Journal of Financial Stability 9 (2013) 498–517

Contents lists available at ScienceDirect

Journal of Financial Stability

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

Systemic risk analysis using forward-looking Distance-to-Default series

Martín Saldías

Banco de Portugal and Católica Lisbon Research Unit, Avenida Almirante Reis 71, 1150-012 Lisbon, Portugal.

ARTICLE INFO

Article history:
Received 31 July 2012
Received in revised form 24 January 2013
Accepted 23 July 2013
Available online 22 August 2013

JEL classification:
G01
G13
G21

Keywords:
Contingent Claims Analysis
Systemic risk
Banking crises

ABSTRACT

Based on Contingent Claims Analysis, this paper develops a method to monitor systemic risk in the European banking system. Aggregated Distance-to-Default series are generated using option prices information from systemically important banks and the STOXX Europe 600 Banks Index. These indicators provide methodological advantages in monitoring vulnerabilities in the banking system over time: (1) they capture interdependence and joint risk of distress in systemically important banks; (2) their forward-looking feature endow them with early signaling properties compared to traditional approaches in the literature and other market-based indicators; (3) they produce simultaneously smooth and informative long-term signals and quick and clear reaction to market distress and (4) they incorporate additional information through option prices about tail risk and correlation breaks, in line with recent findings in the literature.

1. Introduction

One of the key lessons from the financial crisis generated in the US subprime mortgage market is the need to enhance and extend the systemic risk's analytic toolbox to guide policymaking. The interest in systemic risk analysis is not that new[1] and was driven by last decade's financial innovation, liberalization and development. However, the dynamics of this financial crisis has triggered renewed attention and operational focus at a global scale.

The theoretical and empirical work of defining and assessing systemic risk in banking is making great progress (de Bandt et al., 2009). As far as empirical research is concerned, different approaches have emerged in the literature to detect, to measure systemic risk and to attribute systemic risk to individual institutions in the financial system. These new approaches are either replacing or supplementing existing methodologies that failed to capture vulnerabilities prior to this crisis.

This paper introduces a method to detect and monitor systemic risk in the European banking system based on Contingent Claims Analysis. Without strong additional modelling assumptions, this paper generates two series of aggregated Distance-to-Default indicators based on data from balance sheets, equity markets and option markets. The first series is the Average Distance-to-Default (ADD), an average of individual forward-looking Distance-to-Default series, computed using individual equity options. This indicator is standard in the literature and informs about the overall risk outlook in the system and the intensity of systemic distress. The second series is a Portfolio Distance-to-Default (PDD) that aggregates balance sheet information into a single entity and uses the equity and option prices information of the STOXX Europe 600 Banks Index. This indicator supplements the information of the Average Distance-to-Default, outlining the joint risk of distress and embedding interrelations between the banks in the system, and also the dynamics between the bank index and its core constituents under tail risk events and possible correlation breaks. In option pricing theory terms, these two indicators are a basket of options (ADD) and an option on a basket (PDD), where their difference is primarily (yet not only) driven by interdependence among their constituents.

Other models are similar to mine in that they aim to capture and quantify joint risks and interdependence with the use of market-based information and include risk drivers such as leverage, size, interbank linkages or maturity mismatch. Recent and popular contributions and their extensions along these lines are found in Adrian and Brunnermeier (2011), Acharya et al. (2010), Brownlees and Engle (2011), Diebold and Yilmaz (2009), Huang

E-mail address: martin.saldias@bportugal.pt

[1] See for instance European Central Bank (2007b) for an overview of the early research approach in this area conducted by the ECB, the Bank of Japan and the Federal Reserve.

1572-3089/$ – see front matter © 2013 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.jfs.2013.07.003

et al. (2009, 2012), Drehmann and Tarashev (2011b) and Tarashev et al. (2010), Drehmann and Tarashev (2011a). Galati and Moessner (2011) provide a comprehensive review of this literature and their relative performance. The approach in this paper is based on Contingent Claims Analysis and it is therefore closer to the work reviewed in Gray and Malone (2008) and extended in Gray and Jobst (2010) and Gray et al. (2010) to include sovereign risk. Compared to the literature cited above, the CCA approach produces time-varying point estimates of risk indicators that can be periodically updated, becoming more comprehensive than alternative (conditional) measurement approaches to systemic risk (Gray and Jobst, 2013).

Recent contributions in the CCA literature include multivariate density estimations, like the Systemic CCA measure in Gray and Jobst (2013), in order to assess the marginal contribution of financial institutions to systemic risk. In contrast to the approach in this paper, this methodology introduces formally the dependence structure of the financial institutions in the system to assess systemic tail risk and to capture systemic risk contributions. The aim in this paper is limited to set up the framework of a monitoring device that incorporates the information from different market sources with a strong forward looking component and ability to adapt to changing market conditions. As a result, the dependence structure among the banks in the financial system embedded in PDD and ADD series is purely data-based and come from the differences between the benchmark bank index and its constituents, especially in the case of options.

The use of individual and index option information incorporates two innovations in the literature. First, it makes use of information from an additional liquid market, the single equity and equity indices options markets. Second, the construction of the indicator avoids arbitrary or strong modeling assumptions or dependence structures among banks in the sample which tend to weaken its information quality and rely on past information that hinders its ability to anticipate events of high systemic risk. In other words, the information potential of individual equity and equity index options allow the Distance-to-Default indicators to become a forward-looking analytic tool to monitor systemic risk, interdependence between the banks and extreme events in the financial system over time.

The series generated in the paper show a lower noise-to-signal ratio, and allow one to tracking the build-up of risks in the system with a long-term perspective. They are computable on a daily basis and incorporate up-to-date market sentiment from option prices. In doing so, they react quickly to specific market events, when volatility of the components of the system increases and correlations tend to reveal changing interdependences and stock prices moving in tandem. The option prices information also enhances significantly the forward-looking properties of the series and makes their signals timelier than in either literature of market-based indicators or alternative specifications similar to mine in employing comparisons between a portfolio and an average of its components. Finally, information about tail-risk events and correlation breaks are detected through option prices as market events affecting the whole of the banking system have heterogeneous effects on individual banks.

The rest of the paper is structured as follows. Section 2 first reviews the Contingent Claims Analysis' main features and applications -the supporting theory of this approach- then makes reference to a specific application of the literature that is a standard tool of systemic risk analysis. In Section 3, the paper provides a detailed description of the method which produces individual and aggregated series of forward-looking Distance-to-Default (DD) indicators using the information of the European banking system and its core systemic components. Section 4 reports the main results of the DD series, highlighting its main attributes as a systemic risk indicator and its advantages when compared to possible alternative specifications in the related literature. Section 5 concludes.

2. Theoretical underpinnings

2.1. Contingent Claims Analysis

Contingent Claims Analysis (CCA) is a framework that combines market-based and balance sheet information to obtain a comprehensive set of company financial risk indicators, e.g: Distance-to-Default, probabilities of default, risk-neutral credit risk premia, expected losses on senior debt, etc. Based on the Merton (1974) approach to credit risk, CCA has three principles: (1) the economic value of liabilities[2] is derived and equals the economic value of assets (which reflect the present value of future income); (2) liabilities in the balance sheet have different priorities (i.e. senior and junior claims) and associated risk); and (3) the company assets distribution follows a stochastic process (Echeverría et al., 2006; Gray et al., 2010).

In this context, as liabilities are viewed as contingent claims against assets with payoffs determined by seniority, equity becomes an implicit call option on the market value of assets with strike price defined by the default or distress barrier (determined by the risky debt). As company assets decline and move closer to a default barrier, the market value of the call option also falls. The normalized distance between market value of asset and the default barrier is called Distance-to-Default (DD) and constitutes the financial risk indicator used in this paper to assess and monitor systemic risk in Europe's banking sector.[3] Distance-to-Default indicates the number of standard deviations at which the market value of assets is away from the default barrier and can be scaled into probabilities of default, if the distribution of assets were known.

This method has initially been applied to company default risk analysis and disseminated by Moody's KMV,[4] proving very effective in prediction of ratings' downgrading and company default. Gray and Malone (2008) provide a comprehensive review of methodologies and related literature. The CCA-based indicators are attractive in that they combine different sources of information, thus making stress detection in the banking system more comprehensive compared to indicators based on a single source.[5]

DD series and other CCA-derived risk measures incorporate forward-looking expectations and are easy and data-efficient to compute at high-frequencies. They are also good indicators of market sentiment, relatively less affected by government interventions and they incorporate most relevant elements of credit risk. Results in Gropp et al. (2004, 2006), International Monetary Fund (2009) and Tudela and Young (2003), inter alia, show also that DD improves and may even outperform other indicators of financial stability including bond or CDS spreads. More recently, the International Monetary Fund (2011) reports that aggregated

[2] Deposits and senior debt plus equity in the case of banks.

[3] This paper is limited to the development of Distance-to-Default series and their application as a systemic risk monitoring tool. The use of the rest of risk indicators derived from this methodology remains for further research. The indicator is also known as Distance-to-Distress in some applications in order to highlight the fact that, especially in the financial sector, actual defaults seldom occur. I chose not to make that distinction even though the indicators in the paper are designed to detect and monitor distress.

[4] See for instance Arora et al. (2005), Arora and Sellers (2004), Crosbie and Bohn (2003), Dwyer and Qu (2007).

[5] As an example, Krainer and Lopez (2008) show that informational properties of equity and bond markets vary according to the state of stress and the proximity of corporate default.