Systemic Risk and Alternative Investments: *A Summary of Selections from the State of the Art*

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On December 15, 2014, leading researchers on systemic risk gathered at the Massachusetts Institute of Technology (MIT) for a joint meeting cosponsored by the Consortium for Systemic Risk Analytics (CSRA) and the European Commission's Systemic Risk Tomography Project (SYRTO).[1] Participants in the meeting came from a diverse set of organizations, including universities, financial institutions, regulatory bodies, and nongovernment organizations (NGOs). The purpose of this joint meeting was to precipitate collaboration on systemic risk research between U.S. and European researchers. Speakers at the meeting presented on a wide range of topics, highlighting the newest thinking and empirical results on systemic risk, many of which also bear on risks that affect alternative investments (either directly or indirectly through broader exposure to market dislocations). A selection of the articles presented at this meeting, along with a number of additional articles describing new results on systemic risk, that we collected over the course of the following year, form the basis for this Special Issue of the journal.

Although alternative investments, by definition, are chosen by investors to be relatively less correlated with broad market factors, the recent global financial crisis (GFC) demonstrated that during periods of extreme market dislocation even alternative assets may be affected by market dysfunction. Furthermore, a small but meaningful minority of alternative investment strategies rely on taking positions that gain value during periods of severe market downturns. Managers following such strategies have a deep interest in understanding conditions that may presage systemic events.

In this Special Issue, we have collected a number of articles from some of the leading researchers currently studying systemic risk. Our goal has been to provide a sampling of some of the many approaches to measuring systemic risk that have emerged and are emerging in this growing literature. We have focused on approaches that are both practically relevant and quantitatively motivated. Authors who contributed to the Special Issue are based in both the United States and in Europe and conduct research in a range of settings, including academia, government, and the private sector. Within their institutions, authors' backgrounds are similarly diverse, spanning areas such as finance, economics, operations research, data science, and public policy. As a result, this Special Issue addresses questions of systemic risk from a number of different points of view, and the results and implications of these articles are relevant to practitioners, regulators, and academics.

In this short introductory article, we offer a framework for thinking about current

research on systemic risk along with a summary of each of the articles in this Special Issue to help readers navigate to those that may be of most direct interest to their work. We have tried to provide "teasers" rather than "spoilers" so that readers can learn the most compelling results directly from the authors.

SUMMARY OF ARTICLES INCLUDED IN THIS SPECIAL ISSUE

We now present a brief digest of each article in this Special Issue to allow readers with specific interests to more easily prioritize their reading. (More detailed discussions of the results and methods as well as reviews of the relevant literature are, naturally, found in the articles themselves.)

We find it useful to separate the articles into two broad categories:

- Methods for measuring systemic risk directly; and
- Analyses of the behavior of markets and market participants during or in the aftermath of systemic events.

Where appropriate, we have also provided brief observations on the context or motivation for the work the articles describe.

PART 1: Measures of Systemic Risk

The first broad category of articles in this Special Issue relates to methods for measuring systemic risk. Systemic risk analytics, regardless of their methodological details, generally address one or both of two key questions:

1. What is the aggregate level of systemic risk across the financial system (at some point in time)?
2. Which members of the financial system pose the greatest systemic risk (and how much)?

Throughout this section, we will refer to question 1 as the *aggregate question* and question 2 as the *firm-specific question*. Often, measures that aim to answer the aggregate question also produce, as a byproduct, answers to the firm-specific question (e.g., by calculating marginal effects). Interestingly, it is sometimes also the case that measures designed to answer the firm-specific question are used to answer the aggregate question, typically by averaging cross-sectionally. We refer to measures aimed at answering the firm-specific question as *firm-specific measures* and those that answer the aggregate question as *aggregate measures*. Exhibit 1 describes these approaches schematically.

These key questions are closely related, and many of the more common measures of systemic risk address them jointly, often through a common modeling framework. Depending on the interest of the reader, one of these questions is typically of more interest. For example, central bankers and macro hedge fund managers may focus more closely on the aggregate level of systemic risk in the global financial system, whereas risk managers and regulators may, on the margin, focus more closely on which firms in the financial system appear to be most systemically important and to what degree their risk levels are either large (in absolute terms) or increasing (in relative terms).

How Useful Are Aggregate Measures of Systemic Risk?

Mamaysky [2016] provides an overview of some of the more well-known measures of systemic risk; the author also presents normative guidance on how useful these various measures are for forecasting systemic events, based on ex ante empirical tests.

Mamaysky [2016] evaluates nine of the more well-known proposed systemic risk measures with respect to how well they forecast systemic events. The author compares the predictive power of these nine measures to two simple baselines: the VIX volatility index and CDX credit spread index. The central question the author explores is whether various measures of systemic risk provide *incremental* forecasting information beyond that already contained in the baseline observables. In other words, the author examines whether these systemic risk indicators provide any economic value, after controlling for baseline market stress proxies.

EXHIBIT 1
Broad Framework for Systemic Risk Models and Questions

	Aggregate Question	Firm-Level Question
Aggregate Measures	Use model	Marginal effects
Firm-Specific Measures	Cross-sectional calculations	Use model

The nine measures investigated by Mamaysky [2016] include CoVaR (Adrian and Brunnermeier, forthcoming), marginal expected shortfall (MES) (Acharya et al. [2011]), and co-risk (International Monetary Fund [2009])—all of which are portfolio-based measures of systemic tail risk—as well as the absorption ratio (Kritzman et al. [2011]) and turbulence (Chow et al. [1999]) measures (based on principal components analysis).

The author concludes that, when appropriately cast, some classes of systemic risk measures do have incremental forecasting power for future levels of the VIX and unemployment after controlling for observables such as VIX volatility and CDX credit spread indexes.

Mamaysky [2016] also examines the practice of aggregating firm-specific measures to produce an aggregate measure but finds that, in many cases, this aggregation does not result in useful aggregate measures. However, the article presents a new filtering approach that can be applied to some of these to yield significantly more predictive power.

Matrix Metrics:
Network-Based Systemic Risk Scoring

Das [2016] presents a general framework for integrating information on networked entities to answer the aggregate question. The article goes on to demonstrate how this framework may be applied to determine the systemic importance of specific firms and answer the firm-level question.

The author's approach is attractive in that it provides a more general framing of the network analytics that have been introduced in earlier articles (Burdick et al. [2011], Billio et al. [2012, 2016]). The article also proposes a measure of an institution's "potential" (in the electrical sense) for systemic disruption. Although some aspects of these measures are, at their core, recastings of more familiar formulations in a network setting, others are entirely original. Measures proposed in this article may be more intuitive for some readers than their more traditional counterparts. Furthermore, the network representation permits the overlay of useful economic structures, resulting in clear, normative implications. The author's proposed risk measures are not a function of a particular dataset or a particular type of data used (e.g., returns), so the framework can be used with any measure of interconnectedness. As such, the article greatly adds to the growing literature on systemic risk measures.

Finally, the author presents a number of examples of how the framework could be used to answer questions about systemic risk in known networks. In one example, the question of whether too-big-to-fail banks should be broken up or dismantled is taken up with surprising results. The author also examines whether cross risks are less significant than own risk contributions, which bears directly on regulatory concerns regarding moral hazard.

TRC Networks and Systemic Risk

A limitation of many approaches to measuring systemic risk is that they are only able to capture one dimension of risk while ignoring others. Measures of tail risk and correlation such as MES (Acharya et al. [2011]), CoVaR (Adrian and Brunnermeier, forthcoming), and others capture the potential for firms to fail together in times of extreme market stress but do not address the potential impact that these failures may have on other firms. Conversely, network methods such as those described by Billio et al. [2012] capture the connectivity of one organization with many others but do not highlight the importance of these connections in times of stress.

To address this, Lo and Stein [2016] propose a network analysis approach that incorporates both the propensity of systemically important firms to fail during periods of extreme market stress and the implications of such failures. Said differently, they propose an approach that highlights those network connections and nodes that are critical during periods of high systemic risk.

Using a structural model of default, the authors simulate the *global financial portfolio* of financial institutions and then calculate the propensity for specific firms to fail (default) during periods of market stress by calculating the credit tail-risk contribution (TRC) of each entity in the financial network under study. They then use the TRC data, along with data on holdings, to construct a *TRC network* that shows holdings, weighted by the TRC. This may be interpreted as the topology of the network in distress and demonstrates both the potential for specific firms to be caught up in a market dislocation and the corresponding flow of that distress to other entities. Thus, in one picture, the approach provides information on both the firm-level and aggregate questions.

To demonstrate their approach, the authors use data on exposure-level holdings and exposure sizes of a set of 2a-7 money market funds as of July 2011. They show that both quantitatively and qualitatively the TRC-network highlights markedly different relationships than does the traditional network representation,

which only highlights the size of a particular position rather than its risk during market downturns.

DebtRank and the Network of Leverage

Battiston, D'Errico, and Gurciullo [2016] provide a two-step framework that contributes to answering both the firm-specific and aggregate questions. The first-round effect is related to a shock on the external assets of financial institutions. The second-round effects are due to propagation of shocks due to interbank exposures.

The authors introduce the notion of a *network of leverage* to combine the concepts of interconnectedness and capital requirements. For each round, they measure the total *relative equity loss* (REL), which they define as the fraction of equity lost in the bank system after the first- and second-round effects are taken into account, with respect to the initial equity. As such, REL accounts for both external and interbank leverage. The authors show that the REL at the second round can be decomposed into the product of leverage components. This systemic risk measure is designed to also capture distress propagation from one financial institution to another even in the absence of default. To test the approach, the authors apply this measure to 183 banks headquartered in the European Union, collect data on total interbank assets and liabilities for each bank, and estimate bilateral exposures between banks.

Unlike most studies of this sort, which focus on the first-round effect while ignoring or simplifying the second-round effects, Battiston, D'Errico, and Gurciullo [2016] specifically model the second-round effect and study propagation of stress in the bank network. They also combine both effects in order to study the aggregate effect of an external shock on the risk of the whole system.

Battiston, D'Errico, and Gurciullo [2016] find interbank leverage to be a good predictor of the REL at the second round. In their study, the authors find that, even in the presence of low interbank leverage, the propagation of losses is more pronounced in networks with large *external* (i.e., not related to interbank) leverage. Thus, the new measure appears to be a novel approach to capturing the relationship between leverage and interconnectedness. The authors go on to show that neglecting the second-round effects may lead to a dramatic underestimation of systemic risk.

PART 2: The Behavior of Markets and Market Participants

The second broad category of articles in this Special Issue relates to various analyses of the behavior of markets and market participants during or in the aftermath of a systemic event. In this section, we summarize the articles that explore these questions by examining the relationships between systemic risk and hedge funds, sovereigns, and options portfolios. The articles we discuss next present various authors' perspectives on these topics and also provide some interesting conclusions and suggestions about hedge fund strategies and exposures during systemic crises.

Are the Federal Reserve's Stress Test Results Predictable?

Following the recent financial crisis of 2007–2009, stress tests for major bank holding companies became a requirement under the 2009 Supervisory Capital Assessment Program (SCAP). The SCAP presents a unique research opportunity in that the results of these tests have been made publicly available, giving a rare glimpse into the details of a regulatory stress testing exercise. One design objective of the SCAP is to assess the degree to which large U.S. bank holding companies are able to withstand hypothetical worsening in economic conditions, assuming the banks' current capital reserves.

Using data on the results of four rounds of SCAP tests, Glasserman and Tangirala [2016] explore whether SCAP test results have exhibited increasing correlation and are thus becoming more predictable. Specifically, the authors examine the degree to which projected losses under SCAP stress tests for 2013 and 2014 are correlated for banks that participated in stress tests in both years. They then explore equity market reactions to stress tests and seek to determine whether there is evidence that the information contained in the test results is anticipated by market participants.

A key question is whether banks, as they have become more aware of the design of the Federal Reserve Board's stress scenarios and have made corresponding investments in information technology and analytic staff to conduct such tests, have thereby tailored their investments to favor asset classes that would not attract high capital requirements under a SCAP stress test.

If this were the case, it would imply that the banks may be behaving in a more correlated fashion. However, the authors conjecture, although stress test results may

become more predictable, the impact of actual shocks to the financial system do not. As a result, the authors assert that such tests to assess and contain systemic risk may be becoming less effective, even as the banks' investments in risk management systems reduces overall systemic risk.

After exploring these topics empirically, the authors go on to make a number of normative suggestions for constructing stress tests.

Sovereign and Hedge Fund Systemic Risks

Savona and Ciavolino [2016] study the relationship between sovereign and hedge fund risks and explore how this relationship contributes to systemic risk. Using data on sovereign credit default swaps (CDSs) from major European countries and hedge fund indexes, the authors provide evidence that the hedge fund sector contributed significantly to the rise of systemic risk for GIIPS (Greece, Ireland, Italy, Portugal, and Spain) and Core European countries (France and Germany) during the Greek crisis of 2010 and the Eurozone crisis of 2011.

The authors also add to the growing literature (cf., Billio et al. [2012]) on the degree to which financial institutions, and specifically hedge funds, contributed to the rise in systemic risk. Can hedge fund serve as early warning signals to the build-up of systemic risk? Did hedge funds contribute to the rise of systemic risk, or were they simply victims of risk spillovers due to systemic effects? Such questions are central in understanding the interrelationship between systemic risk and financial institutions and the role of certain financial institutions (hedge funds) in the recent global financial crisis. The article is written by European authors and is a part of the European Commission's Systemic Risk Tomography Project (SYRTO). As such, it provides a rich perspective on the European crisis and on possible contributors to it.

Savona and Ciavolino [2016] extract systemic risk measures for Core European countries, GIIPS (peripheral European countries), and hedge funds and then go on to inspect the two-way connections between sovereign and hedge fund systemic risks. The authors define systemic risk as an unobserved (latent) variable that is extracted from sovereign CDS and hedge fund indexes, and they propose a structural model that specifies the relationship between this latent variable and a set of covariates. They choose four covariates to explain systemic risk: the VIX index, U.S. and Euro term spreads, and the TED spread and find, in their framework, that the VIX, the term spread, and the TED spread are able to explain a substantial part of sovereign and hedge fund sector risks.

Hedge Fund Tail Risk: *An Investigation in Stressed Markets*

Billio, Frattarolo, and Pelizzon [2016] study the impact of the recent global financial crisis on the broad portfolio of hedge funds. The article sets out to investigate whether the contribution to tail risk in hedge fund portfolios was driven by the majority of hedge funds or only by a select number of them. The conclusions of this study are relevant to understanding whether diversification among hedge fund strategies provides effective risk mitigation during systemic crises.

The authors construct a portfolio of hedge funds by applying different weighting schemes on individual hedge fund strategies. They then consider how each individual hedge fund strategy contributes to the overall tail risk of the portfolio. They consider three such risk measures: volatility, VaR, and expected shortfall.

The authors identify a number of hedge fund strategies that contribute negatively to the risk of the overall portfolio of hedge funds as well as those that contribute the most to the total portfolio risk. They find that, although some strategies provide natural hedges, others tend to amplify portfolio risk.

The authors also explore various financial crises and find that during such events, all hedge fund strategies tend to be positively exposed to liquidity and credit risk. As such, all positively contribute to the total tail risk of the portfolio of hedge fund strategies. This implies that the natural ability of some hedge fund strategies to act as hedges for total portfolio risk is substantially diminished during crisis periods. This is important since it is especially during these events that investors anticipate diversification and hedging benefits to accrue from investments in hedge funds.

The authors' work has natural extensions to the growing literature on funds of funds. Funds of funds invest in different hedge fund strategies, thus providing diversification benefits to investors. However, this benefit was less pronounced during the recent systemic crisis when all strategies became correlated. As a result, fund investors who may have expected to be hedged may have experienced heightened risk as all strategies began positively contributing to the tail risk of the total portfolio.

Form PF and the Systemic Risk of Hedge Funds: *Risk-Measurement Precision for Option Portfolios*

A number of recent regulatory changes have emerged in response to market dislocations. One such regulation requires reporting by private funds (such as hedge funds) on aspects of their portfolio holdings through *Form PF*. Form PF allows regulators to collect detailed information on risks, returns, exposures, and other characteristics of hedge funds.

Flood and Monin [2016] study the precision of Form PF in capturing the intended portfolio risks. The authors treat the Form PF filing (i.e., a specific set of risk parameters) as a design constraint for portfolio construction and examine the maximum risk a portfolio may exhibit without affecting the reported parameters.

To do this, the authors generate a large collection of simulated hedge fund portfolios and report each fund's risk exposures according to the instructions of Form PF. They then compare these results to actual risk exposures reported by hedge funds on Form PF. Using this simulated data, the authors find that the actual distribution of risk greatly varies across portfolios that would have reported identical results on Form PF.

For example, Flood and Monin [2016] explore the degree to which, under value-at-risk (VaR) and expected shortfall (ES) measures, the maximum portfolio risk may be higher than the median risk, despite all funds reporting the same VaR on Form PF. The authors examine this both for funds required and not required to report their VaR on Form PF. The authors then investigate the degree to which the addition of options to a fund's portfolio leads to higher or lower measurement tolerances on Form PF, as well as the impact of even very simple portfolio and trading strategies on the range of risks associated for the same Form PF filing parameters.

CONCLUSION

In this short survey of the articles in this Special Issue, we have tried to give readers an enticing preview of the diverse approaches that are emerging in the rapidly evolving literature on systemic risk analysis. Though our treatment is necessarily succinct, we have attempted to highlight some of the salient points of each article while avoiding spoilers as much as possible, preferring to let the authors themselves present their most compelling results and conclusions.

We hope readers will find this guide useful as a companion to the main articles in this Special Issue. More than this, we expect that readers will find the main articles both intellectually stimulating and practically useful in thinking through and implementing tools and systems for monitoring and measuring systemic risk.

ENDNOTE

[1]SYRTO Project (details at: http://www.syrtoproject.eu) is funded by the European Union to study systemic risk issues in Europe.

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