The credit quality channel: Modeling contagion in the interbank market

Kilian Fink\textsuperscript{a}, Ulrich Krüger\textsuperscript{a}, Barbara Meller\textsuperscript{b,*,} Lui-Hsian Wong\textsuperscript{a}

\textsuperscript{a} Deutsche Bundesbank, Germany
\textsuperscript{b} European Central Bank, Germany

**Abstract**

We propose an algorithm to model contagion in the interbank market via what we term the “credit quality channel”. In existing models on contagion via interbank credit, external shocks to banks often spread to other banks only in case of a default. In contrast, shocks are transmitted also via asset valuations and deteriorations in the credit quality in our algorithm. First, the probability of default (PD) of those banks directly affected by some shock increases. This increases the expected loss of the credit portfolios of the initially affected banks’ counterparties, thereby reducing the counterparties’ regulatory capital ratio. From a logistic regression we estimate the increase in the counterparties’ PD due to a reduced capital ratio. Their increased PDs in turn affect the counterparties’ counterparties, and so on. This coherent and flexible framework is applied to the bilateral interbank credit exposure of the entire German banking system in order to examine policy questions. For that purpose, we propose to measure the potential cost of contagion of a given shock scenario by the aggregated regulatory capital loss computed in our algorithm.

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1. Introduction

We propose a framework to compute the regulatory capital loss to the banking system caused by the propagation of an external shock through interbank loans. The impact of interbank lending on financial stability is twofold. On the one hand, interconnected banks may improve risk sharing and diversification, thereby alleviating their exposure to idiosyncratic shocks, as noted by Allen and Gale (2000) and Freixas et al. (2000). On the other hand, the network exposes all banks to the risk of contagion, that is, an adverse shock hits one bank or a group of banks and spreads to other interconnected banks, resulting in distress, or – in the worst case – in default. In this spirit, BCBS (2013) classifies the level of interconnectedness as one main driver of systemic risk in the banking system.\textsuperscript{1} In the light of the recent financial crisis, the risk of contagion has increasingly become a matter of importance to regulators. Therefore, this paper focuses on the adverse effect of interbank credits as a source of contagion.

To simulate contagion in the interbank market, we analyze the impact of an increase in the debtor bank’s probability of default (PD) on its creditor banks’ PD, its creditor banks’ creditor banks’ PD, and so on. To this end, we follow regulatory and accounting requirements to compute the reduction of the creditor bank’s Tier 1 capital ratio (Tier 1 capital over risk-weighted assets) induced by the debtor bank’s higher PD. An increase in the debtor bank’s PD results in a deterioration of the credit quality of its creditor banks’

\textsuperscript{1} Systemic risk, as defined by BIS et al. (2001), is the risk that an event will trigger a loss of confidence in a substantial portion of the financial system that is serious enough to have adverse consequences for the real economy.
portfolio because the creditor banks are exposed to higher expected and unexpected credit losses. This will ultimately reduce the creditor banks’ Tier 1 capital ratios. Then, we estimate the impact of a decrease in a bank’s Tier 1 capital ratio on its own PD using a logistic regression. Given the relationship between the debtor banks’ PD and the creditor banks’ PD, our algorithm then simulates a multiple-round contagion process where the PD of all the creditor banks deteriorates, which are connected (directly and indirectly via their counterparties) with those debtor banks subject to an exogenous shock. The increase in banks’ PDs results in higher expected credit losses in the banking system. The corresponding reduction in regulatory Tier 1 capital is proposed as a measure of the adverse effects of interconnectedness caused by contagion via interbank credits.

This paper contributes to the academic literature and policy toolkit in several ways. First, we are the first to use banks’ PD in combination with regulatory requirements and accounting standards as a contagion mechanism in the interbank market, which we term the “credit quality channel”. In so doing, we are introducing a new type of contagion channel, in addition to the already established default cascade channel. While the default cascade channel is based on big shocks triggering sudden defaults, the credit quality channel also tracks the effects of small shocks which lead to increased PDs but not necessarily to immediate defaults. More specifically, the default cascade channel simulates the propagation of incurred losses from sudden bank defaults, whereas the credit quality channel simulates the propagation of incurred as well as expected losses. While the losses in the latter case have not yet (yet) materialized, they are still a relevant source of contagion as they negatively affect banks’ regulatory capital ratio and thereby increase banks’ likelihood of failing in future periods.

Second, we propose an economically meaningful metric to summarize the cost of interconnectedness: the reduction in regulatory Tier 1 capital of all banks in the network. This metric, called BS Loss for short, also allows for an alternative interpretation. By construction, it equals the balance sheet loss due to an increase in loan loss allowances on interbank credits. Third, we test our algorithm on the bilateral interbank credit exposure of the entire German banking system. We quantify the contagion cost of single bank failures and compute the benefit of a capital buffer for systemically important banks. Moreover, we compute the BS Loss that results from a shock to house prices and study the effectiveness of sectoral risk buffers in reducing this loss. The proposed model allows policy makers to monitor the build-up of vulnerabilities over time and gives them a better understanding of the effectiveness of policy actions in response to different types of shocks.

In our policy application, we find that the contagion risk in the German interbank network is concentrated around four or five of the 1710 banks. Moreover, losses from second-round and more round effects (indirect effects) can be much higher than from first-round effects (direct effects). In the case of a failure of one of the five most interconnected banks, the costs from indirect effects exceed the costs from direct effects by a factor of up to 15. From this we conclude that it is crucial to account not only for direct exposure but rather for the entire network when evaluating banks’ level of interconnectedness. When analyzing the effectiveness of additional capital buffers of up to 2.5% (buffer for systemically important financial institutions, SIFIs), we conclude that their buffers are not high enough to absorb the costs of the failure of any other SIFI. In a different policy application, we find that a shock to the mortgage sector hits the banking system twice: once in the form of write-downs to their own portfolio and also, in equal measure, in the form of the losses incurred by their counterparties in the financial system. An additional capital buffer which is proportional to each bank’s exposure to the mortgage sector (systemic risk buffer) can effectively reduce the losses from contagion if they are calibrated well. Given a certain stress scenario, our framework can be used for such calibration.

The paper is structured as follows. Section 2 gives an overview of the relevant literature with a focus on the DebtRank. In Section 3 we introduce the algorithm of the BS Loss. Section 4 presents the results of two policy experiments. Section 5 concludes.

2. Literature

Most of the studies on the adverse effects of interbank credit on the stability of the banking system follow two strands of literature. The first refers to default cascade models: A bank default triggers a loss on interbank lending for its creditor banks. This, in turn, may trigger a default of the creditor banks and a corresponding loss to the creditors’ creditor banks, and so forth. In this spirit, Eisenberg and Noe (2001) propose a static model in which a clearing payment vector describes a fair allocation of losses that result from an external shock. This vector represents a function of the operating cash flows of the members of the financial network and satisfies the requirements of limited liability, debt priority and pro-rata reimbursements. Rogers and Verhaar (2012) extend the modeling framework of Eisenberg and Noe (2001) by introducing default costs in the system. They analyze situations in which solvent banks have an incentive to rescue failing banks and conclude how such a rescue consortium might be constructed. More recently, Acemoglu et al. (2015) have generalized the results of Eisenberg and Noe (2001) by showing that, regardless of the structure of the financial network, a payment equilibrium – consisting of a mutually consistent collection of asset liquidations and repayments of interbank loans – always exists and is generically unique. They provide a comprehensive theoretical analysis between the structure of the financial network and the likelihood of systemic failure due to contagion of counterparty risk. As long as negative shocks imposed on banks are sufficiently small, a dense interconnected financial network enhances financial stability. In contrast, beyond a certain threshold, dense interconnections serve as a mechanism for the propagation of shocks and thus threaten financial stability. Focusing more on empirical findings, Mistrulli (2011) explores how banks’ defaults propagate within the Italian interbank market. He finds that contagion based on actual exposure patterns tends to exceed contagion based on hypothetical exposure patterns (e.g. entropy maximization method), which previous works often had to rely on due to the lack of actual bilateral exposure information. Memmel and Sachs (2013) develop a default cascade model with stochastic losses given default (LGDs) which follows approximately a U-shaped Beta distribution and is calibrated on realized recovery rates from defaulted interbank exposures. They conclude that contagion in the German interbank market can occur and that for rather stable systems, the assumption of a constant LGD systematically yields a lower number of bank failures than the assumption of a stochastic LGD (and vice versa).

The second strand of literature refers to centrality measures, which are used to identify the most important node in a network. Different centrality measures exist which reflect different interpretations of importance. Landherr et al. (2010) provide a critical review of different centrality measures. One of the most simplistic measures is the degree centrality which counts the number of connections one node has to other nodes. More complex measures are recursive centrality measures. According to this concept, the centrality of one node in the network depends not only on the amount of its direct connections, but also on the centrality of the nodes it is connected to. As a result, the centralities of all (connected) nodes influence each other recursively. Recursive centrality can also be described as a weighted sum of all direct and indirect connections of any length. This concept is formalized
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