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Systemic risk in banking networks: Advantages of "tiered" banking systems

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ABSTRACT

This paper studies the risk and potential impact of system-wide defaults in a *tiered* banking network, where a small group of head institutions has many credit linkages with other banks, while the majority of banks have only a few links. A network is *random* and displays a given distribution of the number of banks' linkages, known as degree. We model tiering by a negative correlation between degrees of neighboring banks and by a scale-free degree distribution. The main findings of the paper highlight the advantages of tiering. Both the risk of systemic crisis and the potential scope of the crisis are lower in systems with negative correlation of bank degrees than in other types of systems. Similarly, in scale-free networks, the resilience of the system to shocks is increasing with the *level of tiering*.

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1. Introduction

One of the major concerns in recent policy debates over financial stability is how "tiering" in the banking system may affect systemic risk, the large-scale breakdown of financial intermediation due to the domino effect of insolvency.[1] The tiered banking system is commonly defined as an organization of lending–borrowing relations/linkages between banks, where relatively few first-tier or "head" institutions have a large number of interbank linkages, whereas many second-tier or "peripheral" banks have only a few links. First-tier banks are connected to second-tier banks and are also connected with each other, whereas second-tier banks are almost exclusively connected to first-tier banks.[2] Interbank linkages may act as a device for co-insurance against uncertain liquidity shocks (Bhattacharya and Gale, 1987) and improve market discipline by providing incentives for peer-monitoring (Flannery, 1996; Rochet and Tirole, 1996) but they can also serve as a channel through which problems spread from one bank to another.[3]

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[1] The domino effect of insolvency occurs when the non-repayment of interbank obligations by the failing bank increases the probability that its creditor banks fail to meet their obligations to interbank creditors, and so on.

[2] For a discussion of the properties of tiered banking systems see Fricke and Lux (2014).

[3] For an extensive survey of the literature on financial contagion see Allen and Babus (2009).

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Tiered banking systems are found in a range of countries but the empirical evidence of contagion risk in these systems is mixed.[4] In its 2003 Financial System Stability assessment of the United Kingdom, the International Monetary Fund (IMF) highlights the potential contagion risk arising from the highly tiered structure of the UK large-value payment systems. However, several subsequent studies including Wells (2004), Harrison et al. (2005), Lasaosa and Tudela (2008) report relatively limited scope for contagion among UK banks. Boss et al. (2004c) and Degryse and Nguyen (2007) find that tiered banking systems in Austria and Belgium are stable and systemic crises are unlikely. By contrast, Cont et al. (2012) suggests that in the tiered banking system of Brazil, "the risk of default contagion is significant" (p. 5) and the losses resulting from contagion can be large. In addition, somewhat differently from other studies, Elsinger et al. (2006), Mistrulli (2007) and Upper and Worms (2004) find that while contagious failures in tiered Austrian, Italian and German banking systems are relatively rare, large parts of the system are affected in the worst-case scenario.

The controversy in the empirical literature leaves the question of benefits and risks of tiering open for further investigation. In this paper, we aim to shed more light on this issue by proposing what seems to be the first *analytical* investigation of the effects of tiering and the degree of tiering in the banking system.[5] We develop a stylized theoretical model in which banks are connected by credit linkages and have heterogeneous balance sheets that are determined by the structure of these linkages. Balance sheet interdependence creates the precondition for contagious spread of defaults and can lead to systemic crisis, when large parts of the system are affected. In this setting we study the effects of tiering on the banking system's susceptibility to systemic crisis and the scope of the crisis. We abstract from the issue of the incentives that drive the formation of tiered banking systems and study the impact of tiering within exogenously given structures.

The banking system is modeled as a network where nodes represent banks and links are interbank exposures. The network is *random* in the sense that the number of links that a bank has, known as its *degree*, is determined stochastically, according to a certain *degree distribution*. Following Newman (2003) and Vega-Redondo (2007), we use the term "random" in a broad sense, assuming that the degree distribution can be of any kind rather than just a binomial or Poisson distribution, as in the Erdös–Rényi random graph. Links in the network are directed: *incoming* links of a bank reflect its interbank assets/exposures, while *outgoing* links correspond to its interbank liabilities. An important feature of the links structure is that the number of incoming and outgoing links of each bank is defined by a single random variable and therefore, it is the same for any realization of the random network.[6] As a result, connectivities of banks in the network are determined by a single degree distribution.

To examine the impact of tiering on the stability of the banking system we study the implications of both negative correlation between degrees of the neighboring banks, and of a scale-free distribution of degrees. These two different approaches to modeling tiering are used since there is evidence of both in the empirical literature. For example, the negative degree correlation is found to be a prominent feature of the US banking system (Soramäki et al., 2007; Bech and Atalay, 2010), and the scale-free degree distribution is a common characteristic of banking networks in many other countries (see Boss et al., 2004a, for Austria, Cont et al., 2012, for Brazil, Inaoka et al., 2004, and Souma et. al, 2003, for Japan and De Masi et al., 2006, for Italy).

Using the first approach, we model a tiered banking system by a so-called *disassortative* network, that displays negative correlation between degrees of the neighboring banks,[7] and compare it with other types of structures, showing either a positive degree correlation (an *assortative* network) or no correlation (a *neutral* network). In the second approach, we focus on the effects of a variation in the *level of tiering* of the scale-free network, where the level of tiering is represented by the inverse of the exponent parameter.[8]

In both approaches we analyze (i) the resilience of the networks to systemic failure, (ii) the scale of the failure if systemic crisis occurs, and (iii) the extent of necessary bail-outs that would guarantee the *global* financial stability of the system at minimum costs.[9] The essential findings of both approaches agree. They suggest that as soon as highly connected banks are sufficiently well capitalized, – the condition that is commonly met due to financial regulation and is supported by some of the literature discussed below, – tiering in the banking network improves its financial stability: both the risk of systemic crisis and the scope of the crisis should it occur are lower in a (more) tiered system. Higher tiering also reduces the extent of necessary government intervention as fewer bail-outs are needed to avoid a large-scale breakdown.

[4] A recent summary of empirical studies on the danger of default contagion and the assessment of the simulation methods used in these studies is provided by Upper (2011).

[5] An extensive list of related theoretical and empirical literature is discussed in the next section.

[6] This is clearly a broad simplification. Some justification of this assumption is provided later in text and a robustness check of the model in the framework where the number of incoming and outgoing links can be different is offered in the Appendix.

[7] In Section 3, it is argued that even with negative degree correlation between neighboring nodes, first-tier highly connected banks are still likely to be connected with each other, while the probability of connectedness between second-tier low-degree banks is very small.

[8] The exponent parameter of the scale-free degree distribution governs the rate at which the probability that a node has degree k decays with k. Therefore, for smaller values of this parameter, the fraction of highly connected banks in the network is larger and so is the probability that poorly connected banks are linked with highly connected banks rather than with each other.

[9] The events triggered by the sub-prime crisis of August 2007 highlighted the importance of these questions. For example, the rescue of some institutions, such as American International Group (AIG), remains a highly disputed issue. As a rule, the main argument of policymakers in favor of these rescues is that many yet unaffected banks (across the national or international financial system) might be exposed to the defaulting institutions. But in fact, no rigorous assessment exists of how far contagion could have spread had AIG been allowed to fail.

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