Networked relationships in the e-MID interbank market: A trading model with memory

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A B S T R A C T

In this paper, we introduce a model of interbank trading with memory. The memory mechanism is used to introduce a proxy of trust in the model. The key idea is that a lender, having lent many times to a borrower in the past, is more likely to lend to that borrower again in the future than to other borrowers, with which the lender has never (or has infrequently) interacted. The core of the model depends on only two parameters, which are common to all lenders: one is \( w \) and it is representing the attractiveness of borrowers, the other one is \( Q \) and it represents the memory of lenders in their assessment of counter parties. The stronger the \( w \) parameter, the more random the matching results between lenders and borrowers. The stronger the \( Q \) parameter, the more stable the trading relationships become. Model outcomes and real money market data are compared through a variety of measures that describe the structure and properties of trading networks. These include number of statistically validated links, bidirectional links, and 3-motifs. The model reproduces well features of preferential trading patterns empirically observed in a real market.

1. Introduction

Well functioning interbank markets effectively channel liquidity from institutions with surplus funds to those in need and thus play a key role in banks liquidity management and the transmission of monetary policy. Before the 2007–2008 financial crisis, liquidity and credit risks were perceived as negligible in these markets. Nonetheless the collapse of interbank lending has been a central feature of the subprime financial crisis. Liquidity hoarding and trust evaporation have been identified as two important determinants of the interbank market drying up during the crisis (Heider et al., 2009; Acharya and Merrouche, 2013). Haldane (2009) has advocated that the interbank market freeze is a manifestation of the behavior under stress of a complex, adaptive network, the complexity arising from the interconnectedness of players via mutual
exposures to each other, and the adaptation from the attempts of agents to optimize interdependent strategies in the presence of (Knightian) uncertainty. Several authors have since called for the adoption of network analysis to understand the mechanisms leading to the formation of trading relationships.

Recently some theoretical studies have considered the problem of network formation in a financial system (Castiglionesi and Navarro, 2007; Babus, 2007; Allen and Babus, 2008; Acemoglu et al., 2013) and also, from the perspective of network formation games (Jackson and Wolinsky, 1996; Dutta et al., 2005; Bloch and Jackson, 2007; Goyal and Vega-Redondo, 2007). The presence of a network underlying the bilateral credit interactions occurring, for example, in an interbank market has a role in the setting of both linkages that insure against liquidity risk and linkages that can channel contagion risk.

The empirical network literature has aimed at characterizing the observed topology of the interbank market checking for regularities and stylized facts (Boss et al., 2004; Iori et al., 2008; Iazzetta and Manna, 2009; Bech and Atalay, 2010; Craig and Von Peter, 2010; Brauning and Fecht, 2001; Martinez-Jaramillo et al., 2014; Iyer and Peydro, 2011).

Simulation studies have attempted to quantify more directly the impact of the network structure on the propagation of contagion addressing a number of complementary issues including the relationship between the network structure of the interbank market and its resilience to different kinds of shocks (Gai et al., 2011; Iori et al., 2006; Battiston et al., 2012; Lenzu and Tedeschi, 2012; Georg, 2013; Ladley, 2013); the effects of assets fire-sale (Nier et al., 2007); roll-over risk and portfolio overlaps (Anand et al., 2013; Caccioli et al., 2012); impact of regulatory taxes (Thurner and Poledna, 2013; Poledna and Thurner, 2014); feedback loops between the macroeconomy and the financial sector (Grilli et al., 2012). An actor-oriented model of network formation in the interbank market is proposed in Finger and Lux (2014).

Broadly speaking, two complementary approaches have been adopted. In the agent-based models case, the interbank exposure networks and default events emerge endogenously from the behavioral rules followed by the economic agents (Iori et al., 2006; Georg, 2013; Ladley, 2013). In the stress test experiments case, the exposure network is taken as exogenously given, either calibrated to real market data or generated according to preset specifications (Upper, 2011; Gai and Kapadia, 2010; Caccioli et al., 2012). In this second approach, even when detailed information on banks bilateral exposures is available, the analysis is typically restricted to few snapshots of the banking system. For this reason a probabilistic approach has been advocated consisting in generating an ensemble of random networks, of which the empirical network can be considered as a typical sample. This allows us to analyze not only the vulnerability of one particular network realization retrieved from the real data, but also of many alternative realistic networks, compatible with a set of constraints (Lu and Zhou, 2011; Halaj and Kok, 2013).

In the present study we introduce a model of preferential formation of bilateral credit relationships in a centralized interbank market with heterogeneous market participants. The market heterogeneity, in number of credit transactions, is assumed to be exogenously given. The existence of stable credit relationships is associated with the detection of over-expression of bilateral transactions with respect to a null hypothesis or random matching, taking into account banks’ heterogeneity. Our model contributes to both streams of the literature. In itself it is a simple agent based model, but in assuming a predefined constrain, that can be calibrated from real data, it can be used as a tool for generating scenarios for stress-test experiments.

While our model has a general validity we test its performance against the e-MID market. The e-MID is the only electronic market for interbank deposits in the euro area and the USA. In a centralized interbank market, such as the e-MID, banks publicly quote their offers to lend or borrow money at a given maturity. The quotes can be anonymous but before finalizing the loan contract the lender has the right to know the identity of the borrower and can refuse to finalize the transaction. While early studies on the e-MID market (Iori et al., 2008) have revealed a fairly random network at the daily scale, a non-random structure has been uncovered for longer aggregation periods. Monthly and quarterly aggregated data show that since the 1990s a high degree of bank concentration occurred (Iazzetta and Manna, 2009), with fewer banks acting as global hubs for the whole network. The hubs tend to cluster together and a significant core–periphery structure has been observed (Finger et al., 2013). Lasting interbank relationships, which remained stable throughout the financial crisis, have been observed by Affinito (2011) and Temizsoy et al. (2014). A networked structure of the e-MID market was observed in Hatzopoulos et al. (2013) by using a methodology based on the detection of statistically validated networks (Tumminello et al., 2011) that allows the researcher to control for bank heterogeneity. In the cited study the networked nature of the e-MID market was highlighted by selecting repeated credit interactions (specifically, overnight loan contracts) between pairs of banks that were statistically incompatible with a null hypothesis of random pairing of the loans, which took into account the transaction heterogeneity of the banks. In other words, the underlying trading network of banks was assumed to be primarily driven by the heterogeneity of the banks whereas the networked nature of some bilateral relationships was associated with a dynamical over-expression of the number of bilateral transactions.

Overall empirical studies of the e-MID data have identified important properties of the market but have also shown that the e-MID interbank network remained surprisingly stable during the subprime crisis (Fricke and Lux, 2012) with a structural break only appearing after the Lehman default. These findings were confirmed, at the intraday scale, by Abraham

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1 In these papers the strength of lending relationships is measured by the concentration of lending/borrowing activity between banks. More precisely, for every lender and borrower a preference index is computed, equal to the ratio of total funds that a lender (borrower) has lent to (borrowed from) a borrower (lender) during a given period, over the total amount of funds that the lender (borrower) has lent in (borrowed from) the interbank market during the same period. This measure nonetheless does not take into account the heterogeneity of the banking system and the fact that large banks may have no alternative than to trade with each other if they need to exchange large volumes.
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