Finding the core: Network structure in interbank markets

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ABSTRACT

This paper investigates the network structure of interbank markets. Using a dataset of interbank exposures in the Netherlands, we corroborate the recent hypothesis that the core periphery model is a ‘stylised fact’ of interbank markets. We find a core of highly connected banks intermediating between periphery banks and pay particular attention to model selection. Our analysis can help improve systemic risk assessments, especially as more granular data is becoming available.

1. Introduction

Understanding complex interbank markets is crucial for safeguarding financial stability, as became clear during the financial crisis. Whereas the relevance of the network structure prior to crisis was mentioned only infrequently, it has now caught the attention of both academics (Tirole, 2011) and policy makers (Haldane, 2009; Yellen, 2013). Systemic risk and contagion have become keywords in finance, and debate on their precise definition and implications is ongoing.

Traditionally, the interbank market has been considered without taking the network structure into account. Bhattacharya and Gale (1987) for instance propose that the main reason for interbank trade is to co-insure against idiosyncratic liquidity shocks. For various reasons, banks might not be indifferent with whom they transact, giving rise to non-random networks. One reason might be that interbank lending functions as a peer-monitoring device (Rochet and Tirole, 1996). Recently, some have argued forcefully that relationships matter in the interbank market. Cocco et al. (2009) show that borrowing banks in Portugal pay a lower interest rate on loans from banks with whom they have a stronger relationship, and Bräuning and Fecht (2012) analyse relationship lending in Germany during the financial crisis of 2007–2008. Such relationships will be reflected in the network structure.

As the theoretical literature started to consider networks, it became clear that the actual structure of linkages between banks affects the stability of the systems and the possible contagion after large shocks. In a seminal contribution, Allen and Gale (2000) use stylised examples to show that the fragility of the system depends crucially on the structure of interbank linkages. If a network is ‘complete’, i.e. all banks are connected to all other banks, a shock to a single bank can easily be shared and thus the stability of the system is safeguarded. If instead
the network becomes clustered, spillovers to some of the banks can become substantial.\footnote{The examples in Allen and Gale (2000) are clearly simplified and subsequent research has shown that many other aspects are relevant. For instance, Gai et al. (2011) show in a model with unsecured claims and repo activity that systemic liquidity crises as seen in 2007–2008 can arise with funding contagion spreading throughout the network. Castiglionesi (2007) argues that it is not so much the structure of the market but rather the lack of complete contracting. See Chinazzi and Fagiolo (2013) for a survey of research exploiting networks to explain contagion and systemic risk in financial markets.}

Given its importance in theoretical work, the empirical analysis of financial networks is still lagging behind. Datasets are few and far between. Interbank exposures have mainly been used for stress test exercises. As noted by Upper (2011) in an overview of this literature, the estimated contagious effects are limited.\footnote{Studies include Furfine (2003), Upper and Worms (2004), van Lelyveld and Liedorp (2006), Degryse and Nguyen (2007), and Mistrulli (2011).} This is not surprising as the data generally only covers a single market and because behaviour does not change conditional on the state of the world. The limited literature that uses the tools of network theory and comes closest to our approach is discussed in Section 2.

The first goal of this paper is to find a network model that best describes the structure of actual interbank markets. This is important, as the shape of the observed network is a key determinant of the stability of the system, as discussed in Section 5. To this end we will analyse a long running panel of bank links in the Netherlands. We will focus on the estimation of a core periphery (CP) model as recently applied by Craig and von Peter (2014). We will define this model more formally below, but loosely speaking this is a structure where core banks intermediate between dependent periphery banks. Discriminating between these two types of bank is very useful for bank supervision in practice.

On a more technical note, we place more emphasis on model selection than previous studies in proposing the core periphery model for the interbank market. Another structure that recently has been put forward as a good description for interbank networks (e.g. König et al., 2014) is the so-called nested split graph (NSG). We clarify the apparent confusion between the CP and NSG models, and find a better fit of the CP model in terms of the error score. Using Monte Carlo simulations, we show that the error score is a satisfactory measure of fit to discriminate between networks close to either an CP or NSG network. The simulations also show that the good fit of the CP model is highly unlikely to be generated by random processes of other well-known, stochastic network models. Overall, by combining various existing methods to fit networks on the Dutch data, we make clear that the core periphery model gives a better fit to the interbank market than others used in the literature.

For the Netherlands we find a core of around 15 banks. This core – unsurprisingly – almost always includes all the large banks. Some small banks, however, are also part of the core (although we cannot discuss these because of confidentiality reasons). For a typical period, Fig. 1 shows that the model produces only few errors: There are few missing links in the core, and also relatively few existing links in the periphery.

The second goal is to place the network structure results in context. Are core banks different in terms of (regulatory) risk measures or business models? We will amongst other findings, show that core banks have, on average, lower capital buffers. So, even though they might be seen as more systemic, their buffers are lower. Taking the network structure into account in theoretical modelling and stress testing will be a crucial next step in developing systemic risk assessments. In the core periphery model a small set of core banks is highly connected, while periphery banks are not connected with each other but only to the core. The core banks are thus systemically more important in passing through shocks and should hence be monitored carefully to maintain financial stability.

The remainder of this paper is structured as follows. In Section 2 we discuss different network models that have been applied to the interbank market with an emphasis on the core periphery network. Section 3 describes our dataset and the market network structure. Section 4 contains our main estimation results including a discussion on testing and model selection. In Section 5, we relate our results to financial stability. Section 6 concludes.

2. Network models

Mathematical network or graph theory has been applied to many different fields including biology, technological networks, and information science (see Newman, 2010 for a comprehensive review). In this section we will discuss both stochastic (where link formation is determined by some random process such as the Erdős–Rényi random graph and the Barabási–Albert scale-free model) and deterministic models (where a structure is postulated such as nested split graphs and core periphery network)\footnote{We define a ‘network model’ as a simple representation of a structure of bilateral relations (in our case interbank loans). Thus the word ‘model’ does not refer here to a formal microeconomic characterisation of banks’ decisions. For the four models considered, however, it will become clear that latent microeconomic models exist that capture the concepts of random interaction, preferential attachment, counterparty reliability, and intermediation.}. After describing the Dutch interbank market data in the next section, we will then, in Section 4, compare the relevant network models and will find that the CP model best explains the data.
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