The network structure and systemic risk in the Japanese interbank market

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A B S T R A C T

This paper contributes to the existing systemic risk literature by assessing the network structure of bilateral exposures in the Japanese interbank market, which comprises call and bankers' acceptance markets. The market participants are restricted to financial institutions domiciled in Japan. We analyze the systemic risk implied in the Japanese interbank network based on various network measures such as directed graphs, centrality measures, degree distributions, and modified susceptible-infected-removable (SIR) models. The main findings are as follows: First, betweenness centrality has the highest discriminatory power among three centrality measures in selecting systemically important banks in the Japanese financial system. Second, the topology structure of the Japanese interbank network exhibits characteristics similar to the small-world or scale-free networks, depending on the region of the degree distributions. Third, three mega-bank groups currently designated as globally systemically important banks (G-SIBs) overwhelm others in terms of interconnectedness.

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1. Introduction

Systemic risk has been a focus of financial literature long before the global financial crisis and the European debt crisis. The interbank network represents a significant component in the analysis of systemic risk. This paper contributes to related literature by assessing systemic risk based on bilateral exposures in the Japanese interbank market.

Compared to Western banks, Japanese banks suffered little during these crises, with the exception of Norinchukin Bank, which suffered a loss of 190 billion yen in the fiscal year 2009, by investing in securitized products. The Norinchukin Bank is a cooperative bank in the agriculture, forestry, and fisheries industry, and a major institutional investor. Additionally, other major Japanese banks also suffered during the crises, although their losses in absolute amounts were comparatively smaller.

Some large Japanese financial institutions declared bankruptcy during the Heisei great recession of 1997–1998 prior to the global financial crisis. Hokkaido Takushoku Bank, Yamaichi Securities, Sanyo Securities, Long-Term Credit Bank of Japan, and Nippon Credit Bank all defaulted before the appearance of material systemic risk. Given this history, there is indeed a need in Japan for a system for monitoring and measuring systemic risk. It is mainly recently that banks have begun to contribute to systemic risk by holding securitized products or credit derivatives (Kanno, 2014).

In the last several years, triggered by the global financial crisis, the banking supervisory authorities have focused on micro-level prudential policies by emphasizing traditional consumer protection and macro-level prudence by focusing on the soundness of the financial system in its entirety. This latter approach must consider the interconnectedness between the financial system and the world economy.
In 2009, the Financial Stability Board (FSB) was established as a successor to the Financial Stability Forum. As an international body representing central bankers and international financial bodies such as the Basel Committee on Banking Supervision (BCBS), it intends to promote financial stability. In September 2009, the G20 leaders requested the FSB to designate “Global Systemically Important Financial Institutions” (G-SIFIs). As a result, the FSB, IMF, and BIS cooperatively adopted the three valuation points – size, interconnectedness, and substitutability – as the evaluation criterion for G-SIFIs (IMF, BIS and FSB, 2009).

The BCBS issued a consultative paper for the evaluation method of Global Systemically Important Banks (BCBS, 2011). The BCBS adopted a scoring-based valuation approach, and picked five evaluation criteria – size, interconnectedness, lack of readily available substitutes, global (cross-jurisdictional) activity, and complexity – from wide-ranging categories. In November 2011, BCBS published 29 bank names as G-SIFIs and announced the policy to revise and publish the G-SIFIs list officially every November. Three Japanese mega-bank groups were then selected.

The remainder of this paper is organized as follows: Section 2 reviews the literature related to systemic risk of financial networks. Section 3 estimates the bilateral exposures matrix and analyzes the distribution of exposure sizes. Section 4 analyzes the network structure and systemic risk. Section 5 discusses policy implications associated with the comparison of the network statistics of the Japanese interbank market with those of other countries and the critical contagious rate of the modified SIR model. Finally, Section 6 concludes.

2. Literature review

In recent years, the finance or econophysics literature on financial networks has addressed systemic risk. Financial networks are a complex financial system, with a set of “nodes” connected by “edges,” where the former represent financial institutions, regions, or countries; and the latter the connections between these nodes, such as financial transactions or trade.

The analysis of financial networks provides supervisory authorities or individual institutions with implications concerning contagion risk from the channels through which shocks propagate. Hence, the resilience of a network can be tested, and systemically significant nodes can be identified. Network analysis also provides an empirical tool for testing the effectiveness of macro-prudential policies.

The existing literature on financial networks includes two approaches. The first approach describes network structure using topological indicators. The literature often relates these indicators to model graphs based on network theory. This approach does not assume a mechanism by which shocks are transmitted within the network, and hence is referred to as static network analysis (Alves et al., 2013; Eisenberg and Noe (2001), Boss et al. (2004), Gai et al. (2011), Puhr et al. (2012), Tirado (2012), and Kanno (2015)) describe examples of this approach. For example, based on the Austrian central credit register, Boss et al. (2004) and Puhr et al. (2012) find that the Austrian interbank market is tiered and that banks within sub-sectors tend to cluster together. The topological indicators discussed in Section 4 of our paper are directed graph, centrality measures, and degree distribution.

The financial system comprises various networks. A representative example of analytically tractable financial networks is interbank network. Financial networks are characterized by bilateral exposures in the interbank market. In partial countries such as the Netherlands (in ’t Veld and van Lelyveld, 2009), Germany (Craig and von Peter, 2014; Roukny et al., 2014), Italy (Fricke and Lux, 2012), the UK (Langfeld et al., 2014), the analysts in the supervisory authorities can access bilateral exposures or transaction-level data. However, in many countries, bilateral exposures data are not published, and cannot be used by researchers. Therefore, estimating the bilateral exposures matrix, that is which element is exposed from one bank to another, is a significant endeavor. Recently, some papers adopted a method that minimizes the relative entropy of the bilateral exposures matrix on the information theory, for example, Censor and Zenios (1998), Sheldon and Maurer (1998), Upper and Worms (2002), and Wells (2004).

The second approach observes the financial network structure’s response to shocks to assess the strength of contagion channels and the resilience of the network. The introduction of a shock assumes a specific transmission mechanism, such as defaults by market participants, and is referred to as dynamic network analysis by Alves et al. (2013). Some papers contribute to the literature on systemic risk in interbank markets by focusing on the analyses of contagion effects, for example, Elsinger et al. (2006), Coccomo et al. (2009), Haldane and May (2011), or Duan and Zhang (2013). The modified Susceptible-Infected-Removable (SIR) model discussed in Section 4 of our paper belongs to this approach.

The motivation for our research is the development of a practical systemic risk indicator based on interbank bilateral exposures and the network theory. Additionally, we empirically analyze its applicability to the Japanese banking sector.

3. Estimation of the bilateral exposures matrix

3.1. Estimation methodology

The stylized balance sheets of banks show the interbank assets and liabilities, non-interbank assets and liabilities, and net worth (see Fig. 1). The Japanese interbank market comprises call and bankers’ acceptance markets. The market participants include the Bank of Japan, city banks, trust banks, regional banks, second-tier regional banks, foreign banks’ Japanese branches, Norinchukin Bank, Shinkin Central Bank and Shinkin Banks, security companies, and insurance companies. Major participants in the Japanese interbank market therefore, include city banks, trust banks, Norinchukin Bank, regional banks, and second-tier regional banks.
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