Journal of Financial Stability 8 (2012) 193–205

Contents lists available at SciVerse ScienceDirect

Journal of Financial Stability

journal homepage: www.elsevier.com/locate/jfstabil

# Assessing the systemic risk of a heterogeneous portfolio of banks during the recent financial crisis☆

Xin Huang[a,*], Hao Zhou[b,1], Haibin Zhu[c,2]

[a] Department of Economics, University of Oklahoma, 729 Elm Avenue, Room 329 Hester Hall, Norman, OK 73019, USA
[b] Risk Analysis Section, Federal Reserve Board, Mail Stop 91, Federal Reserve Board, 20th and C Streets, NW, Washington, DC 20551, USA
[c] J.P. Morgan Chase Bank, N.A., 26/F, Charter House, 8 Connaught Road, Central, Hong Kong

ARTICLE INFO

*Article history:*
Received 15 April 2010
Received in revised form 13 October 2011
Accepted 19 October 2011
Available online 30 October 2011

*JEL classification:*
G21
G28
C13

*Keywords:*
Systemic risk
Macro-prudential regulation
Portfolio distress loss
Credit default swap
Dynamic conditional correlation

ABSTRACT

This paper measures the systemic risk of a banking sector as a hypothetical distress insurance premium, identifies various sources of financial instability, and allocates systemic risk to individual financial institutions. The systemic risk measure, defined as the insurance cost to protect against distressed losses in a banking system, is a summary indicator of market perceived risk that reflects expected default risk of individual banks, risk premia as well as correlated defaults. An application of our methodology to a portfolio of twenty-two major banks in Asia and the Pacific illustrates the dynamics of the spillover effects of the global financial crisis to the region. The increase in the perceived systemic risk, particularly after the failure of Lehman Brothers, was mainly driven by the heightened risk aversion and the squeezed liquidity. Further analysis, which is based on our proposed approach to quantifying the marginal contribution of individual banks to the systemic risk, suggests that "too-big-to-fail" is a valid concern from a macro-prudential perspective of bank regulation.



## 1. Introduction

The recent global credit and liquidity crisis has led bank supervisors and regulators to rethink the rationale of banking regulations. One important lesson is that the traditional approach to assuring the soundness of individual banks needs to be supplemented by a system-wide macro-prudential approach. The macro-prudential perspective of supervision focuses on the soundness of the banking system as a whole and the inter-linkages between financial stability and the real economy. It has become an overwhelming theme in the policy recommendations by international policy institutions, regulators and academic researchers.[3]

Such a "systemic" view should not only cover a banking system at the national level, but also at regional and international levels because the global banking sector has become increasingly integrated. As the current crisis has shown, vulnerabilities in one market can be easily spread abroad through various channels (e.g., loss of confidence, higher risk aversion, similarities in business models and market structures), causing disruptions in market functioning and banking distress elsewhere in the world. In Asia and the Pacific, the financial and economic integration in the past decades implies that economic performance and health of the banking

☆ We would like to thank Claudio Borio, Mike Gibson, Michael Gordy, Myron Kwast, Nikola Tarashev, Amy Wong, and seminar participants at the Bank for International Settlements, the Reserve Bank of Australia, Federal Reserve Board and Federal Deposit Insurance Corporation, the Deutsche Bundesbank/Imperial College London conference on "The Future of Banking Regulation", the 22nd Annual Australian Finance and Banking Conference, the 12th Annual Financial Econometrics Conference organized by the Waterloo Research Institute in Insurance, Securities and Quantitative Finance. We are grateful to the editor, Iftekhar Hasan, and an anonymous referee for their helpful comments and suggestions. We would also like to thank the Australian Finance and Banking Committee for their kind award of the BankScope Prize for the best paper in banking. Clara Garcia and Jhuvesh Sobrun provided excellent research assistance. The paper was prepared when Haibin Zhu was a research economist at the Bank for International Settlements. The views presented here are solely those of the authors and do not necessarily represent those of the Federal Reserve Board, the Bank for International Settlements or J.P. Morgan Chase Bank.

* Corresponding author: Tel.: +1 405 325 2643; fax: +1 405 325 5842.
*E-mail addresses:* xhuang@ou.edu (X. Huang), hao.zhou@frb.gov (H. Zhou), haibin.zhu@jpmorgan.com (H. Zhu).
[1] Tel.: +1 202 452 3360.
[2] Tel.: +852 2800 7039.

[3] See, for instance, Acharya (2009), Brunnermeier et al. (2009), Financial Stability Forum (2009a,b) and Panetta et al. (2009), among others. The macro-prudential perspective was first proposed by Crocket (2000) and Borio (2003).

1572-3089/$ – see front matter © 2011 Elsevier B.V. All rights reserved.
doi:10.1016/j.jfs.2011.10.004

system across countries have become more inter-related in the region.[4]

Banks have been the most important financial intermediaries in Asia and the Pacific, by providing liquidity transformation and monitoring services, among all financial firms and the capital market channels. Historical evidence suggests that the soundness of the banking system is crucial for financial sector stability and economic growth in this region. For instance, a weak banking system was one of the key driving factors behind the 1997 Asian financial crisis. In contrast, during the current global economic and financial turmoil, the resilience of the banking sector has by far been a major support to the functioning of financial markets and an early recovery in economic growth in the region (see Bank for International Settlements, 2009).

Against such a background, this paper studies the time variation of systemic risk measures of a heterogeneous banking system. Such analysis is based on the existing work by Huang et al. (2009), who construct a systemic risk indicator from publicly available information.[5] In particular, they construct a systemic risk indicator with the economic interpretation as the insurance premium to cover distressed losses in a banking system, based on credit default swap (CDS) spreads of individual banks and the co-movements in banks' equity returns. Based on this methodology, this paper makes three important additional contributions.

First, we propose estimating the asset return correlation using a coherent model of dynamic conditional correlation (DCC) (Engle, 2002), such that the heterogeneous inter-connectedness of the banks in different subgroups can be well represented in the conditional correlation matrix. The original approach in Huang et al. (2009) assumes homogeneity, i.e., the pairwise correlation for any two banks is the same at a particular point in time. Such simplification is reasonable for any homogeneous system of large US banks as examined by Huang et al. (2009); but can be problematic for a portfolio of heterogeneous banks, for example, from different lines of business or from different sovereign jurisdictions. Huang et al. (2009) also rely on high-frequency tick-by-tick equity price data to construct and forecast the realized correlations, while the dynamic conditional correlation (DCC) approach adopted here only requires a daily frequency of equity prices.

Second, the risk-neutral concept of insurance premium for distressed credit loss can be easily decomposed into various sources that are associated with changes in underlying default risks and risk premia.[6] For instance, this can be achieved by substituting the risk-neutral default probability inferred from CDS spreads with the objective default probability estimated for each bank, like the expected default frequency (EDF) from Moody's KMV.

The concepts of risk-neutral versus physical defaults are associated with the discussion on bank capital. Merton and Perold (1993) proposed a concept of "economic capital", i.e., the capital of financial institutions is a risk-neutral concept reflected in current asset prices. Along the same line, a recent paper by Heaton et al. (2008) explicitly argues that capital reserve is a risk-neutral measurement, and Aït-Sahalia and Lo (2000) regard value-at-risk (VaR) as an inherently risk-adjusted quantity implied by financial markets. Noticeably, the concept of "economic capital" is different from the concept of "regulatory capital" that is based on the actuarial or statistical estimation of potential losses.

Third, our study examines not only the aggregate *level* but also the different *components* of systemic risk as well. In particular, the systemic risk contribution of each bank (or bank group) to the banking system is defined as its marginal contribution to the systemic risk of the whole banking system. Importantly, the marginal contribution of each subgroup adds up to the aggregate systemic risk. As also shown in Tarashev et al. (2009a), this *additivity* property is desirable from an operational perspective, because it allows the macro-prudential tools to be implemented at individual bank levels. Using this framework, supervisors are able to identify systemically important financial institutions and to allocate macro-prudential capital requirements on individual banks.[7] By contrast, alternative systemic risk measures, such as CoVaR of Adrian and Brunnermeier (2008), cannot be consistently aggregated across subgroups, due to the lack of the additive property.

We apply the extended approach of Huang et al. (2009) to a portfolio of twenty-two major banks in Asia and the Pacific, spanning the period from January 2005 to May 2009. The main findings are as follows.

First, the movement in the systemic risk indicator reflects primarily the dynamics of the spillover effects of the global financial crisis to the region. Before the failure of Lehman Brothers, Australian banks were most affected and market concerns on the systemic risk of banks from other economies in the region were quite contained. This situation has changed since late September 2008. All banks across the region felt the stress, which came not only from spillover effects of the spike in risk aversion, but also because the performance of the real economy in the region had weakened substantially. The situation was not improved until the second quarter of 2009.

Second, the evolution of market perception on the systemic risk of Asia-Pacific banks was mainly driven by the risk premium component. By contrast, concerns on increasing actual default losses explained only a small portion of the distress insurance premium, and was not able to account for the increase in the systemic risk indicator before the fourth quarter of 2008. This suggests that the stress faced by Asia-Pacific banks was mostly driven by the heightened risk aversion and liquidity squeeze in the *global* financial markets that were originated from the US subprime crisis.

Third, the analysis on the marginal contribution of each bank (or bank group) to the systemic risk suggests that the size effect is very important in determining the systemic importance of individual banks, which is consistent with Tarashev et al. (2009b). The change in the systemic risk can be largely attributed to the deterioration in credit quality (increases in default probability and/or correlation) of some of the largest banks. The result supports the "too-big-to-fail" concern from a macro-prudential perspective.

The remainder of the paper is organized as follows. Section 2 outlines the methodology. Section 3 introduces the data, and Section 4 presents empirical results based on an illustrative banking system that consists of twenty-two major banks in Asia and the Pacific. The last section concludes.

[4] A similar regional study can be found in Hardy and Nieto (2011) for the European Union. But they focused more on the deposit guarantees.

[5] Along the same line, Lehar (2005) and Avesani et al. (2006) proposed alternative market-based indicators of systemic risk. These indicators are useful supplementary measures to balance sheet information, such as the Financial Soundness Indicators used in the Financial Sector Assessment Program (FSAP). In addition, supervisors sometimes implement risk assessments based on *confidential* banking information, such as the Supervisory Capital Assessment Program (SCAP) implemented by the U.S. regulatory authorities in early 2009 and the European-wide stress testing program sanctioned by the Committee of European Banking Supervisors (CEBS). At the micro level, Knaup and Wagner (2009) proposed a market-based credit risk indicator for measuring a bank's credit portfolio quality.

[6] See Amato (2005) for the economic factors explaining the risk premia in our paper.

[7] The idea of imposing extra capital charges for systemically important banks was well circulated among policymakers these days, including the influential Geneva report prepared by Brunnermeier et al. (2009) and BCBS (2009).