How do we identify which countries and firms currently pose the greatest threat to financial stability? Can we discover these with a statistical analysis of widely available data?

The answer is yes. The method outlined in this article identifies systemically risky firms and countries and shows that it accurately predicted key features of the financial crisis. The approach is similar to a stress test of a financial firm but is done statistically and inexpensively using accounting and market data. The method measures the capital shortfall of individual financial firms in their ability to withstand another financial crisis and call it SRISK. Then we aggregate these to the country and world level to see how severe the shortfall is relative to aggregates, such as GDP. These measures are updated weekly and published on a website for the benefit of consumers, investors, and regulators.

Understanding Systemic Risk

In order to regulate and manage systemic risk one needs to be able to define it. Federal Reserve Governor Daniel Tarullo provided a typical definition: “Financial institutions are systemically important if the failure of the firm to meet its obligations to creditors and customers would have significant adverse consequences for the financial system and the broader economy.”

This definition highlights two important ideas: the core problem is a firm’s difficulty in performing financial services when it fails, i.e., when its capital falls short and that systemic risk matters only to the extent there is an impact on the broader economy. There is a large theoretical and empirical literature that supports these two ideas.

Tarullo’s definition, however, is incomplete because it doesn’t take into account the conditions under which the failure of an individual firm might have significant adverse consequences for the financial system and the broader economy. Specifically, systemic risk can only arise when there is a breakdown in aggregate financial intermediation that accompanies the firm’s failure. When one financial firm’s capital is low, that firm can no longer perform intermediation services (i.e., obtain funds from depositors or investors and provide financing to other firms or entities). This generally has minimal consequences because other financial firms can fill in for
the failed firm. But when capital is low in the aggregate it is not possible for other financial firms to step into the breach. When investors or depositors question the extent to which a class of financial institution or the financial system as a whole can absorb losses, access to short-term funding and liquidity dries up, preventing even solvent institutions from taking over the financial intermediation activities of failed firms. Thus, it is this breakdown in aggregate financial intermediation that causes severe consequences for the broader economy.

Such an event occurred in the fall of 2008 and winter of 2009. A large part of the financial sector was funded with fragile, short-term debt and was hit by a common shock to its long-term assets, especially those related to real estate. As a result, there were en masse failures of financial firms and disruption of intermediation to households and corporations. Full-blown systemic risk emerged only when, in the early fall of 2008, the market value of equity of the Fannie Mae, Freddie Mac, Lehman Brothers, AIG, Merrill Lynch, Washington Mutual, Wachovia, and Citigroup, among others, went close to zero (i.e., were effectively insolvent and could no longer provide financial intermediation services). These failures created a contagious run on the financial system more broadly, as even solvent institutions could not access short-term funding and liquidity in the financial system.

A single institution’s contribution to system-wide risk – not its risk of failure per se – is what matters in assessing its systemic importance. Systemic risk is about co-dependence: how much leverage a firm has when systemic risk is emerging elsewhere; whether it is reliant on short-term sources of liquidity or funding when other troubled firms rely on similar funding; how correlated a firm’s assets are in the bad state of nature; whether other firms can step in to provide the services previously provided by a failing firm (i.e., the degree of substitutability); and whether the firm’s failure increases the likelihood of other firms failing or vice versa.

Academically, the importance of such comovement has gained broad recognition. For example, a survey of systemic risk methodologies by Bisias, Flood, Lo, and Valavanis (2012) point to a general consensus on the importance of comovements. Acharya, Pedersen, Philippon, and Richardson (2010) build a simple model of systemic risk and show that each financial institution’s contribution to systemic risk can be measured as its systemic expected shortfall, i.e., its propensity to be undercapitalized when the system as a whole is

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2 The term “failure” is intended to be broadly construed to encompass formal legal processes such as bankruptcy, as well as forced mergers or rescues that involved regulatory intervention when a firm could no longer function as a going concern.
undercapitalized. Brownlees and Engle (2010) develop an estimation methodology for systemic expected shortfall. Adrian and Brunnermeier (2009) measure the financial sector’s Value at Risk (VaR) given that a bank has had a VaR loss, which they denote CoVaR, using quantile regressions on asset returns computed using data on market equity and book value of the debt. Billio, Getmansky, Lo, and Pelizzon (2011) measure systemic risk through Granger causality (i.e., autocovariances) across and within different parts of the financial sector. De Jonghe (2009) presents estimates of “tail betas” for European financial firms as their systemic risk measure. Huang, Zhou, and Zhu (2009) use data on credit default swaps (CDS) of financial firms and time-varying stock return correlations across these firms to estimate expected credit losses above a given share of the financial sector’s total liabilities. Goodhart and Segoviano (2009) look at how individual firms contribute to the potential distress of the system by using the CDSs of these firms within a multivariate copula setting.

**MEASURING SYSTEMIC RISK**

A systemic financial crisis occurs if and only if there is a capital shortfall of the aggregate sector. In other words, the failure of a financial firm is systemic in nature only if it has spillover effects on the ability of the financial system as a whole to function.

The expected capital shortfall of a financial firm during a crisis, which we denote as “SRISK,” measures the systemic risk across financial firms. SRISK answers this question:

How much capital would a financial institution need to raise in order to function normally if the economy suffers a financial crisis?

We approximate this amount of capital by estimating how much, if any, does a firm’s market value of equity fall below a fraction of the firm’s total assets.

To define the terms in this chart:

- **Debt** is the book value of debt for firm i at time t
- **Equity** is the market value of equity for firm i at time t
- **SRISK** is the expected capital shortfall, i.e., the decline in equity values to be expected if there is another financial crisis.
- **Assets** is the quasi-market value of assets of firm i at time t (i.e., its market value of equity plus book value debt)
- **k** is a prudent level of equity relative to assets
- **LRMES** is the long-run marginal expected shortfall, i.e., the decline in equity values to be expected if there is another financial crisis.

In words, equation (1) shows that the firm will have a capital shortfall (i.e., SRISK) if its decline in equity value (i.e., LRMES) leaves it short of capital given the size of its liabilities and leverage.

We can estimate this measure econometrically using market data on equities and balance sheet data on liabilities. The measure of a firm’s expected capital shortfall in a crisis provides regulators with a quantifiable measure of the relative importance of a firm’s contribution to overall systemic risk. The measure also captures in one fell swoop many of the characteristics considered important for systemic risk such as size and leverage.

For the results to follow, we choose a level of k equal to 8% of total assets and, importantly, we assume that this k is the same across firms. That said, for IFRS firms, due to accounting differences with GAAP, a k equal to 5.5% is used. In practice, one could use varying k across different types of financial firms that would then aggregate to a weighted average of these k at the financial sector level.
This shortfall can be viewed as a negative externality imposed on the economy. Negative externalities cannot necessarily be solved within the private sector and thus this provides a justification for government regulation. Compared to existing regulatory measures, SRISK provides an important addition, most notably the comovement of the financial firm’s assets with the aggregate financial sector in a crisis.

The other major advantage of this measure is that it makes it possible to understand systemic risk not just in terms of an individual financial firm but in the broader context of financial subsectors. For example, because the measure is additive, it is just one step to compare the systemic risk of say the regional banking sector versus a large complex bank.

Before providing such an analysis, we want to make three comments regarding the SRISK calculation.

First, for purposes of implementation, let us look more closely at terms in the calculation. LRMES, the key component of SRISK, captures the comovement of the firm with the aggregate index. LRMES is the average of a firm’s returns across possible future paths when the aggregate index return falls by 40 percent over six months. There are a number of ways to estimate LRMES (many of which are provided and discussed on NYU Stern’s VLAB website: http://vlab.stern.nyu.edu/welcome/risk/), but the most important part of this estimation is the dynamic conditional beta of the firm’s equity against the aggregate index (see Engle (2014)).

The concept of beta in financial economics measures the decline in the firm’s equity as the aggregate index declines. Mathematically, beta is the correlation times the ratio of firm volatility to the aggregate index volatility. Neither the correlations nor the volatilities are constant empirically, so we need a methodology to account for the dynamics. NYU Stern V-LAB discusses various models, but, for the results presented in this piece, we use the dynamic conditional correlation model, Engle (2002), and the Glosten, Jagannathan, and Runkle (1993) generalized autoregressive conditional heteroskedasticity model for volatilities.

In practice, we use global exchange-traded funds (ETF) as the aggregate index and make sure to correct the estimation for the asynchronicity in daily equity and ETF returns. The calculations are performed weekly and posted on the NYU Stern V-LAB website.

Second, measuring the expected capital shortfall during a crisis is analogous to regulatory stress tests to the extent both methodologies are trying to estimate the amount of capital required to ensure that the financial firm cannot only survive a crisis, but continue to intermediate and provide financial services to the real economy. Regulators can estimate this measure using a wide variety of proprietary information about financial institutions and are able to cross-check these institutions across the financial sector. Since the spring of 2009, regulatory authorities in the U.S. and Europe have performed various stress tests. Some of these stress tests have been criticized for being too lax in their implementation, arguably for political reasons. Moreover, due to the nature of the requirements of the tests, they have been implemented only on a periodic basis.

The methodology described in this paper can supplement the regulatory stress tests by allowing for a more continual stream of information regarding the changing nature of financial firms’ systemic risk. NYU Stern studies by Acharya, Pedersen, Philippon, and Richardson (2010) and Acharya, Engle, and Pierret (2013) document a close relationship between the stress test outcomes and those implied by statistical measurements using publicly available data.4 The later study looked at major recent stress tests: the 2009 Supervisory Capital Assessment Program and the 2012 and 2013 Comprehensive Capital Analysis and Review in the U.S. and the stress tests initiated by the Committee of European Banking Supervisors in 2010 and the European Banking

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4 See also Huang, Zhou and Haibin (2012).

The failure of a financial firm is **systemic in nature only** if it has spillover effects on the ability of the financial system as a whole to function.
WHERE IS THE RISK TODAY?

GLOBAL SYSTEMIC RISK BY COUNTRY

U.S. AGGREGATE SRISK

Third, given that SRISK measures systemic risk, SRISK would have been useful prior to and during the financial crisis of 2007-2009. A number of papers studying other types of financial institutions, such as insurance companies, and other time periods, such as prior to the creation of federal deposit insurance in the 1930s, demonstrate the broader applicability of this formula. But for anecdotal evidence supporting SRISK, let’s apply it retrospectively for three dates: March 2005, March 2007, and August 2008:

MARCH 2005 – The 10 firms contributing most to SRISK, in order, were: Fannie Mae, Morgan Stanley, Freddie Mac, JPMorgan Chase, Merrill Lynch, Lehman Brothers, Goldman Sachs, Bear Stearns, Prudential Life, and MetLife. Almost all of these firms either failed or received large capital infusions some 2-3 years later. (The insurance companies were the exceptions.)

MARCH 2007 – The SRISK list at the beginning of the decline in real estate prices is similar: Morgan Stanley, Fannie Mae, Citigroup, Merrill Lynch, Freddie Mac, Lehman Brothers, Goldman Sachs, Bear Stearns, JPMorgan Chase, and MetLife. The addition of Citigroup prior to the crisis is important because in this period the commercial banks were expanding their activities into higher risk areas such as mortgage origination and securitization, and proprietary trading, and Authority 2011. These results provide some independent corroboration that SRISK is capturing capital shortfalls in severe stress scenarios.

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AUGUST 2008 – Just prior to Lehman’s failure the SRISK rankings are: Citigroup, JPMorgan Chase, Bank of America, Morgan Stanley, Freddie Mac, Merrill Lynch, Fannie Mae, AIG, Goldman Sachs, and Wachovia. Three new entrants – Bank of America (through its purchase of Countrywide), AIG, and Wachovia – all ran into deep trouble the following month, with at least two of the firms failing. Lehman Brothers ranked 11 not because it was relatively less risky, but due to its decrease in size (its equity and assets fell leading up to its failure). Other than Fannie Mae, Lehman had the highest LRMES (a staggering 86%) with a conditional beta of 4.99.

PROSPECTS FOR GLOBAL FINANCIAL STABILITY

One application of SRISK is to aggregate over the SRISK of financial firms in a given country and region. This way, we can compare which countries’ financial sectors contribute to financial instability if a crisis were to emerge. Currently the financial sectors of five countries jump out: Japan, United States, China, France, and the United Kingdom, with total SRISKs ranging from $300 billion to $450 billion.

Because the chart (p.30) does not adjust for the size of the economy, a country’s SRISK over its gross domestic product (p.30) provides a better way to understand whether a government could intervene and provide capital to support its financial sector in the event of a crisis. The top five countries in terms of this ratio, SRISK/GDP, are currently (as of February 2015) France, Greece, United Kingdom, Switzerland, and Japan. Both Switzerland and Greece’s economies are fairly small, but Switzerland has a large financial sector and Greece has a very risky financial sector. China and the U.S. drop out as their economies are large relative to the total SRISK in dollars of their financial sectors. Currently, the U.S. is particularly low as a percent of GDP not just because of the size of its economy but also as a result of a large drop in SRISK since the recent financial crisis subsided.

To better understand the time-series dynamics of SRISK within these countries, we break up all the countries into three financial regions – the United States, Europe, and Asia. First, consider the evolution of SRISK in the U.S. over the last decade. From 2005-2007, SRISK hovered around $200 billion and was relatively constant. Once the financial crisis began to emerge in early summer of 2007, SRISK increased dramatically to three times that level. Moreover, the figure below documents increases in SRISK to levels over $1 trillion as the crisis took root in the fall of 2008. By 2010, as the U.S. worked its way through the financial crisis, SRISK dropped to its mid-2007 levels. While this level of SRISK was maintained through 2013, SRISK has now fallen over the past eighteen months, albeit still higher than pre-2007 levels.

In comparing the U.S. to other regions around the world, it is also of some note that the same level of increased regulation, and, for that matter, economic recovery has not taken hold elsewhere in the world. Therefore, it seems worthwhile to look at SRISK in Asia and Europe.

Going into the crisis of 2007-2009, Asia’s SRISK did not increase, instead remaining around $200 billion. As the crisis emerged, and in particular the fall of 2008, SRISK grew, but at a level somewhat below the United States. Even as the financial crisis abated, SRISK remained at crisis levels through 2011. After 2011, SRISK spiked considerably and has hovered between $1.0 and $1.2 trillion over the past four years.

Most of this increase in Asia can be attributed to Japan and China. In China’s case, for example, both the share of liabilities as a fraction of GDP and the risk of the publicly

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traded financial sector have increased fairly dramatically since 2007. Partly because the recent financial crises were centered in the U.S. and Europe. Asian financial regulators and policymakers have not shown the same intensity as their counterparts in the U.S. and Europe. But the evidence described above and shown in the accompanying chart (p.31) should serve as a warning sign to them.

Europe suffered huge increases in SRISK as the financial crisis took off, similar in many ways to the U.S. financial sector, but SRISK in the region has not decreased as the financial crisis subsided. This can be partially explained by the eurozone crisis during the summer of 2011. The accompanying chart (p.31) shows that SRISK still remained high prior to the summer of 2011 and has continued to linger even if at somewhat lower levels. This behavior of SRISK for the European financial sector may be due to either slow implementation of financial reforms or a persistent weak economy or both. If a new crisis occurs, the impact of such a crisis on the European financial sector will be hard to contain. The chart (p.30) shows that, for the 10 highest ranked countries of SRISK as a percentage of GDP, eight of them are in Europe, and several of them are large in an absolute sense.

With the recurring refrain of “how do we prevent the next crisis?” we hope regulators worldwide can use this measure as a tool for identifying firms as well as regions that present the greatest systemic risk, as a way to corroborate other gauges, and as critical flag for appropriate intervention.

REFERENCES


