am honored to be here.

On the tenth anniversary of the financial crisis, I think it is appropriate for us to assess the state of and examine some challenges for macro financial modeling. I'll use my experience at the Office of Financial Research as context for my assessment.

Looking back

Let's first look back ten years. On January 25, 2008, I was Co-Head of Global Economics at Morgan Stanley, worried about the economy, the financial system, my firm and my job. As financial market pressures intensified in November of 2007, I forecast a recession. I knew it was bad, but I did not anticipate the Great Financial Crisis.

As we think about modeling the financial system, it's useful to remind ourselves of a few of the consequential events that occurred ten years ago (Federal Reserve Bank of NY, 2011).

Through early 2008, the Fed was primarily focused on providing sufficient liquidity to firms and markets. The Fed repeatedly eased monetary policy, created two new liquidity facilities,[2] and increased FX swap lines with the ECB and SNB.

In early March, however, Bear Stearns decisively showed how a liquidity run can morph into insolvency that threatens financial stability.

The Fed quickly crossed the Rubicon of lending to nonbanks. On the weekend of March 14, they provided $29 billion in collateralized term financing to facilitate JPMorgan Chase's acquisition of Bear and created the Primary Dealer Credit Facility (PDCF)[3].

I recite this history because few of us foresaw the extent and breadth of the crisis even as it unfolded. We failed to see the many vulnerabilities in the financial system, such as in funding with runnable liabilities (Bao, David and Han, 2015). We underestimated the extent of leverage, liquidity, maturity and credit transformation that extended across interconnected institutions and markets. We overlooked that the regulation and oversight of the financial services industry was

[1] I am grateful for helpful suggestions from and conversations with Steve Cecchetti, Kevin Kleisen, Adam Minson, Phil Monin, Kim Schoenholtz and Venky Venkateswaran. Errors are mine.
[2] The Term Auction Facility (TAF) provided term liquidity to depository institutions, and the Term Securities Lending Facility (TSLF) lent high-quality against lower-quality collateral.
[3] The PDCF extended credit to primary dealers at the primary credit rate against a broad range of investment-grade collateral.

deficient. Consequently, we failed to appreciate the way shocks could spread across the financial system and impair its functioning, with severe consequences for the economy.

We also did not realize that our knowledge of financial data was deficient, overlapping and fragmented. Regulators and policymakers lacked the timely and accurate information needed to monitor emerging threats to financial stability and to develop tools needed to mitigate them.

Addressing shortcomings

In the United States, the Dodd-Frank Act sought to address many of these shortcomings. It created the Financial Stability Oversight Council to coordinate the relevant US regulatory agencies to assess and monitor financial-system vulnerabilities, to develop mitigants for them, and to restore market discipline. It created the Office of Financial Research to serve the FSOC and the public, to better measure and analyze factors affecting financial stability and help evaluate policies to promote it.

Some expected that the OFR would develop new early warning systems to predict the next financial crisis and would provide conclusive forensic evaluation of the last one. Those are noble goals, but we must be humble about our ability to predict or prevent crises. Shocks will happen, and crises will recur. However, better models and better data can be very helpful in designing what I call the shock absorbers and guardrails we need to build a more resilient financial system.

In the years since the crisis, policymakers globally have increased financial-system resilience by improving capital and liquidity; performing regular stress tests at banking firms; instituting new resolution regimes to restore market discipline; and strengthening derivatives markets.

Major strides in improving financial analysis and financial data supported those efforts. Participants in this group have contributed significantly to both.

Good analytics and models have helped to identify and understand financial-system vulnerabilities, such as the procyclicality in crisis dynamics of fire sales and runs; and to calibrate capital and liquidity requirements, and other policy tools. This research conference and the papers presented here show that we are making progress in closing gaps in our understanding.

Good data are also essential for making good policy decisions, managing financial risks and macro financial modeling. Requiring financial firms to report their activities on and off-balance sheet in standard ways creates high-quality data and transparency. Examples include reporting of money-market mutual funds, credit default swaps and other derivatives, and exposures in central clearing counterparties.

Beyond this progress, I am sure the discussions here will also underscore how much more there is still to do. So, I want to use the remainder of my time to discuss three challenges for macro financial modeling. They are:

1. What constitutes relevance?
2. What analytical advances are needed?
3. Where are the gaps in our empirical knowledge?

Relevance

Let me step back and start with relevance.

Relevance requires that we ask the right, and often difficult, questions. I'll explore that in a few minutes. Now, especially at this conference, it may seem irrelevant or even heretical to remind ourselves why we model. As I see it, it's highly relevant: models help us find answers to those tough questions. Models impose structure and discipline on our thinking, and they enable us to develop counterfactuals to quantify answers. But relevance also requires that we discover the right balance between realism and simplicity in our models.

Relevance should also shape the way we ask questions. We often speak casually about modeling systemic risk. But "systemic risk" is an imprecise term (Hansen, 2014). I think it's more useful to think of modeling, assessing and monitoring threats to financial stability.

This is more than semantics, so let me spend a moment on it. It's now widely agreed that financial stability is about resilience. It occurs when the financial system can provide its basic functions, even under stress.

Threats to financial stability arise from vulnerabilities in the financial system — failures in these functions that are exposed by shocks. Resilience has two aspects:

1. Does the system have enough shock-absorbing capacity so it can still function? and
2. Are incentives, such as market discipline or transparent pricing of risk, aligned to limit excessive risk taking?

As the name implies, the shock absorbers buffer shocks that can expose vulnerabilities. What I call guardrails — incentives that affect behavior —are designed to constrain the risk-taking that can create financial vulnerabilities. Likewise, our macroprudential tools must absorb shocks and create appropriate incentives (Berner, 2018).

The Analytical Challenge (s)

This discussion sets up my assessment of the second challenge, that of analysis. I'll offer a few suggestions on how this group can help meet it. I'll confess up front that I have more questions than answers.

A moment ago, I spoke of asking tough questions. I'll start with what are best practices for the ongoing assessment and monitoring of potential threats to financial stability?

At the OFR, we first answered this by surveying existing indicators of financial stability. The first OFR working paper, co-authored by Andrew Lo, Mark Flood and two other researchers at MIT, examined several groups of indicators, the simplest being based on the joint distribution of negative outcomes of a collection of systemically important financial institutions (Bisias, et al., 2012). Among them are familiar indicators such as CoVaR, DIP, MES, and SES.

Importantly, the authors noted that these indicators were a good starting point: "These measures are largely atheoretical, but some may interpret this as a virtue rather than a vice; regardless of one's theoretical priors, these measures can still provide informative estimates of correlated losses. Moreover, the probability distributions on which these measures are based often serve as inputs to other measures with more structure."

Indeed, the next step in the evolution of best practices involved a more structural approach to understanding vulnerabilities. To implement it, we looked to the basic functions of the financial system and weaknesses in each (OFR 2012 Annual Report). That functional framework motivated the OFR's approach to financial stability monitoring – to look at macroeconomic, market, credit, funding and liquidity, solvency and leverage, and contagion risks – wherever they arise. Metrics for them are included in the OFR's Financial System Vulnerabilities Monitor (OFR, 2017a). Some are derived from the indicators in the first working paper; for example, the NYU Volatility Lab's SRISK Measure is an input to contagion risk in the FSVM.

Monitors can help point us in the right direction, but they lack the structure of a model and they don't connect to economic outcomes. Yet, our macro models need fundamental improvement. For example, by assuming the existence of a long-run equilibrium to which the economy returns after experiencing a shock, we assume away default (Goodhart and Tsomocos, 2011). Without it we may analyze exogenous shocks but not the endogenous generation of vulnerabilities that are exposed by even small shocks. Now, putting default front and center in our models is messy and hard (Goodhart, Kashyap, Tsomocos and Vardoulakis, 2012). It violates MM, requires explaining collateral, and may involve multiple equilibria, some of which are unstable.

That doesn't mean we should not try. Questions our models should aim at answering are: what factors affect the probability of default? the loss given default? the exposures, given the loss? the consequences for the supply of credit, for the functioning of the financial system and for the economy?[4] And how should we use today's knowledge of financial conditions, financial vulnerabilities, and financial stress to assess the probability distribution, including skewness and volatility, of risks for future economic growth?[5] To answer these, we should investigate and

[4] We can derive analytical insights about modeling the financial system-real economy interaction from early work on leveraged losses (Greenlaw, Hatzius, Kashyap and Shin, 2008), from the use of the Fed's senior loan officer survey and to assess credit supply (Bernanke and Lown, 1991; Schreft and Owens, 1991; Lown, Morgan, and Rohatgi, 2000), and from analysis of the Fed's survey of the terms of bank lending.

[5] Financial conditions indexes provide summary statistics about the "financial/monetary transmission mechanism" – the way a variety of *current* financial variables can influence the *future* state of the economy – and may thus be useful predictors (Hatzius, et. al., 2010). Financial stress indexes measure *current* stress in the financial system — disruptions in the normal functioning of financial markets that can influence financial conditions (OFR, 2017b). As

embrace modeling techniques that allow us to relax assumptions about the normal or at least symmetric, distribution of outcomes, agent homogeneity, optimization and economic equilibrium.[6]

We also need to incorporate endogenously in our models financial-system procyclicality. We know that several factors contribute: The incentives for market participants to take excessive risks, especially through leverage, when credit is cheap and volatility is low (Danielsson and Shin, 2002; Adrian and Shin, 2008; Bookstaber, 2011; Lopez-Salido, Stein and Zakrajsek, 2015); the related, inherent procyclicality of both risk management tools such as VaR and capital and liquidity requirements (Landau, 2009); and the backward-looking recognition of loan losses and capital needs that may contribute to fire sales when stress is increasing (FSF, 2009).

We need to incorporate endogenously in our models the factors we know affect market and funding liquidity (Brunnermeier & Pedersen, 2009). How should we measure and assess market liquidity, the influence of market micro structure and the relationship between balance sheet constraints and the willingness to provide immediacy services (Adrian, Fleming and Shachar and Vogt, 2016)? We know that market-based intermediation based on runnable liabilities is unstable. How should we understand the cost and availability of liquidity in stressful periods? Mapping funding and collateral can help us understand their sources and uses and where are the weak points in both markets (Aguiar, Bookstaber and Wipf 2014; Aguiar, Bookstaber, Kenett, and Wipf, 2016).

Next, we need to understand how financial innovation – a.k.a. fintech – is changing business models, risk management, reporting, market practices and possibly market functioning. New technologies, such as distributed ledger, promise to speed payments, clearing and settlement and reduce exposures and risk, but may also create operational risks. Is financial regulation promoting regulatory arbitrage away from traditional intermediaries and towards innovations such as peer-to-peer lending, and what are the implications for system functioning? (Brainard, 2016).

Another set of tough questions relates to the macroprudential toolkit: Is it adequate and what are the right tools for the job? To be specific:

- How should we measure the resilience of financial institutions and of the financial system – with balance-sheet measures, market-based metrics, stress tests, changes in the implied support ratings given to financial firms by rating agencies – all four, or will none do?

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noted above, financial vulnerabilities assessments help understand the sources of *potential future* stress exposed by shocks. The IMF October 2017 Global Financial Stability Report provides an important contribution to synthesizing these lines of analysis with methods to forecast probability distributions of future growth rather than just means or medians (IMF, 2017).

[6] Quantile regression techniques facilitate exploring the full range of the distribution of outcomes rather than the condition mean; see Koenker and Hallock (2001). Agent-based models incorporate heterogeneity, behavior that is non-optimizing and which itself is influenced by shocks; see Bookstaber, Paddrik and Tivnan (2014) and Haldane and Turrell (2018).

- What factors influence the credibility of resolution regimes such as orderly liquidation authority, and how should the bankruptcy code be improved to help resolve troubled financial firms?
- In capital regulation, how should risk weights be chosen and how should those based on risk-weighted assets be balanced with leverage ratios?
- How should stress tests be improved and be made more macroprudential? How should we model liquidity shocks in stress tests (Federal Reserve, 2017)?
- How should stress tests be structured for CCPs? Insurance companies? Asset managers?

I'll conclude my discussion of this challenge with four final questions:

- How should we analyze vulnerabilities that arise from interconnectedness?
- How does this work align or not with risk management at financial firms?
- What are operational and cybersecurity risks, and what are their consequences?
- How should regulations be made "efficient, effective, and appropriately tailored," as recommended by the recent Treasury Department reports and Fed officials? (Treasury Department, 2017a, 2017b, 2017c; Quarles, 2018).

The Empirical Challenge

The third challenge is empirical. The crisis exposed the need to improve the quality, scope, and accessibility of financial data. Each of those is essential for transparency in the financial system, and for having the data needed for risk assessment, financial stability monitoring and macro financial modeling. All three are required, like the legs of a three-legged stool.

Let's first discuss data quality. The collapse of Lehman Brothers in 2008 taught us all a lesson about the importance of data quality.

When Lehman failed, financial regulators and Lehman's counterparties were unable to assess many individual exposures to the failing firm. No industry-wide standards existed for identifying parties to financial transactions, so many market participants were exposed to Lehman through its subsidiaries without knowing it.

If only knowledge of those exposures had existed prior to the Lehman failure. Now we have a solution: The global Legal Entity Identifier system, or LEI, is like a bar code for precisely identifying parties to financial transactions. It is a cornerstone for financial data standards. The OFR played a major role in launching the public-private partnership that created the LEI system.

A million LEIs are already in use, but more progress is needed toward universal adoption and the full benefits that we expect to flow from it. Authorities in Europe have required it, but U.S. regulators have been slower to respond. They need to step up and do more.

Precise identification of financial products and instruments is also essential for data quality. That's why the OFR was given a statutory mandate to develop a financial instrument reference

database or data standard, an authoritative source of data describing financial instruments. It would also describe the relationships among financial instruments, like those in your family tree.

These data standards will help firms systematically understand, aggregate, and manage risks across their portfolios, as regulations require them to do. Likewise, it will help officials promote financial stability by helping them aggregate and assess risks across the financial system. And it will promote the quality needed in data for macro financial modeling.

That brings me to the second leg of the stool — data scope. To analyze threats to financial stability, we need data that are both comprehensive and detailed. Although we have made progress, gaps persist in financial data and along with others it's the OFR's job to fill them.

To many of you, talk of data gaps may seem weird. If anything, we seem to be awash in a torrent of Big Data. That's true. But more data aren't always the right or high-quality data. In finance, critical information is lacking, or it is incoherent.

One such key gap that the OFR is filling in collaboration with the Fed involves short-term funding markets; specifically, markets for bilateral repurchase agreements, or repo, and securities lending transactions.

These markets are instrumental in providing funding and liquidity. The U.S. repo market provides more than $3 trillion in funding every day to securities dealers and others. Reforms have made repo markets more resilient. But their vulnerability to runs and fire sales still poses potential threats to financial stability.

The OFR collaborated with the Federal Reserve and Securities and Exchange Commission to conduct two voluntary pilot projects to explore how to collect these data. The OFR and the Fed will soon issue a rulemaking to launch an ongoing data collection, and will make the resulting data available to federal financial regulators and, in aggregated form, to the public.

The repo data will also be critical in developing a secured funding rate as an alternative to LIBOR. ICE-LIBOR, formerly the London Interbank Offered Rate, is an interest-rate benchmark used to price borrowing rates on major consumer purchases, such as homes and cars, and for $150 trillion in derivatives. Attempted manipulation of LIBOR during the financial crisis and ongoing doubts about LIBOR's reliability prompted the Federal Reserve to work with the OFR, other agencies and market participants to devise a reliable, widely accepted, and transparent alternative. The Fed, in cooperation with the OFR, will publish alternatives in the spring.

The third leg of the data stool is about access. To make key data more accessible, we must both overcome obstacles to the appropriate sharing of data and ensure the protection of confidential information. By access, I mean both among regulators and between officials and the public.

The financial system is global, so challenges to data sharing know no borders. The challenges involve restrictions on sharing proprietary data, the need to protect personal and market-sensitive information, and legal constraints that differ among jurisdictions.

Even sharing data among member agencies of the Financial Stability Oversight Council can be difficult. Agencies with mandates to collect data from industry for oversight purposes might lack the authority to share those data, even with the OFR.

The OFR is taking several approaches to overcoming these obstacles. For example, the Office has signed more than 50 memorandums of understanding, or MOUs, with federal, state, and overseas regulators to facilitate data sharing. These agreements include MOUs with state supervisors for insurance industry data, the Securities and Exchange Commission for confidential data about private funds, the Federal Reserve for data on stress testing, and global counterparts for a variety of data.

The OFR is also working with federal financial regulators to develop best practices and a set of common MOU provisions to streamline the process.

To facilitate data access, the OFR is also working with regulators in the United States and overseas to build and link catalogs of metadata — data about data — for transparency among regulators about what data exist and to identify data gaps. These catalogs may eventually also inform the public about available data and how to access them while maintaining data confidentiality and security.

Conclusion

Let me sum up. Thanks to advances in financial stability policy, in analysis and data, in risk management, and the efforts of policymakers and financial firms globally, the financial system is far more resilient than it was ten years ago. And thanks to your thought leadership, we understand far better how to model financial activities and financial-system functioning than ten years ago. I hope it's obvious that there is still much more to do, and that collaboration among thought leaders, market participants, and policymakers is essential to move forward.

Thank you for your attention today. I will be happy to answer your questions.

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