Journal of Financial Stability 13 (2014) 75–94

Contents lists available at ScienceDirect

Journal of Financial Stability

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

Systemic risk in an interconnected banking system with endogenous asset markets

Marcel Bluhm[a,b,*], Jan Pieter Krahnen[c]

[a] The Wang Yanan Institute for Studies in Economics, Xiamen University, 361005 Xiamen, China
[b] Center for Financial Studies, Grueneburgplatz 1, 60323 Frankfurt am Main, Germany
[c] Goethe University Frankfurt and Center for Financial Studies, Grueneburgplatz 1, 60323 Frankfurt am Main, Germany

ARTICLE INFO

Article history:
Received 10 November 2013
Received in revised form 23 March 2014
Accepted 29 April 2014
Available online 9 May 2014

JEL classification:
C15
G01
G21
G28

Keywords:
Systemic risk
Systemic risk charge
Macroprudential supervision
Shapley value
Financial network

ABSTRACT

We analyze the emergence of systemic risk in a network model of interconnected bank balance sheets. The model incorporates multiple sources of systemic risk, including size of financial institutions, direct exposure from interbank lendings, and asset fire sales. We suggest a new macroprudential risk management approach building on a system wide value at risk (SVaR). Under the SVaR metric, the contribution of individual banks to systemic risk is well defined and can be approximated by a Shapley value-type measure. We show that, in a SVaR regime, a fair systemic risk charge which is proportional to a bank's individual contribution to systemic risk diverges from the optimal macroprudential capitalization of the banks from a planner's perspective. The results have implications for the design of macroprudential capital surcharges.

1. Introduction

Since the outbreak of the global financial crisis in 2007, and the dramatic effects of the Lehman collapse in 2008, systemic risk has become a matter of great concern for policy makers and central bankers. However, macroprudential monitoring is still at a very early stage and there is no generally accepted metric capturing the state of systemic risk. Not surprisingly, there is also no general agreement on an adequate policy response. This paper studies the consistency of two macroprudential policy instruments, namely systemic capital requirements and systemic risk charges, in the framework of a network model.

Systemic risk can be characterized as a negative pecuniary externality exerted by financial institutions.[1] Financial institutions may be induced to increase their contribution to systemic risk and their status as a too-big-to-fail or too-interconnected-to-fail institution will put them under the government safety net, thereby delinking bank funding costs from their own asset risk. This has two important consequences. First, regulatory intervention such as, for example, a risk charge, might be used to incentivize financial institutions to internalize their negative externality.[2] Second, systemic banking risk may not be easily inferred directly from debt instruments, like bonds or CDS, because their market prices may be distorted by government guarantees.[3]

We therefore use a structural model portraying a network of interrelated bank balance sheets with endogenous asset markets. This set up in which we extend the model of Cifuentes et al. (2005) for two way interactions between banks allows for measuring systemic risk as well as individual banks' contribution to it. In our

* Corresponding author. Tel.: +86 18859278840.
E-mail addresses: bluhm.wise.xmu@googlemail.com (M. Bluhm), krahnen@finance.uni-frankfurt.de (J.P. Krahnen).

[1] See, for example, Benigno (2013).

[2] Financial stability features characteristics similar to a public good without clearly defined property rights. In this respect government intervention can help achieve better outcomes in terms of welfare or utility. See Snidal (1979).

[3] See, for example, Acharya et al. (2013) and Tsesmelidakis and Schweikhard (2012).

http://dx.doi.org/10.1016/j.jfs.2014.04.002
1572-3089/

setting, systemic risk is driven essentially by three channels: the size of banks, the direct exposures among these institutions, and the asset market-driven correlations. We then suggest a simple method to investigate the relation between systemic risk, capital requirements, and systemic risk charges. The new method applies value at risk, the quantile of a loss distribution, to a system of interconnected financial institutions. The resulting system value at risk (SVaR) metric defines the institutions' optimal macroprudential capitalizations and a risk charge which is proportional to each institution's contribution to overall systemic risk. We then apply our framework to the question how an optimal risk charge should be designed. Recently, it has been argued that required bank capital should be closely related to banks' systemic risk contribution.[4] In the context of our model we show that the optimal bank capitalization will in general diverge from the same bank's contribution to systemic risk. Thus, our findings indicate that the design of a systemic risk charge and the design of macroprudential capital standards should be treated as two separate problems rather than one and the same. In our analyses we also find that direct interconnections between banks are a dominant driver of systemic risk in our model, corroborating the findings in Drehmann and Tarashev (2011) who show that systemic importance depends materially on a bank's role in the interbank network. Furthermore, in line with the results in Shin (2008) we find that the fire sale channel is an important amplifier of exogenous shocks providing evidence that marking-to-market accounting in times of financial turmoil may amplify distress in the financial system.

More generally, our paper is related to three strands of the literature. Firstly, it is related to the literature on financial contagion in which the transmission of shocks across financial systems is investigated. Second, it can be associated with the field of literature measuring financial institutions' negative externality on the financial system which arises in the form of systemic risk. Third, it relates to the literature about macroprudential regulation.

The literature on financial contagion is vast.[5] Influential early analyses were carried out in the seminal works by Allen and Gale (2000) and Diamond and Dybvig (1983). The former investigate financial contagion as an equilibrium phenomenon in a theoretical banking model and show that complete claims structures between banks are more robust than incomplete structures. The latter develop a theoretical model featuring a market for bank deposits with the possibility of bank runs and find that deposit insurance can be beneficial for financial stability. Freixas et al. (2000) model systemic risk in an interbank market in which banks are connected via credit lines to cope with liquidity shocks. They find that though the interbank market allows to minimize the amount of resources held in liquid assets it can lead to contagion. More recently, with the aim to get a general overview on systemic risk from contagion, Haldane (2009) considers the financial network as a complex and adaptive system and applies several lessons from other disciplines such as ecology, epidemiology, biology, and engineering. In this respect, systemic risk in our model of interconnected financial institutions is also largely driven by contagion. Regarding the various approaches to assessing systemic risk in the contagion-related literature, one can distinguish between 'market-based' and 'network-based approaches'.[6] While the former use correlations and default probabilities that can be extracted from market prices of financial instruments, the latter explicitely model linkages between financial institutions, mostly using balance sheet information.

In the market-based literature, systemic risk is mostly quantified using tail-measures ('reduced form approach'), for example, Acharya et al. (2011)'s marginal expected shortfall (MES), Adrian and Brunnermeier (2011)'s value at risk of the financial system conditional on institutions being under distress (CoVaR), and Brownlees and Engle (2012)'s systemic risk indices (aggregate SRISK), or using contingent claims analysis ('structural approach'), for example Jobst and Gray (2013)'s system contingent claims analysis (System CCA).[7] In the network-based literature, the measure for systemic fragility is usually the fraction of financial institutions in default, for example in Cifuentes et al. (2005) and Gai and Kapadia (2010).[8] The model used in our analysis is closely related to that of Cifuentes et al. (2005), extending it among other things to allow for two-way interactions among banks and using Shapley value analysis to investigate banks' expected contribution to systemic risk. Similar, to this strand of the literature, our metric for systemic risk is measured by the proportion of the financial system in default conditional on a shock.

The second strand our paper is related to is the literature assessing the systemic importance of financial institutions. In this field one can again distinguish between market-based and network-based approaches. The market-based approaches use financial institutions contribution or correlation with the tail distribution or contingent claims metrics to measure their impact on systemic stability.[9] In the network-based approaches, the Shapley value metric or variants of it are used to measure banks' contribution to systemic risk.[10] Drehmann and Tarashev (2011) show that systemic importance depends strongly on bank relations in the interbank market and that different risk measures lead to substantial differences in assessments on contributions to systemic risk. Gauthier et al. (2012) use a network model to measure systemic risk and banks' contribution to it employing several risk allocation mechanisms. In our paper we extend the network-based approaches with distributional assumptions on the vector of shocks to the financial system which we combine with the Shapley value methodology to compute expected values for systemic risk as well as banks' contribution to it.

Finally, our paper is related to the literature dealing with macroprudential regulation. An early comparison of micro- and macroprudential dimensions in financial regulation is given in Borio (2003). The author argues that the macroprudential orientation of financial regulation needs to be strengthened to improve

[4] See, for example, Acharya et al. (2009).

[5] An earlier review of the literature on contagion is given by De Bandt and Hartmann (2000). For a more recent overview see Allen et al. (2009).

[6] See the background paper of Financial Stability Board (2009) for a similar distinction.

[7] An overview on these metrics is given in Hansen (2013). Early analyses of systemic risk include Bartram et al. (2007) and Lehar (2005). More recent noticeable market-based analyses include, but are not limited to, Acharya et al. (2012), Huang et al. (2009), Huang et al. (2012), López-Espinosa et al. (2013), Saldías (2013), and Suh (2012).

[8] An overview on methods to assess the danger of contagion in interbank markets is provided in Upper (2011). Other noticeable network-based analyses include, but are not limited to, Degryse and Nguyen (2007), Elsinger et al. (2006), Georg (2013), and Upper and Worms (2004).

[9] For example, Acharya et al. (2011) define an institution's contribution as is its propensity to be undercapitalized when the system as a whole is undercapitalized (system expected shortfall, SES), Adrian and Brunnermeier (2011) define an institution's contribution to systemic risk as the difference between CoVaR conditional on the institution being under distress and the CoVaR in the median state of the institution (ΔCoVaR), Brownlees and Engle (2012) define it as the expected capital shortage of a firm conditional on a substantial market decline (individual SRISK), and Jobst and Gray (2013) measure contribution of a firm by calculating the cross-partial derivative of the joint distribution of expected losses. A comparison of these measures is provided in Benoit et al. (forthcoming). Further applications using market-based measures can be found in De Jonghe (2010), Giglio et al. (2012), Hautsch et al. (forthcoming), Hovakimian et al. (2012), and Weißet al. (2014).

[10] See Tarashev et al. (2010).