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Complex networks and banking systems supervision

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HIGHLIGHTS

- We propose an auxiliary methodology for efficient and swift bank system supervision.
- We identify potential contagion pathways that a Central Bank can exploit.
- We suggest that a regulator may focus on "core" banks instead of just on "big" banks.
- We propose controlling a complex network through a subset of connected nodes.

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ABSTRACT

Comprehensive and thorough supervision of all banking institutions under a Central Bank's regulatory control has become necessary as recent banking crises show. Promptly identifying bank distress and contagion issues is of great importance to the regulators. This paper proposes a methodology that can be used additionally to the standard methods of bank supervision or the new ones proposed to be implemented. By this, one can reveal the degree of banks' connectedness and thus identify "core" instead of just "big" banks. Core banks are central in the network in the sense that they are shown to be crucial for network supervision. Core banks can be used as gauges of bank distress over a sub-network and promptly raise a red flag so that the central bank can effectively and swiftly focus on the corresponding neighborhood of financial institutions. In this paper we demonstrate the proposed scheme using as an example the asset returns variable. The method may and should be used with alternative variables as well.

1. Introduction

The financial sector and more specifically banking system regulation and monitoring is important to maintain economic stability and avoid episodes of bank distress. Banking crises result in significant costs to the whole economy: the IMF in 1998 [1] estimated that the cumulative output loss of a banking crisis in the OECD countries was 10.2% of GDP. Hoggarth et al. [2] studying 33 banking crises over 25 years find that the cumulative costs to the economy were in average 15%–20% of GDP. A more recent IMF study [3] estimates that the total cost of the 2007–2009 crises in thirteen countries resulted in an average of 24.5% output loss, a 23.9% increase in public debt as % of GDP and had a 4.9% of GDP direct fiscal cost. The economic cost of a bank crisis is not associated only with a decline in real output it also extends to household consumption as the latter plays an important role in the adjustment procedure after the crisis [4]. As Ackermann [5] points out these costs tend to be lower when the supervision of the banking system is close and effective. In the literature there is also an

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extensive list of studies that examine the determinants of a bank systemic failure—see for example Demirgüç–Kunt and Detragiache [6,7] where the role of deposit insurance in 61 countries over 18 years spanning the period 1980–1997 is tested and found to affect bank stability.

The financial crisis of 2007–2008 stressed the issue of effective bank supervision and swift response from the regulator in times of bank distress: "The global financial crisis has highlighted the importance of early identification of weak banks: when problems are identified late, solutions are much more costly" [8]. It has also become even more evident that assessing potential contagion risks from banking shocks must be done timely and efficiently. The cascade failures of 2008 and 2009 assert the need for additional monitoring tools and supervision of the financial system. These would allow prompt and decisive action to be taken limiting the associated losses. As a result, the EU leaders in October 2012 agreed to have the ECB closely supervise all six-thousand Eurosystem banks. The reasoning is that a single regulator will effectively assist struggling banks in receiving immediate bailout funds directly through the European Stability Mechanism (ESM). A single supervising authority will thus minimize the adverse effects of asymmetric information and uncertainty, building credibility for the ESM to raise the necessary funds for intervention. Comprehensive supervision of all six-thousand banks is of course cumbersome and may obstruct the identification of distress signals and possible contagion. Barth et al. [9] study bank regulations in 150 countries and assess the validity of the Basel committee's approach to regulation and they also point out that banking restrictions adversely affect the banking system's efficiency and performance. Thus, stricter regulation comes at the expense of reduced economic performance. Better monitoring on the other hand – like the one we propose in this paper – is not associated with any extra burden imposed on financial institutions.

An important branch of the banking literature has focused on the effects of interbank connections on the banking systems. This literature has shown that direct exposure may lead to situations that may threaten the financial system and therefore should be monitored. The aim of this literature is to explore direct links between banks and provide metrics for contagion, bilateral exposure and systemic risk. Several papers employ different datasets and present results for a variety of countries (see for example Refs. [10–19]). On the other hand, other papers focus on developing theoretical models for interbank connections [20–22]. As Gai et al. [23] show, the shape and internal characteristics of a banking network are important factors in determining financial contagion.

This paper proposes a methodology to identify and reveal the "core" instead of just "big" banks that are central within a bank network and the potential pathways for contagion. We propose that this methodology may be used as an auxiliary early warning system within the central bank's arsenal. In addition to the current supervision procedure, the core banks suggested by the proposed scheme can provide a red flag to the regulator for close and detailed attention not only to the core bank but to the whole sub-network associated with it. Moreover, since this methodology requires minimal additional intrusion to the banking institutions and supervising effort for the regulator it may not interfere with the efficiency issues of bank regulation raised by the literature (see for example Ref. [9]) nor increase the monitoring cost of the regulator.

The rest of the paper is organized as follows. In Section 2 we present the methodology. In Section 3 we provide the empirical results, and finally Section 4 concludes the paper.

2. The methodology

We propose a methodology for additional parallel monitoring of the whole banking network using only a subset of banks that are identified as "core". This monitoring system can and should be used simultaneously with the existing ones. It can serve as a minimum cost early warning system increasing efficiency in terms of prompt and accurate intervention. The "core" banks are a subset that contains the most representative banks from the complete network in terms of cross banking linkages and correlations. These core banks can serve as control gauges for the rest of the network and highlight possible contagion paths. The concept is quite simple and easy to implement: first, we construct an undirected graph based on the cross-correlations from a chosen key relevant variable from the banks' financial statements. Then, we compute the Minimum Spanning Tree (MST) of the complete network: the minimum sized interconnected subset that connects all the nodes of the network. The MST has been used in the past in economics and finance to identify and describe stock market networks [24–26], interest rates of various maturities [27], bond markets [28], etc. It has an interesting property for our case: the cardinality of the direct neighbors for every node is a measure of its importance within the network (in graph theory jargon this is referred to as node or vertex degree). Finally, we use the algorithm of a simple and efficient heuristic method that identifies the core banks in the MST.

In what follows, we present the theoretical aspects of the proposed methodology. Empirical demonstration with an application on a small bank network using the log return of total assets as the key variable will be presented in Section 3. Other variables can alternatively be employed, such as credit portfolios, return on equity, total deposits, interbank loans and non-performing loans. The regulator of course can use high frequency daily data providing a real time illustration of the MST.

The initial dataset consists of the selected variable of N banks for a set of T periods: $a_i(t)$, where $i = 1, \ldots, N$ is the individual bank index and $t = 1, \ldots, T$ is the time index. We calculate the symmetric $N \times N$ correlation matrix C, where every element $C_{i,j}$ corresponds to the correlation between the i-th and the j-th banks' selected variable [29]. The similarity distance between a couple of banks is calculated by the D metric:

$$D_{i,j} = \sqrt{2\left(1 - C_{i,j}\right)}. \tag{1}$$