



International transmission of shocks and fragility of a bank network



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HIGHLIGHTS

- International network of banks is constructed based on the number of overseas banks.
- Depending on the origin of crisis, the outcome of the crisis spreading is different.
- The first wave of impact from the origin depends on the out-strength of the origin.
- The second wave of impact depends more on the in-strength of the origin of crisis.

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ABSTRACT

The weighted and directed network of countries based on the number of overseas banks is analyzed in terms of its fragility to the banking crisis of one country. We use two different models to describe transmission of shocks, one local and the other global. Depending on the original source of the crisis, the overall size of crisis impacts is found to differ country by country. For the two-step local spreading model, it is revealed that the scale of the first impact is determined by the out-strength, the total number of overseas branches of the country at the origin of the crisis, while the second impact becomes more serious if the in-strength at the origin is increased. For the global spreading model, some countries named “triggers” are found to play important roles in shock transmission, and the importance of the feed-forward-loop mechanism is pointed out. We also discuss practical policy implications of the present work.

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1. Background

The increasing globalization provides important advantages in terms of risk sharing and risk diversification in banking and financial markets, but it also facilitates the risk spreading among different nations [1]. The recent financial crisis or shock, originated from United States (US) and spread to other countries, has witnessed that many overseas banks cut back their loans to the local markets and withdrew their representations. The withdrawals cause the liquidity shortage of the host countries which then lead to subsequent withdrawals of the host countries' overseas branches in the crisis attacked countries. This process can continue and the shocks in this situation are hence defined as sequential shocks in this study.

There are abundant literature on transmission mechanism of shocks in global banking: [2] examines how Japanese asset bubbles have been transmitted to US via lending responses of Japanese overseas banks in US in the 1980s; [3] explores the

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mechanism of 1998 Russian debt default as a negative liquidity shock to international banking and its impacts on the banking of Peru; [4] studies the effect of financial distress in foreign parent banks on the local SME (small and medium enterprises) financing in 14 central and eastern European countries during the early stage of the 2007 financial crisis.

Within the framework of complex network theory, this paper introduces models for shock transmission and examines the different impacts of the sequential shocks on the global banking network. We find that the damage of the shocks is closely related to the directionality of the edges and the network topology plays an important role.

2. Literature review on complex network methodology

The research using complex system approach in banking has also experienced three stages of the development. In the earlier stage, [6] claims that the possibility of contagion effect depends on the structure of interbank linkages. They believe that a “complete structure of linkages” will share the risk more easily than “an incomplete structure”, hence the risk sharing effect. [7] further considers a structure of uni- and multi-money center banking systems, where the banks on the periphery are linked to the bank at the center but not to each other. Multi-tiered banking system has then been examined with the similar approach. These researches have shown that scholars have started to notice the banking structure has impacts on contagion even though the models are simple and has not yet formally introduced the complex system theory. The second stage is symbolized by a conference entitled “New Directions for Understanding Systemic Risk”, which brought together experts from various disciplines to explore parallels between systemic risk in finance and systemic risk in engineering, ecology, and other fields of sciences [8]. After that a series of interdisciplinary researches using various modeling and theory have emerged [9]. The 2007 US financial crisis becomes another driving force of this line of the research. At this stage researchers have started to apply complex system theory to disclose topology and features of different financial markets such as international trade network, investment network, and interbank clearing network [10].

There are three issues in the current literature that need to be addressed and can be improved: first, the current research has focused on the disclosure of topology of the financial network, the study on dynamics and the interaction between the dynamics and topology are limited; second, the application of knowledge from both economics and complex system is rather mechanic; third, the empirical research has mainly emphasized on two markets, interbank and payment systems, where data are relatively easy to obtain. Other markets, such as a global banking network, have been hardly researched, hence the focus of this research.

In this paper, “fragility” is defined as the reduction of the number of banks as a result of exogenous shocks of different sequence and different sizes. The initial shock will generate rounds of sequential shocks at later stages to propagate throughout the entire network. The initial shock starts from the shock targeted country, such as US in 2007; it then spreads to the hosting countries where US has its overseas banks; resulting in more reduction of banks. A financial crisis in this paper hence is a breakdown of the networks bank linkages, a collapse of all or part of the network structure.

3. Global bank network

3.1. The database

The data used in this research is from Bankscope which has information on over 30,000 public and private banks throughout the world from 2009 to 2011. Each bank report contains detailed consolidated and unconsolidated balance sheet and income statement. Data comes from Fitch Ratings and six other sources. It also provides company and country risk ratings and reports, ownership, and security and price information. This database is produced by Bureau van Dijk.

The information in the database that can be used for network construction are the number of branches and subsidiaries that each parent bank has established overseas. Subsidiaries are banks that are completely or partly owned and wholly controlled by parent banks that owns more than half of the subsidiary's stock. For the purpose of this research subsidiary banks and branch banks are equally treated as overseas banks. The information on the overseas location of the two types of banks can be found in “ownership” category of the database.

3.2. The topology of the global banking network

By using gathered information, we construct the directed and weighted network of $N = 182$ countries, in which the directed arc from the country i to country j is assigned the weight w_{ij} that is the number of banks i puts in j . We in the present work focus on international banks and thus domestic branches of banks are disregarded, i.e., $w_{ii} = 0$. The number of arcs that has nonzero weights amounts to $M = 1055$ (and thus the average out- and in-degree 5.80), which indicates that the network is very sparse since the total number of possible arcs is $N(N - 1) = 32942$, much larger than M .

The network in Fig. 1 is drawn by using the software Gephi. Although sparse, the network is well connected: the giant component size is comparable to the system size and there are 6 isolated very small islands. The top five countries in terms of vertex strengths in global network are United Kingdom (UK), US, France, Germany and Switzerland in this order. The top five countries in terms of vertex strengths in Asia are Japan, China, Hong Kong (HK), Singapore, and South Korea in this order. In terms of in-degree the top five countries are UK, US, Russia, Switzerland, France. It is interesting to note that

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