Journal of Banking & Finance 37 (2013) 1243–1257

Contents lists available at SciVerse ScienceDirect

Journal of Banking & Finance

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

Systemic risk contributions: A credit portfolio approach

Natalia Puzanova [a,*,1], Klaus Düllmann [b,1]

[a] Deutsche Bundesbank, Financial Stability Departement, Wilhelm-Epstein-Str. 14, 60431 Frankfurt/Main, Germany
[b] Deutsche Bundesbank, Department of Banking and Financial Supervision, Wilhelm-Epstein-Str. 14, 60431 Frankfurt/Main, Germany

ARTICLE INFO

Article history:
Received 11 November 2011
Accepted 26 November 2012
Available online 27 December 2012

JEL classification:
G21
G28
C15
C63

Keywords:
Systemic risk
Systemic risk contributions
Systemic capital charge
Countercyclical capital buffer
Expected shortfall
Importance sampling

ABSTRACT

We put forward a framework for measuring systemic risk and attributing it to individual banks. Systemic risk is coherently measured as the expected loss to depositors and investors when a systemic event occurs. The risk contributions are calculated so as to ensure a full risk allocation among institutions. Applying our methodology to a panel of 54–86 of the world's major commercial banks for a 13-year time span with monthly frequency not only allows us to closely match the list of G-SIBs; we can also use individual risk contributions to compute bank-specific surcharges: systemic capital charges as well as countercyclical buffers. We therefore address both dimensions of systemic risk – cross-sectional and time-series – in a single integrated approach. As the analysis of risk drivers confirms, the main focus of macroprudential supervision should be on a solid capital base throughout the financial cycle and de-correlation of banks' asset values.

1. Introduction

The recent financial crisis triggered a paradigm shift in banking regulation from an essentially microprudential approach aiming at individual institutions to a macroprudential approach aiming at the stability of a whole financial system. From this perspective banks are considered not as isolated business entities, but as interacting institutions whose failure may produce externalities and put the system's stability at risk. A macroprudential approach to banking regulation would internalize negative external effects by imposing systemic capital surcharges so that they reflect banks' individual contributions to the risk of the whole financial system. Against this backdrop, our paper contributes to the ongoing regulatory and academic debate on how to make the systemic capital surcharges operational.

This paper focuses on one part of the broader financial system – the banking sector, which we model as a portfolio comprising banks' liabilities. We define the system-wide or systemic risk on the basis of potentially large-scale losses to the debt holders (other banks, depositors and investors) when a low-probability systemic event occurs. From the operational perspective, systemic risk is then measured by the tail risk of the portfolio of the banking sector's liabilities. Starting from this definition, we utilize a widely used credit portfolio model to *measure systemic risk* and decompose it into the *contributions of individual institutions*. By calculating the individual risk contributions we provide a direct link between risk factors such as the banks' size, their individual probability of default and the banks' asset correlation and the notion of banks' systemic importance, making the latter measurable. Based on the risk contributions, we also suggest a method to compute bank-specific systemic capital surcharges on top of the microprudential capital requirements as well as a countercyclical capital add-on in order to mitigate a potentially procyclical effect of regulation.

In summary, we see the following aspects as the main contribution of this paper:

1. We suggest a method for measuring the system-wide risk as the expected extreme loss to the economic agents (depositors and investors in banks' liabilities) and not merely banks' equity capital impairment.
2. We provide a full allocation of the system-wide risk across institutions based on the Euler allocation principle for the assessment of banks' systemic importance. This method

* Corresponding author. Tel.: +49 69 9566 8973.
E-mail addresses: natalia.puzanova@bundesbank.de (N. Puzanova), klaus.duellmann@bundesbank.de (K. Düllmann).

[1] This paper represents the authors' personal opinions and does not necessarily reflect the views of the Deutsche Bundesbank or its staff.

0378-4266/$ - see front matter
http://dx.doi.org/10.1016/j.jbankfin.2012.11.017

for assessing systemic risk contributions remains feasible irrespective of the size and composition of the banking system under consideration.
3. We provide an empirical example in order to investigate the main drivers of systemic risk and systemic importance.
4. We address both dimensions of systemic risk in single integrated policy approach: the cross-sectional dimension by designing a bank-specific systemic risk surcharge, and the time dimension by imposing a capital buffer in good times indicated by low default probabilities estimated on the basis of market information.

The approach suggested for measuring and attributing systemic risk has several merits. It is based on a credit portfolio model that is well understood and widely applied in the practice of risk management. Its application is, in principle, not limited to listed financial institutions since it can also be adapted to non-listed companies as long as reliable estimates of their probability of default and of their sensitivity with regard to systematic risk factors can be obtained. Furthermore, our method can be used for projections of systemic risk or for stress testing based on predictions or on stressed values of input parameters. The model can be utilized either via simulation, as in this paper, or by using a fast analytical approximation as reported in Düllmann and Puzanova (2011).

Apart from its technical merits, our method has further advantages: It takes direct account of main risk drivers such as the size and individual default risk of financial institutions and correlation among interconnected entities. Because the probability of default is a function of the financial leverage, which in turn is a ratio of total assets to the weighted average of long-term and short-term liabilities, the model also takes the leverage into account. However, on the issue of interconnectedness, we have to point out that the model does not go beyond the notion of linear correlation (it does not incorporate contagion effects or tail dependence). Nonetheless, the multi-factor correlation structure suggested is rich and allows for a differentiated treatment of different groups of banks. This reflects the fact that episodes of financial distress often arise from the exposure of groups of institutions to common risk factors and that intragroup dependence is higher than intergroup dependence.

The remainder of the paper is structured as follows: Section 2 provides a brief review of selected literature. Section 3 outlines the modeling approach and the calculation method for the risk contributions of individual banks. Section 4 presents an empirical example of a system comprising the world's major commercial banks and analyzes the impact of different risk drivers. In Section 5 we address the possible policy implications of the proposed methodology. Finally, we discuss a number of model extensions in Section 6 and summarize the main results in Section 7.

2. Related literature

In this section we briefly review the literature on systemic risk (contributions), which our paper is most closely related to, and point out the aspects that distinguish our approach from the others. A more comprehensive review of recent approaches for detecting the tail risk in a financial system by examining direct and indirect interlinkages can be found in the IMF's Global Financial Stability Report (IMF, 2009, pp. 73–149) and in Galati and Moessner (2012).

The approach presented in this paper relies on market information about interlinkages among banks. The study of financial sector interlinkages using market prices of financial instruments has a long tradition and a rational explanation. For instance, De Nicolo and Kwast (2002) argue that the information contained in banks' equity returns can be used to measure total (direct and indirect) dependence since stock prices reflect market participants' collective evaluation of the future prospects of the firm, including the total impact of its interactions with other institutions. The dependence structure of the banking system as given in our paper can be inferred from the empirical correlation of banks' equity returns.

Equity returns and other market data are widely used to measure the fragility of financial institutions at individual and aggregate levels. For example, Bartram et al. (2007) estimate the default probabilities for a large sample of international banks from time series of equity prices and also from equity option prices, based on the assumptions of Merton's structural model (Merton, 1974). They use this information to construct indicators for a systemic event. In our paper we use the estimates of banks' default probabilities obtained from Moody's KMV, whose model is also based on Merton's fundamental idea.

Huang et al. (2009) deduce risk-neutral default probabilities for major banks from their CDS spreads and asset return correlation from the co-movement of equity returns. Using these key parameters as input in a portfolio credit risk model, the authors suggest computing an indicator of systemic risk, namely the price of insurance against large default losses in the banking sector. As in our paper, the banking sector is represented by a hypothetical portfolio that consists of debt instruments issued by a pre-selected group of banks. The theoretical insurance premium equals the risk-neutral expectation of portfolio credit losses given that the losses exceed some minimum share of the sector's total liabilities. Our approach is different from the approach described as we use objective probabilities of default and, thus, can deduce the actual losses to depositors and investors in case of a systemic event. Furthermore, we define the systemic event not by means of a given system-wide loss threshold, but rather by setting the probability threshold for the occurrence of a systemic event.

Another application of the portfolio approach based on market data can be found in Segoviano and Goodhart (2009). The authors estimate the joint multivariate density of the banks' asset value movements, based on which they construct several indicators of banking stability. They do not consider the issue of individual risk contributions. Also by virtue of the joint probability distribution of banks' assets, Lehar (2005) specifies a set of systemic risk indicators, including the value of a hypothetical deposit insurance, its volatility as well as the individual volatility contributions.

While the methods described above mostly focus on monitoring systemic risk, Adrian and Brunnermeier (2011) suggest an approach for measuring the *contributions* that individual banks make to systemic risk. For this purpose the authors make use of the quantile regression technique and construct the so-called ΔCoVaR measure of banks' risk contributions. A bank's ΔCoVaR can be described as the difference between the VaR of the system conditional on the bank being in distress and the VaR of the system conditional on the bank being in the median state. This measure of systemic risk contributions relies heavily on the observations of extremely negative stock returns of banks and is only applicable in the Gaussian setting, in which it is also additive, as shown by Jäger-Ambrozewicz (2012). Otherwise, the individual risk contributions cannot be aggregated to calculate the system-wide risk. They could even be misleading. For instance, an application of the CoVaR methodology to a non-Gaussian setting with tail dependence would result in a paradoxical outcome whereby the system with tail dependence is less risky than the Gaussian system. By contrast, we suggest a methodology that ensures additivity of the risk contributions by construction and can be extended to a non-Gaussian setting.

Acharya et al. (2012) define systemic risk contributions as institutions' marginal expected shortfall which, at first glance, appears to be very similar to our approach. They define their measure by