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# Simulation methods to assess the danger of contagion in interbank markets☆

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ABSTRACT

Researchers increasingly turn to counterfactual simulations to estimate the danger of contagion owing to exposures in the interbank loan market. This paper summarises the findings of such simulations, provides a critical assessment of the modelling assumptions on which they are based, and discusses their use in financial stability analysis. On the whole, such simulations suggest that contagious defaults are unlikely but cannot be fully ruled out, at least in some countries. If contagion does take place, then it could lead to the breakdown of a substantial fraction of the banking system, thus imposing high costs to society. However, when interpreting these results, one has to bear in mind the potential bias caused by the very strong assumptions underlying the simulations. Robustness tests indicate that the models might be able to correctly predict whether or not contagion could be an issue and, possibly, also identify banks whose failure could give rise to contagion. They are, however, less suited for stress testing or for the analysis of policy options in crises, primarily due to their lack of behavioural foundations.

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## 1. Introduction

Will the failure of a financial institution trigger the subsequent failure of others? This is perhaps the most important question financial supervisors have to answer when faced with an institution in distress. For example, the US authorities' decision to bail out AIG in September 2008 was motivated by the fear that its "failure under the conditions prevailing would have posed unacceptable risks for the global financial system and for our economy" (Bernanke, 2009). Just over a year before, German authorities justified the takeover of IKB by state-owned KFW on similar grounds.

Knowing whether the failure of a particular institution could trigger the failure of others is important not only for crisis management but also for crisis prevention. Institutions whose failure would have large knock-on effects could be subject to more rigorous supervision or could face higher capital requirements in order to reduce the incentives to become "too connected to fail". Similarly, regulators could impose measures such as exposure limits to reduce the likelihood of contagion.

The interest in contagion has clearly gained momentum during the global financial crisis, but it is not new. The sell-offs in emerging markets after the Mexican peso crisis in late 1994 and the Asian crisis in 1997 triggered a large body of literature on contagion in financial markets.[1] A number of theoretical papers study contagion between financial institutions, but there has been relatively little empirical work in that area. In part this is because most institutions whose failure could give rise to contagion are rescued before they collapse. Most of the empirical literature in this area has therefore focused on lesser events and studied the response of asset prices (equity prices or risk spreads) of other banks,[2] although there are a small number of studies that looked at deposit flows after bank failures.[3]

The absence of solid empirical evidence on whether contagion is possible poses problems for central banks and other authorities in charge of safeguarding the stability of the financial system. Economists studying contagion have therefore resorted to simulation methods to test whether, given a particular set of exposures, failures could have knock-on effects. Initially, such simulations were primarily used on a stand-alone basis to estimate whether or

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[1] E.g. Bae et al. (2000), Forbes and Rigobon (2002) and Rigobon (2003).

[2] The seminal contribution is Aharony and Swary (1983). More recent papers are Hawkesby et al. (2007) and Gropp et al. (2009).

[3] See De Bandt et al. (2009) for an overview.

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not a particular banking system was prone to contagion. A parallel strand of research embedded contagion modules into more comprehensive macroeconomic stress testing models. Recent examples are the Austrian National Bank's *Systemic Risk Monitor* (Boss et al., 2006) and the Bank of England's *RAMSI* (Alessandri et al., 2009).

In the present paper, I review the methodologies behind simulation methods to test for contagion in interbank markets. I then discuss the results of the various exercises in light of the explicit and implicit modelling choices, and conclude by suggesting possible ways forward. I restrict my attention to papers that study contagion driven by defaults on interbank lending. Contagion can also take place through many other channels (see Section 2), but by focusing on one particular channel of contagion it is possible to compare a relatively homogenous set of papers and discuss their underlying assumptions in greater detail than would be the case with a broader focus. In this context, it is useful to distinguish between the *possibility* and the *severity* of contagion. The former refers to the whether or not contagion can take place if a given bank fails and the latter to the proportion of the banking system that is destroyed by contagion.

The paper is structured as follows. The next section discusses theoretical research that studies the interaction between network structure and the possibility for, and the severity of, contagion. Section 3 reviews the methodology used to perform the simulations. The following section discusses data issues. Section 5 presents the results of the exercises published so far. Section 6 assesses what we have learned, discusses the limitations of the methodology and suggests ways forward.

To give a brief summary of the findings, the literature reviewed here suggests that contagion due to interbank exposures is likely to be rare. However, if it does take place, it could destroy a sizable proportion of the banking system in terms of total assets. That said, it is not clear whether some of these more extreme results are the consequence of the very strong assumptions underlying the simulations. In particular, none of the simulations is based on a model that incorporates more than an extremely rudimentary behaviour by banks or policymakers.

## 2. Relationship to previous literature

### 2.1. Channels of contagion

Contagion can take place through a multitude of channels, which are summarised in Table 1.[4] The papers surveyed here focus on one particular channel, namely direct effects due to losses on interbank loan exposures (marked in italics), although some also consider exposures from the payment system or securities and FX settlements. This raises two questions: first, does it make sense to analyse the individual channels separately rather than estimating their overall effect. Second, even if it does, should we focus on interbank exposures rather than any other channel.

The answer to the first question depends on the reason one is interested in contagion. If the focus is on whether or not contagion is possible, knowing the particular channel is clearly of second order relative to the overall impact of the failure. By contrast, distinguishing between the various channels is important if the intention is to prevent contagion, since this will affect which policy measures are likely to be effective. For example, position limits in the interbank market could prevent direct exposures from becoming so large that they could give rise to contagion, but they would do little to mitigate other effects.

**Table 1**
Possible channels of contagion in the banking system.

| Channel | References |
|---|---|
| *Liability side* | |
| Bank runs | |
| Multiple equilibria/fear of other withdrawals | Diamond and Dybvig (1983), Temzelides (1997), Goldstein and Pauzner (2004) |
| Common pool of liquidity | Aghion et al. (2000), Acharya and Yorulmazer (2008b), Diamond and Rajan (2005), Brunnermeier and Pedersen (2009) |
| Information about asset quality | Chen (1999), Acharya and Yorulmazer (2008a) |
| Portfolio rebalancing | Kodres and Pritsker (2002) |
| Fear of direct effects | Dasgupta (2004), Iyer and Peydró-Alcalde (2005), Lagunoff and Shreft (2001), Freixas et al. (2000) |
| Strategic behaviour by potential lenders | Acharya et al. (2008) |
| *Asset side* | |
| Direct effects | |
| *Interbank lending* | Rochet and Tirole (1996), *studies reviewed in this paper* |
| Payment system | Humphrey (1986), Angelini et al. (1996), Bech and Garratt (2006) |
| Security settlement | Northcott (2002) |
| FX settlement | Blavarg and Nimander (2002) |
| Derivative exposures | Blavarg and Nimander (2002) |
| Equity cross-holdings | |
| Indirect effects | |
| Asset prices | Cifuentes et al. (2005), Fecht (2004) |

If disentangling the various potential channels of contagion is important, on which one should we focus on? Previous experience does clearly not suggest that it should be direct contagion due to interbank exposures. I am not aware of any example of a bank that failed because of losses on its exposures in the interbank market, although the collapse of Herstatt in 1974 arguably came close (Davis, 1995).[5] The lack of historical precedent could mean two things: Firstly, this channel is simply not relevant and can thus be ignored. Secondly, the channel may well be relevant in principle but so far contagious defaults have been prevented by government bailouts. Since bailouts are undesirable because of moral-hazard considerations, ex ante measures to limit the possibility of contagion may increase welfare.

There are numerous recent and not so recent examples of authorities bailing out financial institutions in order to prevent contagion (of any sort, not just due to direct exposures). Almost three quarters of the 104 failures of (mainly large) banks considered by Goodhart and Schoenmaker (1995) involved a bailout of one form or another. More recently, in the 2007–2009 crisis, governments rescued almost all of the financial institutions of relevance that were about to fail. The important exception is, of course, Lehman Brothers, whose bankruptcy in September 2008 was followed by the worst financial crisis since the Great Depression.[6]

Another reason for being interested in the possibility of domino effects is that fear of direct contagion could trigger indirect contagion. There are several models in the literature in which the fear of losses on interbank loans (or similar exposures) trig-

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[4] See De Bandt and Hartmann (2001), De Bandt et al. (2009) and references in Table 1 for more information on the various channels of contagion.

[5] Jorion and Zhang (2009) find evidence for direct contagion between non-financial firms, which tend to have larger individual exposures relative to capital than financial institutions.

[6] The precise mechanism for contagion remains to be explored. Gorton and Metrick (2009) argue that it was a bank run in the repo market.

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