Contagion in the German interbank market*

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Abstract

The interbank market is commonly believed to be a potential channel of contagion. Using a unique data set which includes the bilateral exposures between all German banks, we assess the vulnerability of the German financial system.

We find that the overall risk of interbank contagion is very low. However, contagion may occur if a large bank fails. For a medium range of LGD (loss given default) values the outcome of the contagious process depends very much on the characteristics of the large bank that starts the chain reaction. Our findings demonstrate the importance of banking supervision.

JEL classification: G12, G21

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*The opinions expressed in this paper are those of the authors and need not reflect the opinions of the Deutsche Bundesbank.

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1 Introduction

The costs of financial crises, especially when the crises spread to the real economy, are well recognized both in the academic literature and in policy debates (see e.g. Bernanke and Gertler (1989), Domac and Peria (2003), European Central Bank (2007)). Financial crises raise the costs of intermediation and restrict credit, which in turn reduces the level of activity in the real sector and ultimately can lead to periods of low growth and recessions (see Allen and Gale (2000)). In the last 30 years there were more than 100 banking crises in developed and developing countries demonstrating the policy relevance of financial crises (see Caprio and Klingenbiel (2003)).

One possibility of how financial crises emerge is contagion. The financial distress of a single institution may affect through contagion the solvency of other financial institutions and may eventually have an impact on the rest of the financial system and the state of the total economy (see Allen and Gale (2000)). In this paper, we study one specific channel of contagion, namely contagion through interbank markets. We focus on the German interbank market, one of the largest European markets.

The primary function of the interbank market is to transfer liquidity among banks. Additionally, there are huge derivative exposures between banks as banks use the interbank market also for risk management. Interbank markets have grown considerably over the last years. For example, in Germany, interbank loans have increased by roughly 50% since 2000 and and have reached a level of roughly two thirds of the level of loans to non financial institutions. Since interbank loans are on average much larger than loans to industrial companies and sometimes even exceed a bank's capital, the write-offs of a single interbank loan may expose banks to higher risks than the failure of a loan to a non-financial company.

In our study, we analyse whether the interbank market in Germany is a potential channel of contagion and how large the potential losses due to contagion are. We deal with two issues: (i) We assess a bank's potential vulnerability that arises from the interbank bank. (ii) We analyse the process of contagion, i.e. we investigate which banks are especially prone to initiate a contagious process in case they fail exogenously. We thereby do not look at the probability that a bank initially fails, but we assume that it happens exogenously. Contagion in this study means that the financial distress of one bank affects another bank that is financially sound apart from the exposure to the bank in distress.

Unlike most other papers about interbank contagion (see e.g. Degryse and Nguyen (2004), van Lelyveld and Liedrop (2004), Upper and Worms (2004)) we have much more detailed information about the interbank market. Most papers use aggregate interbank exposures from banks' balance sheets or data about very large loans. Therefore, they have to estimate the matrix of interbank relationships. We have micro data about every interbank loan above m1.5 Euro and can thus calculate the effects of interbank contagion more accurately.

Our results can be summarized in two core statements: (i) Most of the banks will not cause contagion if they fail, even if we set the loss given default to 100%. However, if a large bank fails and no measures are taken, then this failure may initiate a contagious process due to which parts of the banking system may get into distress. (ii) The results depend largely on the loss given default. If the LGD is low, the contagious process comes to end after a few rounds or even will not start at all. If the LGD is high and no measures are taken, a large part of the banking system will be threatened to be seriously affected. Special interest should be given to medium levels of the loss given default. For medium levels, small supervisory actions may prevent the financial system from falling apart. This finding demonstrates the importance of banking supervision and of a lender of last resort.

This paper is structured as follows. In Section 2 we give a short of review of the literature in this field. Section 3 is about the data description. In Section 4 we analyse the vulnerability of the banks by looking at first round effects, and in Section 5 we look at the contagion process when no one stops it until a new equilibrium is reached. Section 6 concludes.

2 Literature

The empirical literature on systemic risk of the banking sector can be divided into three strands, depending on which data is used. The first strand uses stock market data and can be further divided into two different groups. Works in the first group make use of the event study methodology and analyse how adverse events of one bank have an impact on other banks. Studies in the second group uses stock market data to analyse the dependence structure of stock market time series. Recent studies in this group no longer rely on correlation coefficients as the measure of dependence, but on measures of tail dependency from extreme value theory (see e.g. Buehler and Prokopczuk (2007) and Hartmann et al. (2005).

In the second strand of literature, data of large scale payment systems is employed. Furfine (2003) uses interbank payment flows to quantify the pairwise overnight exposures among US banks. His method consists of looking for pairwise transactions of similar size, but opposite signs between two banks. With his method, he can identify about 15,000 interbank transactions per day.[1]

The third strand makes use of balance sheet information and data from national credit registers, mostly large exposures data (see, for instance, for Austria Elsinger et al. (2002), for Belgium Degryse and Nguyen (2004), for Italy Mistrulli (2006), for Germany Upper and Worms (2004), for the Netherlands van Lelyveld and Liedrop (2004) and for the United Kingdom Wells (2004).[2] Most papers in this area (with the exception of Mistrulli (2006)) have only fragmentary information about interbank linkages: banks' balance sheets show only aggregate interbank exposures and large exposures data contain only very large loans, e.g. in the case of Belgium loans which exceed 10% of banks' own funds. The pairwise interbank exposures among banks have therefore to be estimated.

Our study belongs to this third strand of literature. In contrast to the mentioned papers, we have much more detailed information about interbank loans. We have

[1] Amundsen and Arnt (2005) apply this method for the Danish money market.

[2] See Upper (2007) for an excellent overview over this strand of literature.

micro data about every interbank loan above m1.5 Euro. We do not have to estimate the pairwise exposures and can, thus, derive interbank contagion risks more accurately.

3 Data

We use data from two data sets. The first data set is the German credit register (MiMiK).[3] This register includes all loans from German banks when the indebtedness of their borrower exceeds Euro 1.5m. Unlike credit registers in other European countries, the German credit register includes interbank loans as well and it is not confined to non-financials. The credit register applies a very broad definition of loan. Loans in this sense include traditional loans, off-balance sheet positions and exposures from derivative positions. However, positions of the trading book are excluded.
We use quarterly data from the third quarter of 1996 to the second quarter of 2007. This yields a time span of 44 quarters.

The second data set consists of the regulatory reports filed in by the banks[4], especially concerning the regulatory capital. For each German bank and for each month, we have data about its Tier I capital.
Tables 1 and 2 show descriptive statistics of the size of interbank exposures. To make the figures more meaningful, we do not display the Euro-figures of the exposure sizes, but the size normalized to the Tier I capital of the lender. We look at two different exposures: The total exposure, which contains all on- and off-balance sheet exposures for all maturities, and the short term exposure, which only contains the exposures (on- and off-balance) with residual maturities up to one year.[5] These

[3]See Schmieder (2006) for more details about this data set.

[4]See Memmel and Stein (2008) for a description of this database.

[5]Exceptions are relationships between the savings banks and the landesbanks and between the cooperative banks and their central institutions, respectively. In this case, exposures of longer residual maturity may be counted among the short term exposures if these exposures serve as a liquidity transfer. Another exception concerns banks from a Non-OECD-country. Exposures to

two tables give the distribution of the normalized loans broken down into different sectors of the banking system. We see that - compared to their capital - cooperative banks and savings banks hand out larger loans than the banks of other sectors. The median pairwise interbank exposure of cooperative banks (savings banks) is roughly 18% (12%) of their Tier-I capital. 10% of all interbank exposures with a cooperative bank as the lender exceed the respective Tier-I capital. In contrast, for the big banks, this median interbank exposure is about 0.06%, and the 10 percent largest interbank exposures is bit more than one percent of the Tier-I capital. Looking at these two tables, we see that the large banks, especially the big banks, have a well diversified interbank portfolio, whereas the savings banks and especially the cooperative banks concentrate their interbank exposures very much.[6] These banks concentrate their lending and borrowing on their respective central institutions (See Section 4), so that most of the exposures are within the respective pillars.

4 First Round Effects

A financial distress of one bank can be transferred to another bank via the interbank market. In case this other bank has to write off a loan which was handed out to the distressed bank, the capital of this other bank is reduced by this write-off. If the write-off is greater than the other bank's capital, the other bank comes into distress as a consequence of the problems of the distressed bank. In this section, we restrict ourselves to interbank relationships in which the size of the loan exceeds the Tier I capital of the lender. We call these relationships *potentially first round contagious.* Table 3 gives a sectoral breakdown of these potentially first round contagious relationships, ie this table states how many potentially first round contagious exposures are given from banks of one sector to banks of another sector. For confidentiality reasons, the numbers are normalized to the number of the potentially first round

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these banks are principally rated as long term.

[6] A further description of the German interbank market can be found in Deutsche Bundesbank (2000).

contagious exposures of lenders in the respective sector. Therefore, the sum of each column is 100%.

This table reads as follows: 80% of the potentially first round contagious loans from savings banks are exposures to landesbanks. 10% of these loans are granted to mortgage banks. From this table, one can infer the structure of the German interbank market. Savings banks and cooperative banks are believed to deal mostly with their central institutions at the interbank market when it comes to large exposures. And indeed, as mentioned above, 80% of the savings banks' potentially first round contagious loans are relationships with landesbanks. For the cooperative banks, the corresponding figure is 77%. These central institutions itself deal a lot with banks of their own sector, the figures are 55% for the landesbanks and 30% for the central institutes of the cooperative sector. Mortgage banks do a lot of business with the landesbanks: 62% of the potentially first round contagious loans from mortgage banks are handed out to landesbanks. Commercial banks (without the big banks) are prone to shocks from abroad: 40% of their potentially first round contagious loans are given to banks from abroad. These relationships often consist of loans from the German subsidiary to the foreign mother institute.

5 Round by Round Algorithm

The contagion at the interbank market need not stop after the first round. It may be that banks which got in distress as a consequence of the initial distress now become themselves to a source of contagion. This process will continue round by round until the banking system reaches a new equilibrium with a possible huge number of failures or the supervisory authorities manage to put an end to this process.

In this section, we explore by how far the German banking system may be prone to such an contagious process as mentioned above. We apply the round by round algorithm as described in Upper (2007):

1. Initially, bank i fails exogenously.

2. As a result, those banks also fail whose exposure to bank i times the loss given default (LGD) exceeds their Tier I capital.

3. Further banks may fail in case their combined exposure to the banks that have failed so far (times the LGD) is greater than their capital.

4. The contagious process stops when no new failure occurs.

To run the round by round algorithm, one needs information about (i) the pairwise exposures between the banks and (ii) the appropriate loss given a bank fails. Concerning the pairwise exposures, we have detailed information, at least what exposures within the German interbank market concerns (See Section 3). The question remains to determine the loss given default. From literature we know that it is crucial for the contagion exercises. Different solutions are possible:

1. Constant LGD. The loss given default is exogenously set to a constant value, say 35%.[7] To account for the fact that the loss given default crucially drives the results, one can vary the constant loss given default over a wide range of values. The contagion exercise is then run for each different value of the loss given default.

2. Endogenous LGD. If one knew the actual over-indebtedness of the distressed bank, the bankruptcy cost and the degree of collateralisation, one would be able to calculate endogenously the loss given default. However, this information is not available, but one can make guesses based on balance sheet information.

3. Stochastic LGD. From supervisory data concerning the write-offs of interbank loans, we get the impression that the loss given default is often either close to zero or close to 100%. From Figure 1 we see that in 138 of 422 cases

[7] James (1991) find that the average loss of failed US banks during the period of 1985 to 1988 was about 30%. In addition, there were direct costs associated with the bank closures of 10% of the assets.

(= 32.7%) the loss given default of interbank loans is less than 10%, for 92 of 422 cases (=21.8%) the LGD is above 90%.).[8] A possible explanation for this quasi-dichotomy may be that the loans are fully collateralised (as in the Repo-market) or completely unsecured. This finding is not in line with the assumption made in solution 1. Solution 1 would be more in line with a distribution of the losses given default concentrated in one point.

In this study, we restrict ourselves to the first solution, ie the solution in which the loss given default is deterministic, but is allowed to vary in different runs. We discard the solution with an endogenous loss given default because we lack the necessary data, and we decided against the solution with the stochastic loss given default, because even without a stochastic loss given default the number of runs is huge: We run the algorithm from above for each of the about 2,000 German banks, ie in each run, we assume that a different bank initially fails as outlined in step 1 of the round-by-round algorithm. To account for the importance of the loss given default, we vary the the loss given default in steps of 5 percentage points from zero to 100%. This procedure gives 21 runs for each bank. If, instead, we had modelled the loss given default as stochastic, we would have had to run thousand of runs for each bank in order to obtain a meaningful distribution of the number of failing banks.
Please note that we use gross exposures instead of net exposures. The main reason is that in case of a failure the liabilities are pooled and are distributed according to their seniority. [9]
We report the results for the fourth quarter of 2006, the results for the other quarters are qualitatively the same. More than 95% of the German banks will not initiate a contagious process if they fail, even if the loss given default is 100 percent. However, the large banks can be the origin of a process of contagion, and this process of contagion may last for several rounds until a new equilibrium is found and a lot of

[8]In this figure, we display the frequency distribution of the loss given default in the interbank market (for German banks). From 1998 to 2006, we get 422 observations. The mean (median) LGD is 43% (34%), which fits nicely to the round 40% found by James (1991).

[9]See Mistrulli (2006) for this and other reasons.

banks are in distress. In what follows, we restrict our analysis to the large banks belonging to three groups: the big banks, the landesbanks and the central institutes of the cooperative sector, all in all 19 banks. In the Figures 2 and 3 we show the effects of contagion in case one of the 19 banks mentioned above fails initially. We do not give the figures for the individual bank, but three figures that summarize the distribution: the median, the 25th and 75th percentile. Figure 2 reads as follows: If the loss given default is 55%, then the median bank (of the 19 selected large banks) initiates a contagious process that causes the distress of 143 other banks. The 25th and 75th percentile are 9 and 620. When locking at this figure, we can distinguish three different LGD areas: If the LGD is in the interval from zero to roughly 35%, not much happens. In the area from 35% to 70%, the outcome depends largely on which bank fails. If the LGD is above 70%, the outcome for a lot of the large banks is that nearly the entire banking system is affected. This partitioning into three areas can as well be found when looking at rounds necessary to reach a new equilibrium. In Figure 3, we show the number of rounds it takes until a new equilibrium is reached. As in Figure 2, we report summary statistics (median, 25th and 75 percentile) instead of the figures for the single banks. For LGDs up to 40% the contagious process quickly comes to an end. In the second area, for LGDs from 40% to 70%, we see a massive growth in the number of rounds. In the third area, the number of rounds until a new equilibrium is reached goes down again. The tricky LGD area is the second one: This area is characterized by a huge variability in the outcomes. Therefore, it seems that in this area supervisory measures will have the highest effectiveness. In this area, the supervisory authorities and the central bank is able to put an end to the contagious process without having to spend a lot of money.

The results should be interpreted with caution. The results are subject to severe assumptions; for instance that the loss given default is constant and exogenous, that there are no netting arrangements and that the supervisory authorities do not intervene. Nevertheless, the results show that, theoretically, contagion may happen at the German interbank market.

6 Conclusion

In this study, we use a unique data set to analyse interbank exposures at the German interbank market. Although a lot of assumptions have to be made, the results are conclusive. For high values of losses given default and without intervention of the supervisory authorities, there is the possibility that a contagious process takes place in case a large bank fails.

Further research should be directed to the modelling of the loss given default, either by making it endogenous or by modelling it as stochastic. Modelling the loss given default as stochastic, we would obtain a distribution of the banks in distress instead of a deterministic number.

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Appendix: Tables

Banking sector	Obser-	Percentile				
	vations	10th	25th	50th	75th	90th
Commercial banks (ex big banks)	356189	0.06%	0.44%	2.88%	13.14%	36.57%
Big banks	440,511	0.00%	0.01%	0.06%	0.26%	1.08%
Landesbanks	492,174	0.03%	0.14%	0.52%	1.83%	5.60%
Savings banks	639,632	1.74%	4.75%	11.55%	24.85%	49.40%
Central inst. of the coop. sector	151402	0.05%	0.17%	0.48%	1.35%	3.85%
Cooperative banks	752,840	3.57%	8.83%	18.09%	37.35%	119.86%
Mortgage banks	146,258	0.26%	0.89%	3.50%	11.88%	34.98%
Other German financial inst.	155,056	0.22%	0.61%	3.10%	14.08%	39.77%
All German financial inst.	3,134,062	0.05%	0.35%	4.05%	17.07%	41.63%

Table 1: Size of the standardized total interbank loans: Amount of the interbank loan to the Tier I capital of the lender

Banking sector	Obser-	Percentile				
	vations	10th	25th	50th	75th	90th
Commercial banks (ex big banks)	162,578	0.02%	0.22%	2.48%	14.25%	45.26%
Big banks	134,226	0.00%	0.01%	0.05%	0.27%	1.29%
Landesbanks	191,805	0.01%	0.07%	0.37%	1.48%	5.01%
Savings banks	178,509	0.75%	3.15%	7.83%	19.87%	81.99%
Central inst. of the coop. Sector	102,144	0.00%	0.01%	0.05%	0.28%	1.34%
Cooperative banks	208,351	3.07%	8.14%	21.02%	177.71%	350.88%
Mortgage banks	33,520	0.08%	0.53%	2.95%	10.69%	27.40%
Other German financial inst.	66,671	0.00%	0.01%	0.40%	4.59%	19.25%
All German financial inst.	1,077,804	0.01%	0.10%	1.74%	12.42%	68.17%

Table 2: Size of the standardized short term interbank loans: Amount of the short term interbank loan to the Tier I capital of the lender

	Sector of lender								
Sector of borrower	Com. B.	Big b.	Landb.	Savings b.	Cen. B.	Coop. B.	Mort. B.	Oth Germ. B.	All FI
Commercial banks (ex big banks)	17%	16%	7%	0%	19%	1%	3%	18%	3%
Big banks	11%	5%	2%	2%	0%	1%	7%	18%	3%
Landesbanks	11%	8%	55%	80%	1%	2%	62%	24%	22%
Savings banks	2%	0%	0%	0%	0%	0%	0%	6%	0%
Central inst. of the coop. Sector	5%	0%	0%	0%	30%	77%	2%	4%	49%
Cooperative banks	0%	0%	0%	0%	0%	0%	0%	3%	0%
Mortgage banks	8%	43%	3%	10%	28%	9%	2%	12%	9%
Other German financial inst.	7%	16%	19%	7%	1%	9%	14%	7%	9%
Financial Inst. from abroad	40%	12%	13%	0%	20%	1%	9%	9%	5%
All financial inst.	100%	100%	100%	100%	100%	100%	100%	100%	100%

Table 3: Number of relationships between banks from one sector to banks from another sector over all lending relationships of banks from one sector. Only relationships whose exposure exceeds the Tier-I capital of the lender are considered.

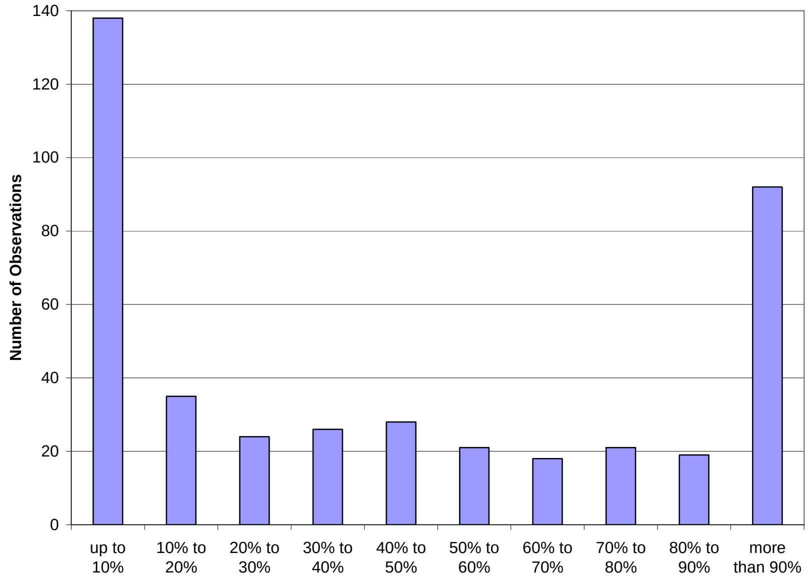

Figure 1: Frequency distribution of the loss given default of interbank exposures (total of 422 observations)).

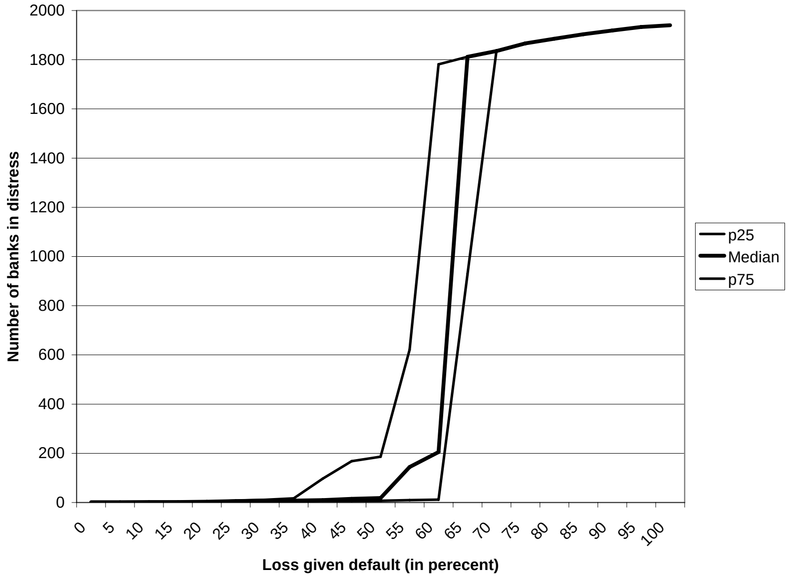

Figure 2: Effects of contagion: Number of banks in distress (median, 25th and 75th percentile); banks that initially fail: Big banks, central institutions of the savings banks and the cooperative sector, all in all 19 banks; time under consideration: 2006Q4

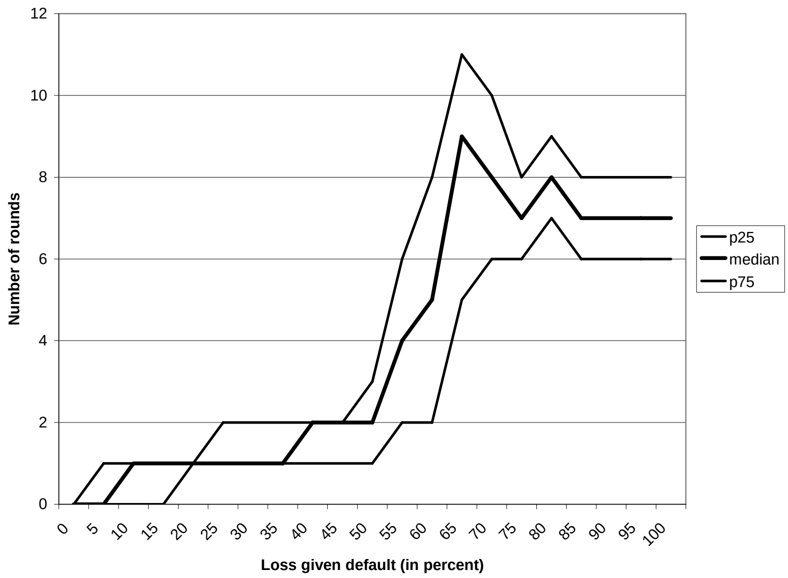

Figure 3: Effects of contagion: Rounds until new equilibrium is reached (median, 25th and 75th percentile); banks that initially fail: Big banks, central institutions of the savings banks and the cooperative sector, all in all 19 banks; time under consideration: 2006Q4