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Systemic risk measures[☆]

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HIGHLIGHTS

- We construct systemic risk measures.
- We use a Contingent Claims and a complex networks Approach.
- Our indicators capture the stress dependency structure.
- The method helps identify Systemically Important Banks.
- We can track the evolution of systemic risk over time.

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ABSTRACT

In this paper we present systemic risk measures based on contingent claims approach and banking sector multivariate density. We also apply network measures to analyze bank common risk exposure. The proposed measures aim to capture credit risk stress and its potential to become systemic. These indicators capture not only individual bank vulnerability, but also the stress dependency structure between them. Furthermore, these measures can be quite useful for identifying systemically important banks. The empirical results show that these indicators capture with considerable fidelity the moments of increasing systemic risk in the Brazilian banking sector in recent years.

1. Introduction

Since the early 19th century it is well known that one bank may jeopardize the soundness and/or confidence of the whole financial sector [1]. The advances in information technology and computing sectors, among other factors, have paved the way for financial innovation and strong and continuous integration between global and local financial markets. As a consequence, the complexity and systemic consequences of risk materialization have largely increased over time.

Unlike other types of risk to which financial institutions are exposed, systemic risk is much more recognized for its effects rather than its causes. Systemic risk generally occurs in many distinct forms and is the result of the interconnection

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of a number of factors. These traits make it difficult to describe systemic risk clearly *ex ante*, but, once materialized, this risk becomes easily identifiable. The consequences of a systemic risk materialization can be quite dire, specially when affecting the real sector.

Ever since the genesis of the discipline, researchers have tried to find ways to better comprehend systemic risk and the means to mitigate it. The sub-prime crisis has renewed the interest of academics, regulatory bodies and Central Banks on this issue. The result was the production of a wide array of papers regarding the measurement of systemic risk, its regulation and the identification of threats to financial system stability.

The definition of systemic risk is the first step to measure it accurately. However, despite the ever increasing number of works regarding this issue, there is still no agreement over a unique systemic risk definition. For example, Ref. [2] defines it as the risk of occurrence of a chain reaction of bankruptcies. The European Central Bank [3], in turn, describes systemic risk as the probability that the default of one institution will make other institutions default. This risk interdependence would harm liquidity, credit and the stability and confidence of the markets. Acharya et al. [4] affirm that systemic risk may be seen as generalized bankruptcies or capital market freezing, which may cause a substantial reduction in financial intermediation activities. More recently, the related literature has posed systemic risk definitions from the quantitative viewpoint. In line with that, Puzanova and Düllmann [5] define systemic risk as the potential losses to both depositors and investors that it causes when a systemic event with low probability occurs.

On the one hand, a wide spectrum of definitions may indicate the comprehension of the various nuances of systemic risk. On the other hand, it makes systemic risk measurement harder. Besides, it suggests the need for more than one type of measure in order to properly capture the complexity and the adaptability of the financial system. Using a single measure might not be adequate or even possible for its relative simplicity may not reflect an unpredicted aspect or a new mechanism created by the market. In contrast, a robust framework for monitoring and managing financial stability must incorporate a range of perspectives and a continuous process of revaluation of the financial system structure and adaptation of systemic risk measures to reflect eventual changes. This premise is supported by the literature, where one may find various models of systemic risk measurement.

Lehar [6] proposes a method, derived from correlated assets portfolios, to measure systemic risk. Based on the structural approach, he uses the contingent claims analysis to estimate the market value of a bank's assets and Monte Carlo simulations to encounter the probability of these assets to fall below a given proportion of the total assets of the financial system. Gray et al. [7] also use the contingent claims analysis to provide a general form of systemic risk measurement between countries and various sectors of the economy.

We can find many other examples of systemic risk measuring in the literature. Among them, we highlight: De Jonghe [8] uses the extreme-value analysis; Acharya et al. [4] use Systemic Expected Shortfall (SES) to measure the contribution of each single financial institution to systemic risk, i.e., its propensity to become undercapitalized when the system is also undercapitalized. Brownlees and Engle [9] measure systemic risk by focusing on the Marginal Expected Shortfall (MES). They develop ways to estimate and predict MES using econometric tools (GARCH and DCC—Dynamic Conditional Correlation) together with non-parametric tail expectation estimators. Using CDS (Credit Default Swap) of financial firms and correlations between their stock returns, Huang et al. [10] estimate a systemic risk indicator as the credit portfolio's expected loss that is above a proportion of a sector's total obligations. Huang et al. [11] propose some methodological changes developed by Huang et al. [10], such as the heteroskedasticity of banks interconnectivity and the possibility of estimating each bank's contribution to systemic risk. Adrian and Brunnermeier [12] measure the Value of Risk (VaR) of the financial sector conditioned by the VaR loss in one single bank of the system, denoted by CoVaR, using quantile regressions. Segoviano and Goodhart [13] define the financial sector as a portfolio of individual financial firms and build the multivariate density of this portfolio tail adjusted with empirical data from each institution. This density provides some measures of systemic risk. This paper is related to Segoviano and Goodhart [13] and to Jin and de Simone [14]. Both papers present banking stability measures using the Consistent Information Multivariate Density Optimizing Methodology (CIMDO) proposed by Segoviano [15].

There are alternative approaches to measuring systemic risk that take into account insolvency and contagion [16], susceptibility and diffusion of potential impacts [17], network centrality measures [18], clustering coefficients [19] and MST [20]. These methods can be used to perform banking stress tests and are useful for bank supervision purposes.

According to Borio et al. [21], problems with the financial system usually arise from the banks' underestimation of exposures to their counterparts due to a common factor. In fact, the literature shows that it is rare the contagion associated to an individual bank failure due to purely institution-specific factors. Based on this statement, we define systemic risk as a generalized increase in the probabilities of default as a consequence of an event that make financial markets stop functioning properly, leading to an increase in asymmetric information. In this outlook, prices no longer provide useful information for decision making. Systemic risk steams from different sources. In general, a systemic event starts with a shock to a specific market, which is amplified through different channels to other markets (including real sector). While credit risk is a very important source of risk, banks' connectivity is an important loss amplifier. This paper focuses on systemic risk that comes from bank credit risk and from the connectivity of banks.

This paper contributes to the literature related to the construction of systemic risk indicators in several ways. First, using accounting data and following the approach in Ref. [22], we adapt the method for building the banking system multivariate density proposed by Segoviano and Goodhart [13]. Accounting data becomes relevant to analyze the banking system stability when Credit Default Swaps, stocks and other public information are not available for every bank. Balance-sheet data do not