

Financial and Macroeconomic Connectedness

A Network Approach to Measurement and Monitoring

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Preface

Issues of connectedness arise everywhere in modern life, from power grids to social networks, and nowhere are they more central than in finance and macroeconomics – two areas that are themselves intimately connected. The global crises of 1997-1998 (the “Asian Contagion”) and 2007-2009 (the “Great Recession”) are but two recent reminders, with countless ancestors and surely countless progeny. But financial and economic connectedness nevertheless remains poorly defined and measured, and hence poorly understood.

Against this background, we propose a simple framework for defining, measuring, and monitoring connectedness. We focus on connectedness in financial and related macroeconomic environments (cross-firm, cross-asset, cross-market, cross-country, ...). Our scope is in certain respects desirably narrow – specific tools for specific problems – but in other respects also desirably broad, as issues of connectedness arise everywhere in economics.

Our work stems from our struggling to understand the Asian Contagion during a 2003-2004 KY sabbatical working with FXD at the University of Pennsylvania, and struggling to understand the Great Recession during a second 2010-2011 KY sabbatical with FXD at the same institution. Fascinating questions surround those crises, and many others, past and future: How can we conceptualize and measure connectedness at different levels of granularity, from highly-disaggregated (pairwise) through highly aggregated (system-wide)? Does connectedness vary through time, and if so, how and why? Is connectedness related to crises, and can connectedness measurement be used to improve risk management? Asset allocation? Asset pricing? Can it be used to improve public policy and regulatory oversight?

We opted for a book rather than a large set of separate journal articles for two reasons. First, because the underlying methodological framework is the same for each application, the book format lets us develop the theory first and then draw upon it repeatedly in subsequent chapters, without re-expositing the theory. Second, we feel strongly that our whole is greater than the sum of its parts (much as we like the parts!). That is, the natural complementarity of our analyses across assets, asset classes, firms, countries, and so on, makes a book an unusually-attractive vehicle for describing our methods and thoroughly illustrating the breadth of their applications.

We hope that the book will interest a broad cross-section of students, researchers and professionals in finance and economics. Specifically, it should be of use in aca-

demics at a variety of levels, from advanced undergraduates, to masters and Ph.D. students, to cutting-edge researchers. Simultaneously, it should interest professionals in financial services, asset management, and risk management. In addition, the book should interest those in official organizations such as central banks, country fiscal and regulatory authorities, and non-government organizations. Indeed, although we are economists, and our intended audience is largely economists (broadly defined), issues of connectedness go far beyond economics, and we hope that our ideas will resonate more widely, from technical areas like applied mathematics, statistics, and engineering, to applied areas like political science and sociology.

The book's structure is very simple. Chapter 1 provides the foundation on which the rest of the book builds, defining and presenting methods for measuring connectedness, in population and in sample, and we relate our approach to modern network theory. The remaining chapters then apply our methods to connectedness measurement in a variety of contexts. Many of the ideas developed in earlier chapters run throughout later ones, which contain generalizations, specializations, and variations that are usefully compared and contrasted. In chapter 2 we examine U.S. asset classes, in chapter 3 we examine equities of individual major U.S. financial institutions, in chapter 4 we examine global equities, in chapter 5 we examine sovereign bond markets, in chapter 6 we examine foreign exchange markets, in chapter 7 we examine multiple asset classes and multiple countries, and in chapter 8 we examine the global business cycle in real activity.

Many people and organizations have contributed to the development of this work. For helpful comments we thank conference and seminar participants, and for financial support we thank the U.S. National Science Foundation (NSF), the Sloan Foundation, and the Scientific and Technological Research Council of Turkey (TUBITAK) for Grant No. 111K500. We are especially grateful to Michael Binder, Christian Brownlees, Nuno Crato, Kathryn Dominguez, Mardi Dungey, Rene Garcia, Raquel Gaspar, Craig Hakkio, Peter Hansen, Ayhan Kose, Andrew Lo, Asgar Lunde, Vance Martin, Barbara Ostdiek, Esther Ruiz, Vanessa Smith, Erol Taymaz, and Dimitrios Tsomocos. For research assistance we thank Fei Chen, Mert Demirer, Deniz Gok and Metin Uyanik.

Last and far from least, we thank Scott Paris and his team at Oxford University Press. The project that produced this book probably would not have been started, and almost surely would not have been completed, without Scott's infectious enthusiasm and insightful guidance.

Finally, before proceeding farther, we apologize in advance for the many errors of commission and omission that surely remain, despite our efforts to eliminate them.

FXD and KY

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This book draws upon certain of our earlier writings, including:

“Measuring Financial Asset Return and Volatility Spillovers, With Application to Global Equity Markets,” *Economic Journal*, 119, 158-171, 2009.

“Equity Market Spillovers in the Americas,” in R. Alfaro (ed.) *Financial Stability, Monetary Policy, and Central Banking*. Santiago: Bank of Chile, 2011.

“Better to Give than to Receive: Predictive Directional Measurement of Volatility Spillovers” (with discussion), *International Journal of Forecasting*, 28, 57-66, 2012.

“On the Network Topology of Variance Decompositions: Measuring the Connectedness of Financial Firms,” *Journal of Econometrics*, 2014, in press.

“Measuring the Dynamics of Global Business Cycle Connectedness,” In S.J. Koopman and N. Shephard (eds.), *Festschrift in Honor of Andrew Harvey’s 65th Year*, Oxford University Press, 2014, in press.

Chapter 1

Measuring and Monitoring Financial and Macroeconomic Connectedness

In this book we develop theoretically rigorous yet practically (i.e., empirically) relevant measures of connectedness for use primarily in financial markets. Our interest centers on financial market connectedness because of its centrality for understanding the workings of the markets, and for successfully navigating core financial market activities like risk management, portfolio allocation and asset pricing. In financial markets we are often interested in connections among different assets, asset classes, portfolios, etc. The objects connected are typically returns or return volatilities.

Associated with financial markets are networks of financial institutions, such as retail banks, wholesale banks, investment banks, and insurance companies, as well as asset management firms, such as mutual funds and hedge funds. Hence we are interested in measuring connectedness not only among aggregate markets, but also among individual institutions via, for example, individual firm equity returns.

Finally, financial assets are of course claims on real output streams, which are the fundamentals that determine prices. Hence our interest in financial markets also implies interest in underlying macroeconomic fundamentals. And if financial markets are in part driven by macroeconomic fundamentals (aspects of the business cycle, inflation, etc.), then the the converse is also true: the macroeconomy is in part driven by financial markets, as emphasized for example by the Great Recession of 2007-2009, which was preceded by financial crisis.

1.1 Motivation and Background

In this section we elaborate on the importance of connectedness in financial contexts, stressing the role of connectedness among various financial risks. We proceed for now at a verbal intuitive level, reserving rigorous definition of connectedness for later

sections. We highlight the many areas in which issues of connectedness appear (risk management, portfolio allocation, business-cycle analysis, ...), and we also introduce the idea of connectedness measurement for real-time crisis monitoring, an idea that recurs throughout the book.

1.1.1 Market Risk

Risk measurement is a basic ingredient to successful risk management. Huge attention and resources are therefore devoted to measuring various financial risks. One of the most fundamental is market risk, the risk of changes in portfolio value due to changes in the value of its underlying components. Connectedness is presumably part of any comprehensive market risk assessment, because it separates the risk of a portfolio from the risk of its underlying components. That is, the risk of a portfolio is not simply a weighted sum of the risks of its components. Overall portfolio risk depends on how the pieces interact – whether and how they are connected. The likelihood of extreme market movements, typically associated with all or most assets moving in the same direction, depends on connectedness.

1.1.2 Portfolio Concentration Risk

Thus far we have emphasized risk measurement considerations, emphasizing that connectedness is what separates portfolio risk from the sum of component risks. But portfolio allocation is about minimizing portfolio risk, so optimal portfolio allocation must require awareness and measurement of connectedness. That is, connectedness must govern “portfolio concentration risk,” which determines the scope of effective diversification opportunities.

Exogenous Aspects

Note that time-varying connectedness implies time-varying diversification opportunities. Connectedness may be relatively low much of the time, for example, implying good diversification opportunities. In crises, however, connectedness may increase dramatically, implying loss of diversification just when it is needed most. Skillful timing of portfolio shares to exploit time-varying connectedness can potentially be exploited to generate extra risk-adjusted excess returns, as in Fleming et al. (2001), Fleming et al. (2003), Kyj et al. (2009), and Kirby and Ostdiek (2010).

Endogenous Aspects

Our discussion thus far has the flavor of time-varying portfolio concentration risk arising due to time-varying connectedness, due in turn to factors beyond the control of portfolio managers. Often that is the case. It is interesting to note, however, that time-varying connectedness can also be caused by managers themselves. Disparate portfolio management styles, for example, may converge over time, as style