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Evaluating systemic risk using bank default probabilities in financial networks☆

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ABSTRACT

In this paper, we propose a novel methodology to measure systemic risk in networks composed of financial institutions. Our procedure combines the impact effects obtained from stress measures that rely on feedback centrality properties with the default probabilities of institutions. We also present new heuristics for designing feasible and relevant stress-testing scenarios that can subside regulators in financial system surveillance tasks. We develop a methodology to extract banking communities and show that these communities have a relevant effect on systemic risk. We find that these communities are mostly composed of non-large banks, suggesting that regulators should also broaden their surveillance efforts to these banking communities other than to the usual SIFIs and large banks. Finally, our results provide insights and guidelines for policymakers.

1. Introduction

The occurrence of international financial crises in recent years has highlighted the need of understanding and assessing systemic risk. Besides the identification of mechanisms that may lead a financial system to a systemic crisis, it stands as an important task to identify the potential financial institutions (FIs) that may play a key role on a crisis onset. Furthermore, it is essential to have tools for assessing financial system conditions at any given time: is it next to a crisis? Is it possible to

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intervene to mitigate this risk and assure the financial stability? How do we optimally accomplish that, using the minimum possible resources to reach the desired effect?

Systemic crises usually begin in a single or small group of FIs and spread to a larger portion of the financial system, eventually affecting the real sector. Besides the surveillance of individual FIs, it is necessary to identify contagion mechanisms and define actions to mitigate the effects that systemic outbreaks provoke. The literature has been concerned with the possibility that the manner in which FIs relate to each other in a network is relevant to the contagion process. See, for instance, Boss et al. (2004), Furfine (2003), Inaoka et al. (2004), and Soramäki et al. (2007).

Interbank markets play an essential role in a well-functioning integrated financial system through the provision of liquidity among banks. FIs lend or borrow money among themselves and make commitments of repayments at the due dates. If an FI fails in the repayment of its loans, its creditors may have trouble in honoring their debts, propagating the effects of the original failure to other institutions, in a contagion process. Problems affecting one institution may spread to other ones and even to institutions across international borders.

The contribution of this work is threefold. The first contribution is the proposal of a novel network-based scheme for evaluating systemic risk, which is inspired by the well-known DebtRank methodology (Battiston et al., 2012) and Merton structural model (Merton, 1974). Our framework combines financial stress levels of banks, which we evaluate using network measures that rely on feedback centrality mechanisms, together with the default probability (DPs) of banks, which we compute using banks' balance sheets. We then estimate the systemic risk using the expected impact of the financial system. We motivate the use of a network-based approach because it is able to capture topological aspects of the data relationships, which in turn may help in extracting nonlinear features of the risks embodied into the FIs relationships (Silva and Zhao, 2012, 2015). We analyze this new scheme in the Brazilian interbank market network. With this modification, we move forward with respect to the methodology presented by Battiston et al. (2012), by modulating the impact effects estimated by their DebtRank methodology proportionally to the DPs of the institutions. To the best of our knowledge, this is the first paper that evaluates systemic risk by combining DPs and loss given default (LGD) using network analysis methodologies.

The main finding is that medium-sized banks contribute more to the systemic risk in the Brazilian interbank market network, followed by small and large banks, in this order. The reasoning behind this is that, even though large banks inflict the largest financial stress levels, their DPs are very small, yielding a very small modulated expected impact in our proposed framework. Opposed to that, medium- and small-sized banks, though only causing moderate or small financial stress levels, hold non-negligible DPs. Putting together these two indicators make their contribution to the systemic risk in the interbank market superior to that of large banks.

The second contribution of this paper is the development of new heuristics for designing stress-testing scenarios using network analysis tools. From a regulator viewpoint, a key issue in stress testing is how to develop credible and relevant scenarios that can help in assessing overall risks for the banking system. In this respect, most research to date has focused on how to calculate expected losses given that fixed initial scenario occurred. There is very little discussion in the literature on how to construct scenarios, which may be relevant for stress-testing purposes. A relevant scenario for banking stress tests would be to detect those banks that are likely to jointly default and to evaluate the impact of these joint defaults on the banking system. With this tool, we can also assess how they may lead to cascade failures and losses amplification.

We develop a methodology to detect bank communities that are likely to default jointly. While the main literature stream makes efforts to finding the systemically important financial institutions (SIFI) according to some centrality criterion (Papadimitriou et al., 2013), here we devise a strategy that relies on the identification of bank communities that potentially can inflict large losses to the financial system. We employ a community detection algorithm to uncover these communities with non-negligible joint default probabilities and show that they have larger systemic risk impacts than those provoked by large banks. This suggests that, although size and interconnectedness matters, it is crucial to evaluate the emergence of these kinds of bank communities, which may also be a trigger for systemic risk. Moreover, the identification of whether or not these bank communities exist stands as an important practical task, as bank communities with high pairwise joints DPs may turn the occurrences of joint bank defaults from rare to probable events.

Our third contribution is the development of a new systemic risk measure for the banking system: the systemic stress amplification. While the expected stress measures the additional stress that results from the combination of default events (1, 2 and 3-bank simultaneous defaults) weighted by their probability, the systemic stress amplification identifies the general condition of the capitalization of the banking system, providing an information of additional stress per unit of initial shock. We note that the measure responded coherently to liquidity issues related to foreign capital inflows and bank reserves regulation, in 2010 and 2012.

The recent financial crises have provided evidence for the following contagion channels. Risk concentration channel, in which a significant number of banks is exposed to a common risk factor; balance sheet contagion channel, in which failure on debt repayment causes the write off of these assets by the corresponding creditors; price-mediate contagion, related to asset fire sales, that induces losses due to marking-to-market or to having to sell assets that are being fire-sold; and the occurrence of illiquidity spirals, due to margin calls or short-term liabilities. Though these contagion channels can potentially propagate large losses, we focus on the balance sheet contagion channel in this paper. In addition, our framework only deals with solvency issues. Hence, we do not take into account the liquidity of the institutions. Despite this restriction, this approach has the advantage of measuring the stress levels of the entire financial system or of individual institutions. This positive property gives room to the analysis of sources of stress in the financial system, as well as to the identification of groups formed by SIFIs. We can use the proposed methodology as an auxiliary tool for monitoring the financial system,