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Network formation in the interbank money market: An application of the actor-oriented model☆

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ABSTRACT

This paper investigates the driving forces behind banks' link formation in the interbank market by applying the stochastic actor oriented model (SAOM). Our data consists of quarterly networks constructed from the transactions on an electronic trading platform (e-MID) for interbank credit over the period from 2001 to 2010. The analysis strongly supports the hypothesis that the existence and extent of past credit relationships is a major determinant of credit provision (i.e., link formation) in subsequent periods. We also find explanatory power of size-related characteristics, but little influence of past interest rates. The actor-based analysis, thus, confirms the prevalent view that interbank credit is mainly determined by lasting business relationships and less so by competition for the best price (interest rate). Our findings also show that topological features exert a certain influence on the network formation process. The major changes found for the period after the onset of the financial crisis are that: (1) large banks and those identified as 'core' intermediaries became even more sought of as counterparties and (2) indirect counterparty risk appeared to be more of a concern as we find a higher tendency to avoid indirect exposure as indicated by clustering effects.

1. Introduction

In recent years the focus of banking regulation as well as the academic banking literature has started to shift from the analysis of the behavior of single banks to what is now called a systemic perspective. Pertinent literature has started to study the structure of the financial system from the viewpoint of a network approach.[1]

The literature analyzing the interbank market as a network has taken advantage of the fact that network related research has experienced a surge of interest recently in various scientific disciplines. The internet, friendship relations, cellular networks and ecosystems are just a few examples of complex systems investigated in terms of their network properties. The first applications of network theory to the banking system have been focusing on measures from the natural sciences describing the topology of the banking network to determine its general resilience or vulnerability in the presence of shocks. Examples are Inaoka et al. (2004) for the Japanese interbank market, Boss et al. (2006) for the Austrian banking sector, Soramäki et al. (2007) for the US Fedwire network, Bech and Atalay (2010) for the US Federal funds market and De Masi et al. (2006) and Iori et al. (2008) for the Italian interbank market. The most prominent findings of these studies are: (a) that degree distributions are characterized by pronounced right hand skewness,[2] (b) the density of the network is relatively low, (c) the networks show disassortative mixing with respect to their degree, (d) the average shortest path is very small (i.e., the networks exhibit a small world structure).

More recently, Craig and von Peter (2014) and Fricke and Lux (2015a) show that the interbank network is close to a core-periphery structure, in the spirit of Borgatti and Everett (2000), for both German and Italian data of interbank credit relationships. This

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[1] See, e.g., Iori et al. (2006), Nier et al. (2007) and Haldane and May (2011).

[2] Some of the authors quoted above have claimed that the degree distribution follows a power law (which is a signature of a scale-free network topology). However, in the present data set, Fricke and Lux (2015b) found no evidence of such power-law behavior.

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provides support to the idea that a few money-center banks (the core) are highly interconnected among themselves and act as intermediaries for the banks in the periphery, and actually suggests that banks take into account topological features of the network of interbank credit and even actively contribute in shaping this system in a particular way.

Another important finding of the econometric literature on interbank credit is what is called 'relationship banking'. This means that banks show a preference for continuing credit relationships to other banks, rather than shopping for better prices (which here are interest rates) and avoid to frequently change their creditors or debtors. The high persistence of credit links in extant data confirms this hypothesis. The rationale of this behavior might lie in the need to built up stable and reliable banking relationships that can be activated whenever the need for liquidity arises. Preferential lending might go along with preferential interest rates as a reward for a continuing, reliable relationship. Cocco et al. (2009) and Massimiliano (2012) have provided evidence for such lending behavior governed by persistent relationships. Cocco et al. (2009) show for the Portuguese interbank market that banks pay lower interest rates on loans from banks they had frequently traded with in the past. Massimiliano (2012) also emphasizes long lasting trading relations and their positive effect during the global financial crisis (GFC) in the Italian interbank market. Iori et al. (2014) model an agent-based interbank market with relational trading and compare the generated networks with real world networks aggregated from transactions of the e-MID platform.

In this paper we approach the same topic from a complementary perspective: we use the stochastic actor-oriented model (SAOM) developed by Snijders (1996) to analyze the dynamics of the interbank network from a behavioral perspective. While the above studies use more traditional statistical methods, the SAOM analyzes the evolution of the network from an actor point of view and so provides an avenue for identification of the driving forces behind banks' decisions about which other banks to choose as counterparties in the interbank market. Stochastic actor-based models have been applied to a variety of research questions in different fields. They have been used to investigate the early evolution of the network of friendships among pre-school children (Schaefer et al., 2010), the influence of friendships and acquaintanceships on television use and smoking habits among adolescents (Mercken et al., 2010; Steglich et al., 2012), and the influence of networks of acquaintanceships on the formation of norms of individuals in different professional environments (e.g., de Klepper et al., 2010; Lazega et al., 2012). One advantage of an actor-based approach against other statistical approaches to network analysis lies in the possibility to distinguish between social selection and social influence. For example, individuals with the same behavioral attitude might become friends just because of this similarity or might have become friends independently from this attitude but might have converged over time to similar behavior because of the influence exerted by one on the other. Related questions and disentanglement of different endogenous and exogenous factors of influence on individual behavior are investigated in applications of the same approach to recruitment decisions (Koskinen and Edling, 2012), the impact of the mobility of managers on venture capital firms (Checkley and Steglich, 2007), and the analysis of seasonal changes on ecosystems (Johnson et al., 2009).

Investigating link formation from the perspective of the actors' decisions allows us to distinguish between the influence of individual characteristics and a variety of network structural processes that motivate the formation and dissolution of links. These might include measures that pertain to a particular node (e.g., its popularity as measured by the indegree), measures of tendencies in bilateral relationships (e.g., reciprocity) or 'higher' order attributes that provide evidence of overall structural characteristics of the network that influence the behavior of individual banks. All these effects (if significant) should shed light on the behavioral underpinnings of credit link formation. For instance, a high parameter of the indegree popularity effect would point towards reputational concerns with banks lending preferentially to those banks which many other banks appear to trust as well. Higher-order effects like transitive triplets could indicate hierarchical structures and concerns about the risk emanating from indirect links to other banks connected to the same counterparty.

Since network modeling of the interbank market is a relatively young subject, our aim is mainly to provide a most comprehensive analysis of the influence of various actor-specific and network effects. We, therefore, abstain from formalizing particular hypotheses to be tested, but provide arguments on how previous findings concerning the interbank market should be reflected in the outcomes of an actor-oriented model. As a consequence, we include a large number of network-related effects, actor-specific and dyadic variables as potential determinants of agents' link formation. While we adopt a list of standard effects from the SAOM literature, we have also added a number of effects that here may be important explanatory variables, but do not exist in this form in other applications. These include monadic network statistics, e.g., whether an agent has been in the core or periphery of the network in the previous period as determined by pertinent algorithms for the classification of agents. A second type of more uncommon effects pertains to the quantitative and qualitative features of links, i.e., the number of transaction executed that indicate the intensity of a relationship, and the interest rate that has been recorded in credit transactions between two actors, as well as the average interest rate that has been recorded for creditors or borrowers over all their transactions within one period. These features are allowed to interact with network measures in various ways to allow for different channels of influence of interest rates.

Our data set comprises all Euro denominated overnight transactions by Italian banks in the electronic market for interbank deposits (e-MID) from 2001 to 2010 aggregated into quarterly networks. Due to time heterogeneity the models are first estimated separately for each quarterly aggregate, and subsequently a meta analysis is conducted to reveal general behavioral tendencies as well as changes of behavior before and after the financial crisis.

The most salient result of our analysis is that banks heavily rely on lasting relations thus confirming the importance of 'relationship banking', although an electronic platform like e-MID reduces the direct costs of trading with 'new' counterparties practically to zero. In general, banks' choices of counterparties in the interbank credit market seem to favor hierarchical ordering on the local (no cycles) and global level (degree distributions). Moreover, reciprocity also appears to strengthen a relation. Furthermore, while we find a high level of the directed clustering coefficient for the complete network we do not observe that banks would put any value on such triadic intermediate relations in our disaggregate analysis. Hence, it appears that the high clustering statistics emerges unintendedly from the interaction of the individual banks. Another interesting aspect is that we find support for the relevance of the core-periphery distinction since the binary categorisation of banks along the results of Fricke and Lux (2015a) enters as a significant effect although the model also controls for the size of banks and many other effects capturing hierarchical aspects of the network. A number of changes are observed after the onset of the GFC: (1) while relationship banking still prevails in the crisis period, banks terminate a certain number of previously existing links and the overall density of the network declines, (2) larger banks and 'core' banks are becoming more popular, and (3) banks are avoiding intermediate relations more than before. These changes indicate that counterparty risk might have become a more important factor.