The Achilles' Heel of Interbank Markets: Financial Contagion due to Interbank Linkages[*]

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Abstract

This paper tests financial contagion due to interbank linkages. For identification we exploit an idiosyncratic and sudden shock caused by a large-bank failure in conjunction with precise data on interbank exposures. We find that banks with higher interbank exposure to the failed bank experience higher deposit withdrawals. In addition, we find that the impact of exposure on deposit withdrawals is higher for banks with weaker fundamentals. To further push on causality, we use overall lending in the interbank market (excluding lending to the failed bank) as an instrument of exposure to the failed bank. The results suggest that interbank linkages act as a channel of contagion and hold important policy implications.

"Despite its importance for distributing savings to their most valued use, short-term interbank funding may turn out to be the Achilles' heel of the international financial system" Alan Greenspan (1998), Statement before the Committee on Banking and Financial Services, U.S. House of Representatives.[1]

1 Introduction

The idea that interbank markets can act like a double-edged sword is widely acknowledged. On the one hand, interbank markets play a very important role for the provision of liquidity among banks (Allen and Gale, 2000). On the other hand, if a bank fails, the interbank market could transmit the shock (contagion), thereby increasing the likelihood of a banking crisis.[2] Given the economic importance of interbank markets and the large economic costs associated with banking crises, it is of utmost importance to understand the role of the interbank market in financial contagion.[3] In this paper, we empirically address whether interbank exposures act as a channel of financial contagion.

After the failure of a bank, the risk of financial contagion due to interbank linkages is primarily due to a loss in value for creditor banks that hold interbank claims in the failed bank (henceforth, exposure). Furthermore, the loss for creditor banks may increase over and above the exposure in the failed bank due to the (over) reaction of the creditor banks' depositors. In consequence, the degree of contagion from the failed bank to another bank should depend on its level of interbank exposure to the failed bank (Allen and Gale, 2000).[4] Unfortunately, despite the importance of the question, there are no empirical papers that test for financial contagion due to interbank linkages.

A major problem in testing for financial contagion due to interbank linkages is the lack of detailed data on interbank linkages during a crisis time. Most often it is almost impossible to get information on the interbank exposures of banks. In consequence, at the time of the failure of a bank, it is very difficult to map the transmission of the shock due to interbank linkages. Apart from the lack of data on interbank exposures, there is also dearth of large-bank failures, which implies a lack of events for empirical studies. One of the main reasons for lack of large-bank failures is

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[1] See http://www.federalreserve.gov/Boarddocs/Testimony/1998/19980130.htm.

[2] There is contagion if the failure of a bank causes a significant negative externality to other banks (e.g. high levels of deposit withdrawals). For a very similar definition of contagion, see Kaminsky and Reinhart, 2000. For an excellent survey on bank contagion, see Kaufman, 1994.

[3] For the costs of banking crises, see e.g. Friedman and Schwartz, 1963; Bernanke, 1983; Ongena et al., 2003; Calomiris and Mason, 2003b; Dell'Ariccia et al., 2005. On the other hand, notice that bailing-out the failed bank to avoid the potential banking crisis also has costs associated.

[4] For similar theoretical predictions, see Freixas et al., 2000; Dasgupta, 2004; Brusco and Castiglionesi, 2005; Iyer and Peydró-Alcalde, 2005. See also Flannery, 1996; Rochet and Tirole, 1996; Aghion et al., 2000; Cifuentes et al., 2005; Diamond and Rajan, 2005 and Leitner, 2005.

that regulators generally resort to bailouts whenever there is a large-bank failure that poses the risk of contagion due to interbank linkages. For example, after studying more than 100 bank failures, Goodhart and Schoenmaker (1995) conclude that: "it has been revealed preference of the monetary authorities in all developed countries to rescue those large banks whose failure might lead to a contagious, systemic failure". This view also comes forth in the statement issued by the U.S. Comptroller of Currency C.T. Conover justifying the bailout of Continental Illinois Bank.[5] At the time of its failure in 1984, Continental was the seventh biggest U.S. bank and approximately 2300 banks had exposures to Continental. In his testimony before the Congress, C.T. Conover asserted that: "Had Continental failed and been treated in a way in which depositors and creditors were not made whole, we could very well have seen a national, if not an international financial crisis, the dimensions of which were difficult to imagine. None of us wanted to find out."[6]

In this paper, we overcome these hurdles by exploiting: (i) an event of sudden failure of a large bank in India – the bank failed due to fraud and was not bailed out;[7] (ii) a unique dataset that allows us to identify interbank exposures at the time of the bank failure. Our dataset provides us with detailed information on the interbank exposures of banks in the system with the failed bank. We also have information on the interbank linkages of banks among themselves apart from the exposures with the failed bank. This provides us with an ideal platform to test the hypothesis of financial contagion due to interbank linkages. More specifically, in this paper we address the following questions: Does higher interbank exposure (credit outstanding as a fraction of total assets) to the failed bank affect deposit withdrawals? Is the impact of exposure on deposit withdrawals lower for banks with stronger fundamentals? Do interbank linkages among banks (apart from the failed bank) further propagate the shock?

Our main finding is that banks with higher level of exposure to the failed bank face higher deposit withdrawals thus experiencing a reduction in liquidity. After controlling for bank fundamentals and local macroeconomic conditions, we find that banks with higher level of exposure to the failed bank experience lower deposit growth. We also find that banks with weaker fundamentals experience lower deposit growth. While the effect of higher level of exposure on deposit growth is negative, this does not necessarily imply that banks with higher level of exposure suffer large deposit withdrawals as predicted by theories of financial contagion. To address this concern, we investigate whether

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[5] See U.S. Congress, House of Representatives, Inquiry into Continental Illinois Corp. and Continental Illinois National Bank, pp. 98-111, 98th Congress 2nd session, 1984.

[6] Paul Volcker, the Chairman of the Federal Reserve, was asked why he acted so rapidly and aggressively in the bailout of Continental Illinois. "Simply," he said, "As if we had not stepped in, the ultimate domino effect that so many people have feared for so long, would have occurred and wiped out the Western financial system" (see Degryse and Nguyen, 2005).

[7] Note that there was no other fraud in other banks and the economy was performing well. For more details, refer to the section on event description.

banks with higher level of exposure face a higher probability of large deposit withdrawals.[8] We find that the probability of facing large deposit withdrawals increases by 0.34 if a bank has a high level of exposure. Thus, exposure has an economically significant effect on deposit withdrawals. Finally, through piece-wise linear regressions, we find that the impact of exposure on deposit withdrawals is greater for higher levels of exposure.

A potential concern in the interpretation of our findings is that exposure levels to the failed bank are voluntarily chosen by banks. To address this concern, we first check whether banks with higher exposure levels are ex-ante different in terms of riskiness and profitability. We do not find any significant differences. Second, we check if exposure level is just a proxy for physical distance from the failed bank or for correspondent banking relationship with the failed bank. We find that, despite these controls, the level of exposure to the failed bank is significant in explaining deposit withdrawals. Finally, to further push on causality, we instrument for exposure using a variable that indicates whether a bank lends in the interbank market excluding the lending to the failed bank. The economic intuition for the instrument is that banks that lend in general in the interbank market are also likely to have exposure to the failed bank and, lending in the interbank market (apart from the exposure to the failed bank) by itself should not be related to deposit withdrawals. We find that interbank lending is highly correlated with exposure (t-statistic in the first stage regression is 3.46), thus the instrument does not suffer from weak instrument concerns.[9] Moreover, from the second-stage regression, the estimates suggest that the component of exposure to the failed bank predicted by the overall lending in the interbank market has a highly significant effect on the probability of facing large deposit withdrawals.[10]

Apart from exposure to the failed bank, we also investigate the effect of other outstanding interbank linkages on deposit withdrawals. We find that the amount of lending in the interbank market (excluding exposure to the failed bank) does not affect deposit withdrawals. We also find that the amount of borrowing in the interbank market does not affect deposit withdrawals. Interestingly, we find that the impact of exposure on deposit withdrawals is greater for banks with higher amount of borrowing in the interbank market. Our analysis suggests that this finding may be driven by banks liquidating their deposits in banks with high level of exposure to the failed bank due to the fear of contagion. In addition, even if we limit the analysis to banks with no interbank

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[8]We define large deposit withdrawals as deposit withdrawals exceeding 12.75% of deposits, this in turn implies that 20% of banks in our sample suffer large deposit withdrawals. Our results are robust to other definitions of large deposit withdrawals.

[9]Also, the instrument does not have a direct effect on deposit withdrawals (independently whether exposure is in the regression or not).

[10]The effect exposure on deposit withdrawals could also be due to the regulator requiring banks with higher exposure to reduce their deposit rate, thereby creating difficulty in retaining deposits. However, we find that changes in the deposit rate paid by banks are not related to the level of exposure.

borrowings (i.e. banks which do not have other banks as depositors), we still find that exposure to the failed bank has a significant effect on deposit withdrawals.

We also investigate whether the effect of exposure on deposit withdrawals varies based on differences in bank fundamentals. Specifically, we find that the impact of exposure on deposit withdrawals is higher for banks (i) with lower level of capital, (ii) with higher number of depositors (more coordination problems), (iii) smaller in size and (iv) classified as weak by the regulator. These results suggest that the magnitude of contagion is larger for banks with weaker fundamentals. This result in turn implies that weaker fundamentals of the banking system amplify the magnitude of contagion stemming from interbank exposures to a failed bank.

The most important contribution of our paper is that we show evidence that suggests interbank exposures transmit the shock of a bank failure. Our results are consistent with theories of financial contagion due to interbank linkages (Allen and Gale, 2000; Freixas et al., 2000; Dasgupta, 2004; Brusco and Castiglionesi, 2005; Iyer and Peydró-Alcalde, 2005).[11] Our results also contribute to the literature that examines the role of depositors in banking crises (Calomiris and Mason, 1997; Martinez Peria and Schmukler, 2001; Schumacher, 2000) by showing that, in addition to bank fundamentals, interbank linkages affect deposit withdrawals. To the best of our knowledge, this is the first paper that explores whether interbank exposure to a failed bank transmits the shock. Existing studies on financial contagion due to interbank linkages have been limited to simulations due to lack of actual failure events. In addition, papers that test for contagion using an actual bank failure do not address the issue of interbank contagion due to lack of data on interbank linkages. Our paper bridges this void, in turn providing some directions for policy-making.

Related Literature: Most of the existing empirical studies on contagion focus primarily on measuring equity returns around large failures. They test whether all banks experience negative abnormal returns, or whether negative returns are limited to banks with similar characteristics to the failed banks.[12] Aharony and Swary (1983) study the market reaction to the three biggest US bank failures prior to Continental Illinois. Swary (1986) and Jayanti and Whyte (1996) examine the market effect of the failure of Continental Illinois. Aharony and Swary (1996) study the market reaction in the context of five large bank failures that occurred in the Southwest region of the U.S. during the mid-1980s.[13] These papers find that surviving banks are most affected if they

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[11] See also Flannery, 1996; Rochet and Tirole, 1996; Aghion et al., 2000; Cifuentes et al., 2005; Diamond and Rajan, 2005 and Leitner, 2005.

[12] In a similar spirit, Lang and Stulz (1992) investigate the contagion effects of bankruptcy announcements of firms.

[13] More recently, Gropp et al. (2005) use the tail properties of distance to default to study contagion risk in Europe; they find that contagion risk in Europe is important. Hartmann et al. (2005) study tail risk in major banks in the Euro Area and United States; they find that multivariate tail risks among major banks have recently increased.

have portfolio characteristics similar to the failing institution. This, they argue, is evidence of information based contagion. The most important feature that differentiates our paper from the literature cited above is that we use direct financial linkages among banks to test financial contagion due to interbank linkages.

There is an alternative stream of literature that studies the possibility of financial contagion due to interbank linkages via simulations. Humphrey (1986) uses data from the Clearing House Interbank Payments System (CHIPS) to simulate the impact of a settlement failure of a major participant in the payment system. He shows that this failure could lead to a significant level of further settlement failures. Upper and Worms (2004) study financial contagion due to interbank exposures in the German interbank market. Through a simulation, they find that the failure of a single bank could lead to the breakdown of 15% of the banking system. In contrast, Furfine (2003) uses exposure data on interbank federal funds to simulate the risk of financial contagion and finds it to be negligible.[14] Elsinger et al. (2003) use detailed data from the Austrian interbank market and study the possibility of contagious failures due to an idiosyncratic shock. In their simulations, they find the probability to be low.[15] While the above papers explore the issue of financial contagion due to interbank exposures, they do not capture the endogenous response of depositors and creditors during a crisis.[16] Our paper differs from the papers cited above by using an actual failure in order to test financial contagion in the banking system, in turn allowing us to study the endogenous response of depositors and creditors in the propagation of the crisis.

Another related strand of empirical literature investigates depositor runs on banks during a crisis. This literature explores whether depositors run randomly across banks or run on banks based on fundamentals (i.e., a test between the sunspot-based theory of bank runs by Diamond and Dybvig, 1983, versus the fundamental and information-based theory of bank runs by Chari and Jaganatthan, 1988, Jacklin and Bhattacharya, 1988, and Allen and Gale, 1998).[17] Schumacher (2000) studies depositor behavior in Argentina following the Tequila Shock, and finds that depositors primarily concentrate their runs on fundamentally weak banks. Martinez Peria and Schmukler (2001) also find evidence of depositor discipline in Argentina, Mexico and Chile. Calomiris and Mason (1997) look at the Chicago Banking Panic of 1932, and investigate whether solvent banks fail during the crisis.[18] They find that banks that fail during the panic are ex-ante weak banks.

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[14] Furfine (2002) studies the federal funds market during the LTCM and Russian crises; he finds that risk premia on overnight lending were largely unaffected and lending volumes increased.

[15] Although the probability of contagious default is low, there are cases in which up to 75% of the defaults are due to contagion.

[16] See also Upper (2006) for an excellent review of the literature on simulations of interbank contagion.

[17] See also Bhattacharya and Gale (1987) and Bhattacharya and Fulghieri (1994).

[18] See also Calomiris and Mason (2003a) and Calomiris and Mason (2003b)

Gorton (1988) studies the banking panics during the U.S. National Banking Era (1865-1914). He finds them not random events but products of revisions in the perceived risk of the banking system based on the arrival of new information. Our paper adds to this literature by including financial linkages of banks with other banks in the bank fundamental characteristic variables and then studying depositor runs.[19]

The rest of this paper is organized as follows. Section 2 describes the institutional details of the Indian banking system. Section 3 provides a description of the event. Section 4 summarizes the data used in the analysis. Section 5 discusses the empirical strategy of the paper along with a discussion of the results. Section 6 provides conclusions and suggests some policy measures.

2 Institutional details

Before we proceed to describe the event that we use to study contagion, a brief summary of the institutional setting is helpful to set things in perspective. The Indian banking system primarily constitutes of three types of banks: public sector, private, and co-operative banks. The co-operative banks in each state have a three tier structure. At the top of the chain is the state co-operative bank, followed by the local district central co-operative bank, and then the urban co-operative banks.[20] Co-operative banks' deposit base primarily constitutes of small depositors. One point to take note of is that depositors of co-operative banks are not required to hold an equity claim in the bank. Also, shareholders of co-operative banks have limited liability. Thus the co-operative structure of the banks does not lead to significant differences in characteristics of depositors as compared to banks with other ownership structures. With regard to the loan portfolio, it is mandatory for co-operative banks to lend at least 60% of their loan portfolio to the 'priority' sector.[21]

The main regulatory authority of the banking system in India is the Reserve Bank of India (RBI). Co-operative banks, however, come under dual regulation, i.e. they are supervised by the RBI as well as by the local state government. The RBI is responsible for monitoring the banks portfolios while the state government is responsible for governance issues. The insurance cover granted under

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[19] A paper close to ours in spirit is the one by Kho et al. (2000). They analyze the impact of emerging market currency crises, and the subsequent bailouts, on bank stock prices. They categorize banks into groups of exposed and non-exposed banks based on whether they had exposure to the crisis country. They find that the market was able to discern between exposed and non-exposed banks. Our paper differs substantially from this paper as we study whether a shock, due to the failure of a bank, is transmitted due to interbank linkages. Furthermore, we use exact interbank linkages of banks with the failed bank.

[20] The state co-operative bank and district central co-operative bank can be considered as public banks as they are under control by the local governing body of the state.

[21] The priority sector constitutes primarily of small scale industries. It is not mandatory for banks directly to lend to the priority sector. Another way banks can fulfill this mandate is by placing their money in other government institutions that are engaged in priority sector lending. For a detailed discussion on priority sector lending see Banerjee and Duflo (2002).

the deposit insurance scheme is Rs. 100,000 (approximately 2,000$) for each account.[22] Though deposit insurance is present, there are several delays in processing the claims of depositors, as the central bank first suspends convertibility when a bank approaches failure. After suspension of convertibility, the central bank takes a decision of whether to liquidate a bank or arrange a merger with another bank. During this period, depositors are allowed a one time nominal withdrawal up to a maximum amount that is stipulated by the central bank.[23] The stipulated cash reserve ratio and statutory liquidity ratio to be maintained by the banks are 5.5% and 25% respectively.[24]

The interbank market for funds in India is primary composed of two parts. One is the call money market which is similar to the Fed overnight market for funds. The call money market is primarily dominated by private banks and public sector banks, though some large co-operative banks do have a presence. The other interbank market is the market for direct placement of deposits and borrowings by banks among one another. The co-operative banks are generally very active in this market and use this market to park their surplus funds (mostly with other co-operative banks). The contracts entered in this market take the form of demandable debt unlike those in the call money market which are standard debt contracts.[25] While the funds transacted in the call money market are not insured, the funds placed by banks as deposits in other banks are only insured up to the ordinary deposit insurance levels.[26]

3 Event description

We now turn to the description of the event that we use to study contagion (refer to the Appendix for the time line of the event). The whole episode started with a fraud in the largest co-operative bank named Madhavpura Mercantile Co-operative Bank (hereafter referred to as MMCB) in the state of Gujarat.[27] MMCB had granted loans to a stock broker without appropriate collateral in contravention of the guidelines prescribed by the central bank.[28] The amount of loans given to the stock broker amounted to nearly 80% of the deposit base (Rs. 10 billion were advanced as

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[22] The deposit insurance is based on a flat premium. See www.dicgc.org.in.

[23] In most cases, depositors are allowed a one time withdrawal of up to Rs. 1,000 (20$) per account.

[24] Statutory Liquidity Ratio (SLR) is the one which every banking company shall maintain in India in the form of cash, gold or unencumbered approved securities, an amount which shall not, at the close of business on any day be less than such percentage of the total of its demand and time liabilities in India as on the last Friday of the second preceding fortnight.

[25] The contracts in the call money market are entered for a stipulated period of time and cannot be liquidated before maturity, unlike the demandable debt contracts.

[26] See Demirguc-Kunt et al. (2005).

[27] See www.manupatra.com/downloads/JPC/part%201.pdf.

[28] Co-operative banks were not allowed to have direct exposure to stock market or lend to stock brokers. They were, however, allowed to lend to an individual against collateral of shares up to Rs. 1 million if the shares are in physical format, and up to Rs. 2 million if the shares are in demat (electronic) format.

industrial loans to stock brokers without appropriate collateral). On the 8th of March 2001, some major brokers defaulted on their pay-in obligations to the stock exchange. Rumors were floating around that MMCB had over-stretched lending positions to a major stock broker who had suffered huge losses in his share dealings in a select group of stocks. This led to a run on the bank on the 9th and 12th of March 2001. As the bank failed to repay depositors on the 13th of March 2001, the central bank suspended convertibility and restrained the bank from making payment to depositors beyond Rs. 1,000 per account.[29]

Apart from the fact that MMCB was the biggest co-operative bank in the state, another crucial aspect of the MMCB failure was that it had a significant number of banks connected to it via interbank transactions. Out of the total deposit base of Rs. 12 billion, deposits from other banks constituted about Rs. 6 billion. The primary reason for a large number of connections was due to the fact that MMCB had a status of a scheduled bank, allowing it to carry out multi-state operations.[30] Smaller co-operative banks in the state maintained deposits with MMCB as MMCB provided remittance facilities within and across the state.[31] Many co-operative banks also used the deposits placed with MMCB to fulfil the statutory liquidity requirements.[32] This setup is similar to the reserve pyramiding that prevailed in the U.S. prior to the passing of the Federal Reserve Act that lead to the establishment of Federal Reserve Banks.[33] Apart from the linkages banks had to MMCB due to direct placement of deposits, some banks were also linked to MMCB due to their call money lending and pay orders.[34]

An important point to note is that, at the time of failure, the economy of the state was performing well: Gujarat's GDP growth was 9.8% in 2001 as compared to 0.6% in 2000 and -1.6% in 1999. The public sector banks witnessed an increase in deposits and also increased the amount of lending in the period after the shock. Furthermore, there were no other frauds in the banking system and none of the other banks had any lending to the defaulted broker.[35] Also, ex-post in the report released after the investigation of the fraud, it was found that none of the other co-operative

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[29] See the report of the Joint Parliamentary Committee at www.manupatra.com/downloads/JPC/part%201.pdf.

[30] Co-operative banks have branching restrictions similar to those which existed in the United States. A scheduled bank status is granted by the central bank if the bank meets certain norms in terms of deposit base and capital adequacy.

[31] Remittance facility is a mechanism to transfer funds to other areas. For example a bank which does not have a branch in location X might use the services of another bank that has a branch at X to transfer funds to that location. MMCB had provided remittance facility/cheque collection services free of charge to other banks.

[32] Smaller co-operative banks in the state normally maintain deposits with the scheduled banks as these deposits can be used to fulfill their SLR requirements (statutory liquidity requirements).

[33] See Broaddus (1993).

[34] The issuing bank is supposed to debit the account of the person who takes a pay order. MMCB had issued pay orders to the brokers without debiting their account and these pay orders were discounted by other banks to the tune of Rs. 1.2 billion.

[35] As discussed later, none of the other banks had any positions to the defaulted brokers that were revealed in the audits ex-post by the central bank.

banks were involved in the fraud.[36] Thus the shock was idiosyncratic as it only affected the failed bank.[37]

After the collapse of MMCB, there was a huge debate whether MMCB should be bailed out. A committee was constituted to study the possibility of its revival. The fundamental aspect of the revival plan addressed by the committee was to choose one of the three following options: closure, merger or takeover, or comprehensive financial and operational restructuring. Based on the recommendations of the committee, it was finally decided on August 2001, that MMCB would be revived. The revival scheme was organized in terms of a privately arranged bailout. The revival package required the participation of all the co-operative banks in the state, contributing 4% of their deposit base to the revival fund. This money was to be insured by a guarantee provided by the government. The revival package, however, did not insure the deposits that banks already held with MMCB.[38] The deposits and call money exposures that banks had with MMCB prior to its failure were to be retained and converted into term deposits for a period of four years at 7.5% per annum.

Though there was a guarantee provided by the government, the revival scheme never took off. Most of the co-operative banks in the state were reluctant to contribute funds. The committee in charge of implementing the revival scheme also noted that the recovery of the amount lent to the stock brokers was very unlikely.

After the failure of MMCB, the immediate concern of the central bank was to limit the contagion. The central bank was primarily concerned with the propagation of the crisis due to interbank connections. The prominence of this fact was highlighted in the statement made by the Governor of the central bank in his monetary policy address 2001-2002.[39] He stated that "*recent experience has shown that irresponsible and unethical behavior on the part of even a few co-operative banks in the country can have some contagion effect beyond the particular area or the state concerned.*" The immediate policy response by the central bank was to limit the amount of exposure banks could have in the call money market. As on April 2001, co-operative banks were not allowed to borrow more than 2% of their deposit base as on the end of March in the previous year.[40] The central bank, however, was ready to provide liquidity to banks against appropriate collateral if need arose.[41] The

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[36]See the report of the Joint Parliamentary Committee at www.manupatra.com/downloads/JPC/part%201.pdf.

[37]Iyer and Puri (2007) exploit the same shock to study the characteristics of depositors that run in one of the banks in our sample and find that the runs only started after the failure of MMCB.

[38]The central bank also made it clear that it would not waive penalties for non compliance of cash reserve requirements and SLR requirements by banks that had exposure to MMCB.

[39]Monetary policy statement 2001-2002, page no. 47 (www.rbi.org.in).

[40]There was however no restriction on lending in the call money market. See circular DS.PCB.CIR. 40 /13.01.00/2000-01 at www.rbi.org.in.

[41]The central bank issued a statement that some co-operative banks were facing liquidity problems and were not

central bank also noted that parking of funds by co-operative banks with other co-operative banks posed a systemic risk. In response, it issued a directive asking all the co-operative banks not to renew or place fresh deposits with other co-operative banks.[42] It was, however, left to the discretion of the banks if they wanted to unwind their deposits prematurely, though it was stipulated that by the end of June 2002, they should unwind their deposits with other co-operative banks. Another regulatory response of the central bank, immediately after the failure, on the 16th of March 2001, was to issued a public statement that all banks had adhered to the prescribed norms related to stock market lending.[43]

4   Data

As there is no single source that has all the balance sheet information (either in paper or in electronic format), we had to hand collect annual reports of banks. Given the enormity of the task, we streamlined the data collection. We first limit our analysis to co-operative banks located in the state of Gujarat as there were only very few banks outside the state of Gujarat which had connections with the failed bank. We further limit our sample to banks that have a deposit base with more than Rs. 250 million (5 million dollars) as on March 31st, 2001.[44] We find that using this cutoff lead to a total of 142 banks, constituting 87% of the total deposit base of the co-operative banks in Gujarat and 13% of the total banking system in the state. Moreover, these banks cover a major portion of the linkages with the failed bank.[45] For the 142 banks in the sample, we obtain data on their deposit figures as on March, 31st 2000, March 31st 2001, and December 31st 2001, along with the relevant balance sheet variables as on March 31st 2000 and March 31st 2001. Note that the deposit data as on 31st of December 2001 is obtained from the central bank as co-operative banks only publicly report their deposit data as on the 31st of March of every year.

We also have data on the outstanding credit and debit position each bank has with MMCB as on March 13th, 2001 (date of failure). In addition, we have data on the aggregate outstanding level of claims of each bank has with and from other banks in the interbank market as on 31st of March

able to raise funds in the call money market. In view of this, the central bank announced that co-operatives could avail liquidity from the central bank against appropriate collateral. See press release no. 1371 on April 4th, 2001, at www.rbi.org.in.

[42]See circular BR. 43/16.20.00/2000-01 at www.rbi.org.in.

[43]See www.financialexpress.com/fe/daily/20010316/fec16032.html.

[44]Banks headquartered in the region of Kutch were also excluded from the analysis as there was an earthquake which severely affected this region on January 26th, 2001 (prior to the MMCB failure). The central bank and the state government provided several concessions to banks located in this region to facilitate economic growth. Also there was a huge increase in deposits in banks in this region as aid agencies opened accounts to help facilitate the rehabilitation process.

[45]The placement of deposits and dealings between co-operatives and private and public banks is limited. There were no private or public banks that had deposits placed with MMCB.

2001. All this data is obtained from the central bank. Thus for each on-going bank, we know: (i) its exposure to the failed bank (MMCB); (ii) the amount of credit outstanding it has with other on-going banks in the system; (iii) the amount of funds it has from other on-going banks in the system. We also compile deposit rates offered by banks from the annual reports (i.e., on March 31st, 2001, and on March 31st, 2002), if they were available. Finally, we collected information on media articles about bank runs that were published during the crisis. We first collected information on the articles that appeared in the national newspapers and then looked for additional information in the regional newspapers.[46] In addition, we also looked in the annual reports of banks to check for voluntary release of information pertaining to the credit and debit outstanding with the failed bank (MMCB).

5 Empirical strategy

We now return to the central question of whether there is financial contagion due to interbank linkages. To study financial contagion due to interbank linkages with the failed bank, we first construct a variable called *exposure* that represents the credit outstanding of a bank with the failed bank (MMCB) as fraction of its total assets. One point to take note of is that the failed bank (MMCB) did not lend to any bank in our sample. Notice also that the variable *exposure* is measured on March 13th, 2001 (as on the date of the failure). We then construct a variable called *deposit growth* that for each bank captures the change in the level of deposits between March 31st, 2001, and December 31st, 2001.[47] We also define a dummy variable that reflects large deposit withdrawals (tail risk). Since we only have 142 observations in our sample, we select the tail risk as the 20% of the observations in our sample with the highest deposit withdrawals.[48] This corresponds to a cutoff of deposit withdrawals greater than 12.75% (i.e., deposit growth lower than -12.75%). Thus *large deposit withdrawals* is a dummy variable that takes the value of 1 if deposit growth is lower than or equal to -12.75%, and 0 otherwise.[49] We also define the variable *deposit growth* for the period between March 31st 2000 and March 31st 2001.

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[46] We found a perfect overlap between the coverage in national and regional newspapers. One reason for this could be that national newspapers generally outsource regional news from various correspondents. Also, another reason could be that given that banking panics attract reader attention, it is therefore likely that most of the news is covered in national newspapers.

[47] We use change in the aggregate level of deposits to construct the measure as data on uninsured versus insured level of deposits is not available. Though insured depositors should not have an incentive to run, the delays in payment due to partial suspension of convertibility reduces the effectiveness of the deposit insurance scheme. Martinez Peria and Schmukler (2001) find that insured depositors disciplined banks in Argentina, Mexico and Chile. They attribute this behavior to problems in the implementation of the deposit insurance scheme.

[48] To be more precise, with the cutoff of 12.75%, there are 28 banks in our sample with deposit withdrawals larger than 12.75%. This implies that 19.71% of all the banks in our sample suffer large deposit withdrawals.

[49] Notice that even if we use other thresholds like 15% we do not find any change in the results of the paper.

To control for other factors that could influence deposit withdrawals, we construct several measures using 31st of March 2001 balance sheet information. We measure bank profitability by return on assets ratio (see the Appendix for exact definitions of all the variables). We also use the capital to asset ratio as measure of financial health of the bank. We also control for the size of banks. The measures that we use to proxy for riskiness of banks, or susceptibility to a crisis, are: the ratings by the regulator (which classifies banks as weak or not) and credit to deposit ratio. Ideally, we would like to use the level of non-performing assets as a measure of riskiness, but co-operative banks are not required to disclose the details of non-performing assets. The ratings by the regulator provide a substitute for the level of non-performing assets.[50] The credit to deposit ratio captures the illiquidity risk of a bank. We also define a dummy variable called 'media release' which takes value of 1 for a bank if a report appeared in the newspapers about runs in the bank and zero otherwise.[51] In addition, to control for local macro economic factors that could affect deposits, we use dummies for districts where banks are headquartered as the bulk of a co-operative bank's business and deposit base is in the district where it is head quartered.

Table 1 provides summary statistics of the data. We find that on average banks experience a negative deposit growth (4.96% loss in deposits) in the period between March 31st 2001 and December 31st 2001. The average deposit growth in the period between March 31st 2000 and March 31st 2001 is 14.1%. The average exposure that banks have to the failed bank is 3.27% of their total assets. The average of other interbank lending (lending in the interbank market apart from the exposure to the failed bank) is 2.9%. The average capital-to-asset and return-on-assets ratios are 11% and 1% respectively. The average credit-to-deposit ratio is 64%.[52]

Table 2 provides a detailed description of deposit growth and exposure levels of banks. From Table 2 we see that there is wide degree of variation in the deposit growth across banks (the standard deviation is 13.3%), with some banks experiencing a 50% loss in deposits, while other banks experience a positive deposit inflow to the tune of 50%. A detailed look at the exposure levels of banks shows that out of a total sample of 142 banks, 121 banks are connected to the failed bank, with the highest exposure level being 23% of total assets. The average exposure that banks have to the failed bank is 3.27% of their total assets, while the median is 0.5%. Out of the total of

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[50] Banks whose owned funds have been eroded to the extent of 25% or more by un-provided for bad and doubtful debts are classified as weak. Banks that have overdues exceeding 50% of loans outstanding, or banks not complying with minimum share capital requirements or viability norms prescribed by the central bank are also classified as weak. Banks that are classified as weak have restrictions placed on them in terms of dividend payouts and disposal of assets.

[51] An important point to note is that most of the media articles just stated a bank was facing a huge depositor withdrawal. Also all the articles except one appeared immediately after the failure, i.e. between 13th of March 2001 and 31st of March 2001 (before our sample begins).

[52] Refer to Table 1 for the summary statistics of the remaining main variables that we use in the paper.

121 banks that are connected to the failed bank, 20 banks have more than 9.21% (average plus one standard deviation of banks with positive exposure) of their assets invested in the failed bank. We define these banks as having high exposure. 21 banks have exposure levels between 3.83% (average of banks with positive exposure) and 9.21%. We define these banks as having medium exposure. Finally 80 banks have positive exposure levels but lower than 3.83%. We define these banks as having low exposure.

Decomposing the deposit growth and the probability of large deposit withdrawals for different categories of exposure, we can see that the deposit growth that banks experience is decreasing in the exposure levels to the failed bank (Table 3). We also see that the probability of large deposit withdrawals is increasing in the exposure levels. For instance, banks that are in the high exposure region face a 35% probability of facing large deposit withdrawals, while the corresponding probability is only 4.76% for banks in the zero exposure region. Table 3b presents the results excluding the 12 banks that have a media report. The results are even more stark. While banks in the high exposure region continue having a 35% probability of facing large deposit withdrawals, the corresponding probability for banks in the zero exposure region is 0%. In addition, banks in the zero exposure region experience an inflow in deposits as against a 9% average deposit loss for banks in the high exposure region. Moreover, we find that banks with a high level of exposure to failed bank do not differ in ex-ante characteristics as compared to banks with low levels of exposure. As results in Table 4 show, there are no significant differences in terms of profit, risk (proxied by deposit rate) and size across these two categories of banks.[53]

5.1 The effect of exposure on deposit withdrawals

From the results reported in Table 3, there appears to be a correlation between exposure and deposit withdrawals. To further examine whether the level of exposure to the failed bank has an effect on deposit withdrawals, we first examine the effect of exposure on deposit growth using a cross-sectional regression approach. In Table 5, column 1, controlling for other fundamental characteristics of banks and local macroeconomic conditions, we see that exposure to the failed bank is a significant predictor (at 1%) of deposit growth. We find that banks with higher level of exposure to the failed bank experience lower growth in deposits. We also find that banks with higher return on assets have significantly higher deposit growth. Banks that are classified as weak by the regulator experience lower deposit growth. Furthermore, banks with higher fraction of illiquid assets – proxied by credit-to-deposit ratio – have a lower deposit growth. We also find that

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[53]Not reported, even if we compare ex-ante characteristics of banks as on March 31st 2000, we find similar results.

the media release dummy is highly significant in explaining deposit growth, i.e. banks that have a media report about them have lower growth in deposits after the media release.

As it is possible that exposure could just be proxying for other characteristics of banks like distance from the failed bank or a correspondent banking relationship with the failed bank, in column 2, we introduce controls both for correspondent banking relationship with the failed bank and for distance from the failed bank. In column 2, we also control for deposit growth in the previous year (between 31st March 2000 and 31st March 2001) to capture past performance of banks.[54] As results in column 2 show, we find that lagged deposit growth has a positive and significant effect on current deposit growth. We do not, however, find any significant effect of correspondent banking relationship or distance from the failed bank on deposit growth. More importantly, we find that despite these controls, exposure to the failed bank continues to have a significant negative effect on deposit growth. In column 3, we look at the effect of deposits held in other banks (apart from the failed bank) on deposit growth. Interestingly, we find that only the level of exposure to the failed bank has a significant negative effect on deposit growth. There is no significant effect of higher lending to other banks on deposit growth.

In column 4, we introduce a dummy variable that takes the value of one for banks with no exposure to the failed bank, and zero otherwise. The dummy variable is statistically and economically significant: banks with positive exposure to the failed bank on average experience a negative deposit growth of 6.2% as compared to banks with no exposure. We also find that banks with high level of exposure to the failed bank experience, on average, an additional lower deposit growth of 8.2% as compared to banks with low exposure (column 5). The preliminary results in Table 5 suggest that depositor withdrawals are based both on the exposure to the failed bank and on bank fundamentals.

While in Table 5 we find that higher level of exposure to the failed bank has a negative effect on deposit growth, theoretical models of interbank contagion (Allen and Gale, 2000; Dasgupta, 2004; Brusco and Castiglionesi, 2005) predict that higher exposure to the failed bank leads to higher probability of large deposit withdrawals. Hence, to check whether exposure to the failed bank affects the probability of large deposit withdrawals, we run probits where the dependent variable is a dummy variable that takes the value of 1 if deposit growth is lower than or equal to -12.75% (large deposit withdrawals). With this cutoff, 20% of the banks in our sample suffer large deposit withdrawals.[55]

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[54] Banks with worse previous performance might have higher incentives to take risks.

[55] None of the results of the paper are altered if we use other cutoffs like -15%.

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As we can see in Table 6, column 1 to column 3, higher exposure to the failed bank increases the probability of facing large deposit withdrawals. The variable exposure is statistically significant at 1%. In column 4 and 5, we find that the dummy for banks with high exposure is statistically significant at 1%. Moreover, if we derive the marginal effects for the probit in column 5, we find that (at the average level) a bank with high level of exposure (vis-a-vis a bank with low level of exposure) experiences an increase in outcome probability of large deposit withdrawals of 0.34. Hence, not only is exposure statistically significant but it is also economically significant. Notice that in column 1, when we put district controls, we lose many observations since many district controls predict perfectly the outcome (we have 16 district controls and only 142 banks). Nevertheless, exposure is still significant at 1%. Also notice that most of the bank fundamental variables have similar effects (in terms of signs) as those reported in Table 5. Finally, in column 6, we find that banks with positive exposure to the failed bank experience higher probability of facing large deposit withdrawals as against banks with zero exposure. We find that (at the average level) a bank with positive exposure (vis-a-vis a bank with zero exposure) experiences an increase of 0.19 in outcome probability of suffering large deposit withdrawals. All in all, the results in Table 5 and 6 suggest that exposure impacts deposit withdrawals.

5.2 The non-linear effect of exposure

Apart from exposure to the failed bank leading to large deposit withdrawals, theoretical literature (Allen and Gale, 2000; Dasgupta, 2004; Brusco and Castiglionesi, 2005) also points towards non-linearities in the effect of exposure on large deposit withdrawals and, possibly, on deposit growth. To investigate this hypothesis, we run a piecewise linear regression (see Morck et al., 1988). As we can see from Table 7, column 1, we cannot reject that the coefficient for banks in the low exposure region is different from zero. In addition, in column 2, the dummy for banks with zero exposure has a positive and significant coefficient in turn implying that banks with zero exposure have higher deposit growth. More importantly, we reject the hypothesis that the coefficient of the high exposure region is equal to the coefficient of the low exposure region, thus suggesting that the effect of exposure on deposit growth is non-linear.

In column 3 and 4, we investigate non-linear effects of exposure on the probability of large deposit withdrawals. As the results show, we only find that banks in the high exposure region face a higher probability of large deposit withdrawals. In addition, we reject that the coefficients are equal. Interestingly, we find that banks with zero exposure experience lower probability of large deposit withdrawals. All in all, these results suggest that there is a non-linear effect of exposure

on deposit withdrawals. In particular, the sensitivity of exposure on deposit withdrawals is greater for banks with high levels of exposure.

5.3 The effect of exposure on deposit rate change

While the results so far suggest that exposure to the failed bank has a significant effect on deposit withdrawals, it could be possible that banks with higher exposure reduced their rate offered on deposits (due to regulatory pressure), thereby facing higher deposit withdrawals. In order to investigate this possibility, we analyze whether changes in the deposit rate paid by banks is related to the level of exposure. As results in Table 8, column 1 through 3, show, we do not find any significant relationship between change in the deposit rate and exposure levels. Moreover, the correlation coefficient between high exposure dummy and deposit rate change is -0.03. These results suggest that the effect of exposure on deposit withdrawals is not due to change in deposit rates.

5.4 The immediate effect of exposure on deposit growth

To partially analyze the immediate impact of exposure on deposit growth (between the 13th of March and 31st of March, 2001), we use data on deposit growth for the period between the 31st of March 2000 and 31st of March 2001.[56] In addition, we also use balance sheet data as on 31st of March 2000. In Table 9, column 1, we find that exposure has a significant negative effect on deposit growth. Notice also that banks closer in distance to the failed bank also experience lower deposit growth. In column 2, we find that dummy for banks with high level of exposure is significant and has a negative effect on deposit growth. When we run the piece-wise linear regression, we again find a non-linear effect: only banks with high levels of exposure experience lower deposit growth (column 3). The results in Table 9 suggest a negative correlation between exposure to the failed bank and deposit growth in the period immediately after the failure.

5.5 Instrumental variable approach

One of the problems of the regressions reported in Table 9 is that banks which are badly performing (experiencing a lower deposit growth) may choose higher levels of exposure. Therefore, to address this self-selection problem and get a better understanding of the causal link between exposure and deposit growth, we run a treatment-effects model using a two-step consistent estimator for the

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[56]In fact, this is another way to investigate whether change in deposit rate is the prime driver of deposit withdrawals. As it is generally difficult for banks to change the interest rate offered on deposits in a short span of time, we check whether exposure to the failed bank has an effect on deposit growth in the period immediately after the failure.

period between March 31st 2000 and March 31st 2001. The endogenous variable in the first stage regression is a dummy variable that takes the value of one for banks with high level of exposure. In the second stage regression, we analyze the impact of exposure on deposit growth.

For identification, a natural candidate to instrument for exposure is a variable that proxies whether banks lend in the interbank market (excluding lending to the failed bank): banks that lend in the interbank market are also likely to lend to the failed bank and vice versa. We, therefore, create a dummy variable that takes the value of one for banks that have deposits outstanding (lend) in the interbank market (excluding exposure to the failed bank), zero otherwise.[57] In particular, the dummy for banks that lend in the interbank market does not have any direct effect on deposit withdrawals in the period between 31st of March, 2000, and 31st of March, 2001.[58]

As results in Table 10, column 1, show, in the first stage regression, the dummy for banks that lend in the interbank market is highly significant in explaining high level of exposure (the t-statistic is 2.66). We also find that the Wald test rejects independence of the two equations, Lambda (the inverse of the Mills Ratio) is positive and significant, and the correlation between the errors of the two regressions are positive. This implies that (i) exposure levels of banks are subject to self-selection problems and (ii) using OLS leads to an underestimation of the coefficient of dummy high exposure. In column 2, in the second stage regression, we find that the component of exposure to the failed bank predicted by the overall lending in the interbank market has a highly significant (both statistically and economically) effect on deposit growth.

For the period between 31st of March and 31st of December 2001, even though exposure is measured before the period we measure deposit withdrawals, for robustness and to push the causal interpretation of the main results of the paper, we use the instrumental variable approach. In column 3 and 4, we run a probit for the effect of exposure on large deposit withdrawals (for the period between 31st March 2001 and 31st December 2001). To instrument for exposure, we use the dummy that takes the value of one for banks that also lend to the other banks in the interbank market (excluding the lending to the failed bank).[59] As we can see in the first stage regression (column 3), the dummy for banks that overall lend in the interbank market is a highly significant determinant of exposure. In particular, the t-statistic of the hypothesis that the overall lending based instrument can be excluded from the regression, i.e. that the coefficient on it is 0, equals 3.46.

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[57] As we only have interbank claims with other banks (apart from the failed bank) as on the 31st of March 2001, we use this information to create the dummy.

[58] Also, in table 5, column 3, we find that only the level of exposure to the failed bank has an effect on deposit growth for the 2001 period, whereas the level of deposits with other banks in the interbank market does not have a significant effect on deposit growth.

[59] This variable is not significant in explaining large deposit withdrawals (see also table 6), independently whether we include exposure in the regression or not.

Hence, the F-statistic of the exclusion hypothesis (F=11.97) exceeds the rule-of-thumb threshold of ten recommended by Staiger and Stock (1997) to avoid weak instrument concerns. The second stage regression estimates (column 4) suggest that the component of exposure to the failed bank predicted by the overall lending in the interbank market has a highly significant effect on the probability of facing large deposit withdrawals.

5.6 Communication of exposure in the banks' annual reports

The finding that banks with higher levels of exposure to the failed bank experience higher deposit withdrawals raises the question whether depositors have access to the information on the outstanding credit position of banks with the failed bank. One possible way depositors might get this information is through voluntary disclosure by banks of their interbank positions in their annual report. To investigate the possibility of banks voluntarily releasing information in the period, in which we measure deposit withdrawals, we check whether information on exposure is provided by banks in their 2001 annual report – released between July and December 2001.[60] We find that some banks voluntarily release information.

In order to further investigate the characteristics of banks that release information on exposures to the failed bank, we run a probit, the results of which are reported in Table 11, column 1. We find that banks with lower level of exposure to the failed bank are more likely to release information.[61] We also find that banks that have a media release are less likely to release information. Interestingly, we find that banks that have a correspondent banking relationship with the failed bank are more likely to release information. These results are partially consistent with the predictions of games of voluntary disclosure with verifiable information, where good types have an incentive to disclose their type (Okuno-Fujiwara et al., 1990; Vives, 2004). However, we do not find complete unravelling of information.

When we re-estimate the deposit growth regression and the probability of large deposit withdrawals excluding the banks that released information, we find that exposure to the failed bank is still a highly significant predictor of withdrawals in this sub-sample (column 2 and 3). In other words, even for banks that reported no information on exposure to the failed bank, the exposure level is a significant predictor of deposit withdrawals. This coupled with the findings in Table 9 and Table 10 that banks with high level of exposure experience lower deposit growth immediately after the failure suggests that depositors might be acting on private information obtained through mon-

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[60]Banks release their audited annual report generally around August, but their deadline is December. Furthermore, the annual reports are not mailed to depositors but only circulated among members of the co-operative.

[61]While interpreting the results from the probit, one should keep in mind that we do not have deposit changes before the information release by banks, which could have influenced the decision to release information.

itoring (Calomiris and Kahn, 1991) and/or on alternative channels like rumors or word of mouth communication (Kelly and O'Grada, 2000).

5.7 Interbank linkages among on-going banks

The results so far suggest that exposure to the failed bank has a significant effect on deposit withdrawals. In addition, from Table 5 and 6, column 3, we find that lending in the interbank market (excluding the lending to the failed bank) does not affect deposit withdrawals.

We now proceed to investigate whether banks with a higher fraction of their deposits held by other banks (i.e., banks with higher borrowing from the interbank market) face higher deposit withdrawals.[62] There are several possible reasons why banks with higher fraction of deposits/borrowings from other banks may face higher deposit withdrawals: (i) banks may liquidate their interbank deposits in order to obtain liquidity in a crisis time; (ii) banks with higher interbank lending may fear contagion due to interbank linkages, thus liquidating their deposits in other banks – especially in banks with higher levels of exposure to the failed bank; (iii) banks might unwind their deposits in other banks due to the mandate of the central bank to not renew deposits in other banks.

In Table 12, column 1, we do not find that banks with a higher fraction of their deposits held by other banks experience lower deposit growth. The finding that the fraction of borrowings from other banks does not directly affect deposit growth suggests that the mandate of the central bank was not binding. It also suggests that banks did not randomly liquidate their deposits in the interbank market. However, interestingly, we find in column 2 and 3 that the interaction of exposure and fraction of borrowings from other banks is both economically and statistically significant. This implies that the effect of exposure to the failed bank on deposit withdrawals is higher for banks that borrow more from the interbank market.

It could be possible that banks with higher exposure to the failed bank borrow more from the interbank market in order to obtain liquidity. If this were true, the interaction of exposure and fraction of deposits from other banks should be significant but not because of fear of banking contagion. To address this concern, we regress fraction of deposits from other banks on bank fundamentals – including exposure. From the results in column 4, we do not find any significant relationship between bank fundamentals and the fraction of deposits from other banks. More importantly, we do not find any relationship between exposure levels to the failed bank and the fraction of deposits from other banks. In sum, the finding that the interaction variable between exposure and interbank borrowings affects deposit withdrawals suggests that banks might liquidate

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[62]Notice that the failed bank (MMCB) did not lend to any bank.

their deposits in other banks with high levels of exposure to the failed bank due to the fear of further contagion. Also, the results from Table 12 show that for banks with lower exposure to the failed bank, the fraction of deposits from other banks do not affect deposit withdrawals, thus suggesting that there is no random panic in the interbank market.

Given the findings in Table 12, column 1 through 4, a natural question that arises is whether the effect of exposure on deposit withdrawals is primarily driven by the liquidation of deposits by banks. To address this concern, we run the regressions for banks that do not have deposits from other banks. We find that – even for banks that have no deposits from other banks – exposure has a significant effect on deposit withdrawals (column 5 and 6).

5.8 The effect of exposure when bank fundamentals are weaker

The results so far suggest that higher exposure to the failed bank significantly increases deposit withdrawals (i.e., contagion due to interbank linkages). In addition, the results also suggest that depositor withdrawals are higher in banks with lower fundamentals. However, theory (Allen and Gale, 2000; Dasgupta, 2004; Brusco and Castiglionesi, 2005) also suggests that contagion due to interbank linkages should be higher when bank fundamentals are weaker – i.e., the effect of higher exposure on deposit withdrawals should be lower for banks with stronger fundamentals since they can better withstand the crisis. To investigate this hypothesis, we interact exposure with variables that proxy for bank fundamentals.[63] Table 13 presents the results.

From column 1 and 5, we find that the effect of exposure on large deposit withdrawals is lower for banks with higher capital to asset ratio.[64] From column 2 and 5, we find that the effect of exposure on large deposit withdrawals is increasing in the number of depositors in the bank. We also find that the effect of exposure on deposit growth is decreasing in the number of depositors in the bank (column 6).[65] This result suggests that contagion is higher when there is higher likelihood of coordination problems among depositors (proxied by the number of depositors). From column 3 and 6, we also find that the effect of exposure on deposit growth is lower for banks classified as *weak* ex-ante by the regulator. Also, we find that the effect of exposure on large deposit withdrawals is

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[63]Notice that we normalize the interaction variables of exposure with bank fundamentals. We do this both to gain in efficiency and also to reduce the correlations among the regressors: e.g., the variable weak has two values (0 and 1); hence, if we would not normalize the interaction variables, then, when weak is equal to 0, the interaction term of exposure and weak would equal to 0 independently of whether exposure is high or low. Therefore, without normalizing, then (i) the correlation between weak and exposure*x*weak would be higher and (ii) we would not differentiate between weak banks with higher vs. weak banks with lower exposure.

[64]From column 6, we find that (at 11%) the effect of exposure on deposit growth is higher for banks with lower capital to asset ratio.

[65]Notice that we use the number of depositors as on 31st March 2000 as the number of depositors as on 31st March 2001 is partially determined by the levels of exposure to the failed bank.

higher for banks classified as *weak.* From column 6, we find that the effect of exposure on deposit growth is lower for smaller banks.[66] Finally, in column 5 and 6 we present the results of all the interactions including the interaction of exposure and interbank borrowings.

All in all, these results suggest that contagion due to interbank linkages is stronger when bank fundamentals are weaker. This suggests that the effect of an idiosyncratic shock on the rest of the banking system is higher when both exposure of the banking system to the failed bank is higher and fundamentals of the banking system are weaker.

6   Conclusion

We exploit an idiosyncratic and sudden shock caused by a large-bank failure, in conjunction with precise data on interbank exposures, to test for financial contagion due to interbank linkages. Interestingly, our results suggest that higher level of exposure to the failed bank leads to higher deposit withdrawals thereby reducing liquidity. We also find that the effect of exposure on deposit withdrawals is non-linear (the impact of exposure on deposit withdrawals is higher for high exposure levels). Furthermore, the impact of exposure on deposit withdrawals is higher for banks with weaker fundamentals. Finally, our results also suggest that interbank linkages (apart from linkages to the failed bank) further propagate the shock. These results lend support to the theories of financial contagion due to interbank markets (Allen and Gale, 2000; Dasgupta, 2004; Iyer and Peydró-Alcalde, 2005; Brusco and Castiglionesi, 2005).[67]

Our results have important policy implications, both for prudential regulation and for crisis management. Since we find that interbank linkages transmit shocks, regulators and banks can devise ex-ante risk management systems to curtail excessive exposure to single institutions in order to limit the destabilizing effects that could arise from idiosyncratic shocks.[68] A potential solution could be that bank capital requirements take into account the concentration risk of large single exposures.[69] Furthermore, the other interesting policy implication stemming from our paper is that systemic risk implications of a failure of a large financial institution are very important specially when *both* the rest of the financial system has (i) a high interbank exposure to the failed institution

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[66] From column 5, we find (at 14%) that the effect of exposure on large deposit withdrawals is higher for smaller banks.

[67] For similar theoretical predictions, see Freixas et al., 2000; Flannery, 1996; Rochet and Tirole, 1996; Aghion et al., 2000; Cifuentes et al., 2005; Diamond and Rajan, 2005 and Leitner, 2005.

[68] As stated by Thomas M. Hoenig, President of the Federal Reserve Bank of Kansas City, at the World Economic Forum 1996 Annual Meeting "First, instead of regulating to make institutions fail-safe, an alternative approach is to strengthen the stability of the financial system by designing procedures that prevent large interbank exposures in the payments system and interbank deposits."

[69] The costs of limited liquidity provision should also be carefully weighted.

and (ii) weak fundamentals.[70] Therefore, our paper helps in better clarifying the circumstances in which bailouts and/or lender of last resort (LoLR) policies are desirable: e.g. if the fundamentals of the banking system are strong, bail-out may not be necessary since the costs associated with contagion may be lower than the costs associated with bail-outs (moral hazard and fiscal costs).[71]

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[70] This conclusion is also important for other type of financial institutions: e.g., the different repercussions of LTCM failure vis-à-vis Amaranth's failure. In the case of LTCM, the exposure of other financial institutions to LTCM was high and the fundamentals of the financial markets were not very high after the Russian crisis. In contrast, the exposure of the financial institutions to Amaranth was not so high and the fundamentals of the financial markets were strong.

[71] See Rochet and Tirole, 1996; Rochet and Vives, 2004.

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Table 1
Summary statistics

This table provides summary statistics for the banks in the sample. *Deposit growth* is log (D $_t$/D $_{t-1}$) where D $_t$ is the level of deposits as on 31st of December 2001 and D $_{t-1}$ is the level of deposits as on 31st of March 2001. *Large deposit withdrawals* is a dummy variable that takes the value of 1 if deposit growth is lower than or equal to -12.75% (which implies that 20% of the observations exhibit large deposit withdrawals). *Exposure* is the credit outstanding of a bank with the failed bank divided by its total assets as on 13th of March 2001. *Return on assets* is the profits of the bank divided by its total assets. *Size* is the log of total assets of the bank. *Media* is a dummy variable that takes the value of 1 if a report about the bank appeared in newspapers in the period between 13th of March and 31st of March 2001. *Weak* is a dummy variable that takes the value 1 when a bank is classified as weak by the central bank. *Credit to deposit ratio* is the total loans of a bank divided by its total deposits. *Capital ratio* is the book value of shareholder equity plus reserves divided by total assets. *Deposit growth (t-1)* is log (D $_{t-1}$/D $_{t-2}$) where D $_{t-1}$ is the level of deposits as on 31st of March 2001 and D $_{t-2}$ is the level of deposits as on 31st of March 2000. *Correspondent relationship* is a dummy variable that equals one for banks that a have correspondent banking relationship with the failed bank. *Distance* refers to the physical distance (in Km) between the headquarter of a bank and the headquarter of the failed bank. *Interbank borrowing* is the ratio of deposits held by other co-operative banks to total deposits as on 31st of March 2001. *Other interbank lending* is the ratio of deposits held in other co-operative banks to total assets as on 31st of March 2001. *Deposit rate change* is defined as (DR $_t$-DR $_{t-1}$)/ DR $_{t-1}$ where DR $_t$ is the deposit rate (offered to depositors for a deposit of 1-year maturity) prevailing as on 31st of March 2002 and DR $_{t-1}$ is deposit rate prevailing as on 31st of March 2001. *Deposit rate 2001* is the rate prevailing as on 31st of March 2001 offered to depositors for a deposit of 1-year maturity. *Information release* is a dummy that takes the value of 1 if the bank released information on its exposure with the failed bank in the year 2001 annual report. *# of depositors* is the number of depositors in the bank as on March 31st 2000. All balance sheet variables are measured as on 31st of March 2001 unless stated. Dummy variables take the value of zero otherwise.

	Mean	Median	Standard Deviation	Min	Max	N
Deposit growth	-0.049	-0.039	0.133	-0.506	0.508	142
Large deposit withdrawals	0.197	0	0.399	0	1	142
Exposure	0.327	0.005	0.051	0	0.235	142
Return on assets	0.010	0.009	0.008	-0.036	0.040	142
Size	9.165	9.097	0.775	7.993	12.088	142
Media	0.070	0	0.256	0	1	142
Weak	0.091	0	0.289	0	1	142
Credit to deposit ratio	0.636	0.624	0.160	0.262	1.044	142
Capital ratio	0.112	0.107	0.039	0.039	0.291	142
Deposit growth (t-1)	0.141	0.128	0.128	-0.215	0.586	142
Correspondent relationship	0.464	0	0.500	0	1	142
Distance	121	79	98	0	345	142
Interbank borrowing	0.008	0	0.025	0	0.155	124
Other interbank lending	0.029	0.002	0.053	0	0.258	121
Deposit rate change	0.044	0	0.103	-0.251	0.310	70
Deposit rate 2001	0.087	0.09	0.012	0.055	0.12	84
Information release	0.316	0	0.466	0	1	142
# of depositors	45897	40013	24822	8000	139611	121

Table 2
Details on deposit growth and exposure

This table provides more detailed information on *exposure* and *deposit growth*. *Deposit growth* is log (D_t/D_{t-1}) where D_t is the level of deposits as on 31st of December 2001 and D_{t-1} is the level of deposits as on 31st of March 2001. *Exposure* is the credit outstanding of a bank with the failed bank divided by its total assets as on 13th of March 2001. *Dummy high exposure* is a dummy variable that takes the value of 1 if exposure is higher than or equal to 9.21% (average plus one standard deviation of exposure if exposure is positive). *Dummy medium exposure* is a dummy variable that takes the value of 1 if exposure is higher than or equal to 3.83% (average of exposure if exposure is positive) and lower than 9.21%. *Dummy low exposure* is a dummy variable that takes the value of 1 if exposure is lower than 3.83% and higher than 0%. *Dummy zero exposure* is a dummy variable that takes the value of 1 if exposure is equal to 0%. Dummy variables take the value of zero otherwise.

Table 3
Relationship between deposit withdrawals and exposure

Table 3A presents the relationship between different thresholds of *exposure* with *deposit growth* and *large deposit withdrawals*. Table 3B reports the same results excluding the 12 banks that have a media release about them. *Deposit growth* is log (D $_t$/D $_{t-1}$) where D $_t$ is the level of deposits as on 31st of December 2001 and D $_{t-1}$ is the level of deposits as on 31st of March 2001. *Large deposit withdrawals* is a dummy variable that takes the value of 1 if deposit growth is lower than or equal to -12.75% (which implies that 20% of the observations exhibit large deposit withdrawals). *Exposure* is the credit outstanding of a bank with the failed bank divided by its total assets as on 13th of March 2001. *Dummy high exposure* is a dummy variable that takes the value of 1 if exposure is higher than or equal to 9.21% (average plus one standard deviation of exposure if exposure is positive). *Dummy medium exposure* is a dummy variable that takes the value of 1 if exposure is higher than or equal to 3.83% (average of exposure if exposure is positive) and lower than 9.21%. *Dummy low exposure* is a dummy variable that takes the value of 1 if exposure is lower than 3.83% and higher than 0%. *Dummy zero exposure* is a dummy variable that takes the value of 1 if exposure is equal to 0%. Dummy variables take the value of zero otherwise.
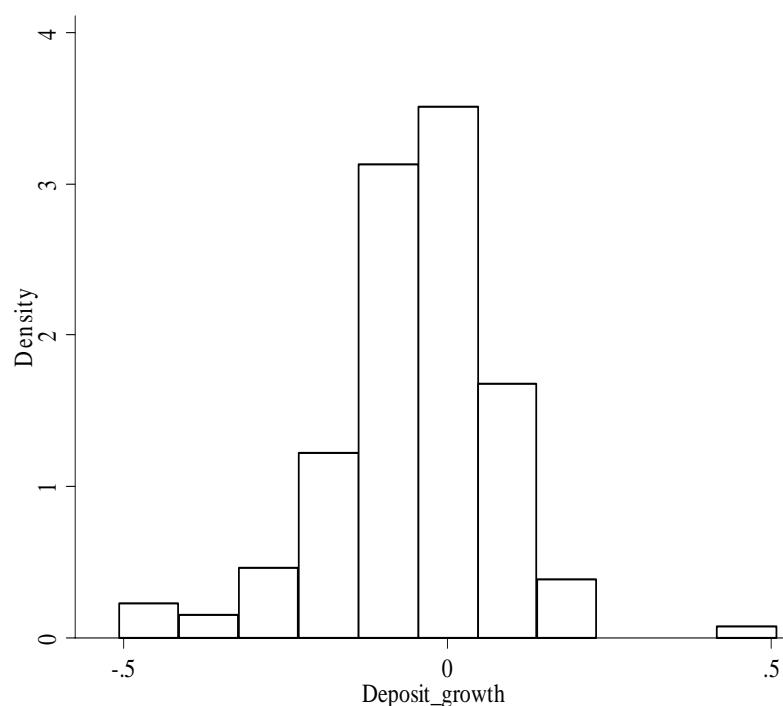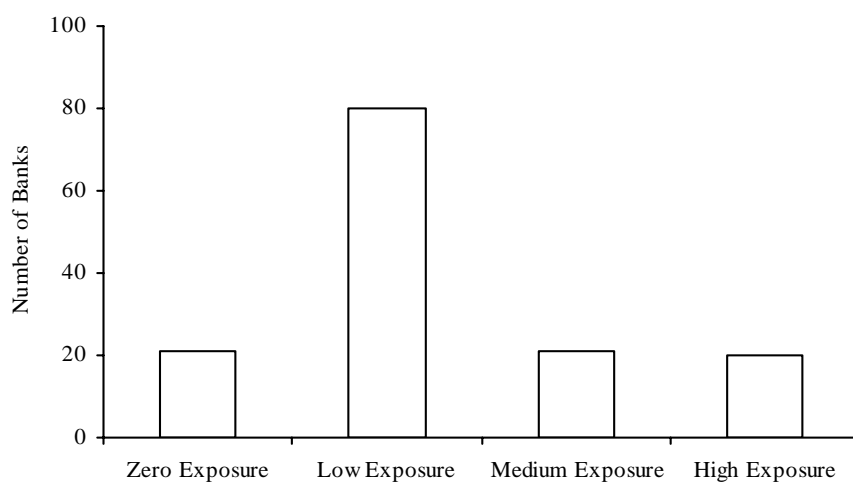
Table 3A

Large Deposit Withdrawals (right scale)

Deposit Growth (left scale)

Table 3B

Large Deposit Withdrawals (right scale)

Deposit Growth (leftscale)

Table 4
Ex-ante differences in bank fundamentals between banks with high versus low exposure

This table presents the results of a two-sided t-test of the mean of bank fundamentals between banks with high level of exposure versus banks with low level of exposure. To distinguish between high vs. low exposure, in Table 4A, *high exposure* refers to banks with the exposure higher than or equal to 9.21% (average plus one standard deviation of exposure if exposure is positive), whereas *low exposure* refers to banks with exposure lower than 9.21%. By contrast, Table 4B uses banks with *positive exposure* versus banks with *zero exposure*. The bank fundamentals are the following: (i) *Return on assets* is the profits of the bank divided by its total assets; (ii) *Size* is the log of total assets of the bank, and (iii) *Deposit rate* is the rate prevailing as on 31st of March 2001 offered to depositors for a deposit of 1-year maturity. All balance sheet variables are measured as on 31st of March 2001 unless stated. *, **, *** denote statistical significance at the 10, 5 and 1% levels, respectively.

	Return on assets	Size	Deposit rate
	(1)	(2)	(3)
Table 4a			
Low exposure			
Mean	0.0105	9.1734	0.0872
Standard Error	(0.0007)	(0.0729)	(0.0014)
N	122	122	68
High exposure			
Mean	0.0114	9.1142	0.0896
Standard Error	(0.0016)	(0.1280)	(0.0032)
N	20	20	16
Tests for differences between means (p-values)			
Low vs. High exposure	0.6525	0.7529	0.4740
Table 4b			
Zero exposure			
Mean	0.0115	8.9822	0.0875
Standard Error	(0.0014)	(0.2001)	(0.0055)
N	21	21	8
Positive exposure			
Mean	0.0105	9.1968	0.0876
Standard Error	(0.0007)	(0.0680)	(0.0013)
N	121	121	76
Tests for differences between means (p-values)			
Zero vs. Positive exposure	0.6145	0.2431	0.9661

Table 5
Effect of exposure on deposit growth

This table presents results of OLS regressions where the dependent variable is *deposit growth*. *Deposit growth* is log (D_t/D_{t-1}) where D_t is the level of deposits as on 31st of December 2001 and D_{t-1} is the level of deposits as on 31st of March 2001. *Exposure* is the credit outstanding of a bank with the failed bank divided by its total assets as on 13th of March 2001. *Dummy High Exposure* is a dummy variable that takes the value of 1 if exposure is higher than or equal to 9.21% (average plus one standard deviation of exposure if exposure is positive). *Dummy Zero Exposure* is a dummy variable that takes the value of 1 if exposure is equal to 0%. *Other interbank lending* is the ratio of deposits held in other co-operative banks to total assets as on 31st of March 2001. *Size* is the log of total assets of the bank. *Return on Assets* is the profits of the bank divided by its total assets. *Media* is a dummy variable that takes the value of 1 if a report about the bank appeared in newspapers in the period between 13th of March and 31st of March 2001. *Weak* is a dummy variable that takes the value 1 when a bank is classified as weak by the central bank. *Credit to Deposit ratio* is the total loans of a bank divided by its total deposits. *Capital ratio* is the book value of shareholder equity plus reserves divided by total assets. *Correspondent relationship* is a dummy variable that equals one for banks that a have correspondent banking relationship with the failed bank. *Distance* refers to the physical distance (in Km) between the headquarter of a bank and the headquarter of the failed bank. *Deposit growth (t-1)* is log (D_{t-1}/D_{t-2}) where D_{t-1} is the level of deposits as on 31st of March 2001 and D_{t-2} is the level of deposits as on 31st of March 2000. District controls are dummy variables that take the value of one if the bank is headquartered in a district. There are 16 different districts in our sample. All balance sheet variables are measured as on 31st of March 2001 unless stated. Dummy variables take the value of zero otherwise. Heteroscedasticity- robust standard errors are in parentheses. Unless otherwise stated, regressions are estimated with constants, but the coefficients are not reported. *, **, *** denote statistical significance at the 10, 5 and 1% levels, respectively.

	OLS Deposit growth				
	(1)	(2)	(3)	(4)	(5)
Exposure	-0.712***	-0.670***	-0.636**		
	(0.262)	(0.231)	(0.317)		
Dummy high exposure					-0.086**
					(0.038)
Dummy zero exposure				0.062**	
				(0.031)	
Other interbank lending			-0.114		
			(0.150)		
Size	-0.015	-0.018	-0.015	-0.017	-0.018
	(0.016)	(0.013)	(0.017)	(0.015)	(0.016)
Return on assets	3.333**	1.776*	3.318**	2.655*	3.254**
	(1.350)	(1.053)	(1.478)	(1.392)	(1.363)
Media	-0.193***	-0.163***	-0.177***	-0.189***	-0.193***
	(0.047)	(0.045)	(0.051)	(0.048)	(0.045)
Weak	-0.069*	-0.068*	-0.071	-0.050	-0.061
	(0.038)	(0.037)	(0.045)	(0.040)	(0.037)
Credit to deposit ratio	-0.168**	-0.154*	-0.131**	-0.110	-0.181**
	(0.081)	(0.079)	(0.075)	(0.071)	(0.086)
Capital ratio	-0.111	0.018	0.082	-0.157	-0.041
	(0.246)	(0.244)	(0.256)	(0.249)	(0.251)
Correspondent relationship		0.016	0.023	0.020	0.018
		(0.018)	(0.021)	(0.020)	(0.019)
Distance		-0.000			
		(0.000)			
Deposit growth (t-1)		0.217**			
		(0.101)			
Constant	0.222	0.210	0.164	0.168	0.231
	0.185	(0.148)	(0.172)	(0.175)	(0.185)
District controls	yes	no	yes	yes	yes
Number of banks	142	142	121	142	142
Adj./pseudo R-squared	0.283	0.348	0.326	0.234	0.255

Table 6
The effect of exposure on large deposit withdrawals

This table presents results of probits where the dependent variable is *large deposit withdrawals*. *Large deposit withdrawals* is a dummy variable that takes the value of 1 if deposit growth is lower than or equal to -12.75% (which implies that 20% of the observations exhibit large deposit withdrawals). *Exposure* is the credit outstanding of a bank with the failed bank divided by its total assets as on 13th of March 2001. *Dummy High Exposure* is a dummy variable that takes the value of 1 if exposure is higher than or equal to 9.21% (average plus one standard deviation of exposure if exposure is positive). *Dummy Zero Exposure* is a dummy variable that takes the value of 1 if exposure is equal to 0%. *Other interbank lending* is the ratio of deposits held in other co-operative banks to total assets as on 31st of March 2001. *Size* is the log of total assets of the bank. *Return on Assets* is the profits of the bank divided by its total assets. *Media* is a dummy variable that takes the value of 1 if a report about the bank appeared in newspapers in the period between 13th of March and 31st of March 2001. *Weak* is a dummy variable that takes the value 1 when a bank is classified as weak by the central bank. *Credit to Deposit ratio* is the total loans of a bank divided by its total deposits. *Capital ratio* is the book value of shareholder equity plus reserves divided by total assets. *Correspondent relationship* is a dummy variable that equals one for banks that a have correspondent banking relationship with the failed bank. *Distance* refers to the physical distance (in Km) between the headquarter of a bank and the headquarter of the failed bank. *Deposit growth (t-1)* is log (D $_{t-1}$/D $_{t-2}$) where D $_{t-1}$ is the level of deposits as on 31st of March 2001 and D $_{t-2}$ is the level of deposits as on 31st of March 2000. District controls are dummy variables that take the value of one if the bank is headquartered in a district. There are 16 different districts in our sample. All balance sheet variables are measured as on 31st of March 2001 unless stated. Dummy variables take the value of zero otherwise. Heteroscedasticity- robust standard errors are in parentheses. In column 2, 3, 5 and 6 standard errors are clustered at the district level. Unless otherwise stated, regressions are estimated with constants, but the coefficients are not reported. *, **, *** denote statistical significance at the 10, 5 and 1% levels, respectively.

	Probit Large deposit withdrawals				
	(1)	(2)	(3)	(4)	(5)
Exposure	10.328***	8.357***	9.624***		
	(3.726)	(2.938)	(3.455)		
Dummy high exposure				1.068***	
				(0.387)	
Dummy zero exposure					-1.350***
					(0.226)
Other interbank lending			0.770		
			(1.948)		
Size	-0.095	-0.048	0.016	-0.041	-0.050
	(0.237)	(0.168)	(0.187)	(0.152)	(0.139)
Return on assets	-39.193*	-33.977**	-36.013*	-32.098**	-25.013
	(20.391)	(15.863)	(20.415)	(16.250)	(18.681)
Media	1.352**	1.503***	1.596***	1.710***	1.836***
	(0.619)	(0.274)	(0.382)	(0.237)	(0.317)
Weak	1.595***	0.840**	0.872**	0.851**	0.690**
	(0.513)	(0.346)	(0.815)	(0.363)	(0.287)
Credit to deposit ratio	1.305	1.465*	1.383*	1.170	-0.119
	(0.957)	(0.813)	(0.815)	(0.820)	(0.715)
Capital ratio	0.154	-0.385	1.815	0.691	2.249
	(3.995)	(2.550)	(3.194)	(0.251)	(2.808)
Correspondent relationship		-0.451	-0.426	-0.286	-0.199
		(0.335)	(0.407)	(0.297)	(0.309)
Distance		0.003*	0.002	0.002	0.002
		(0.001)	(0.001)	(0.001)	(0.001)
Deposit growth (t-1)		-1.871***			
		(0.687)			
District controls	yes	no	no	no	no
Number of banks	112	142	121	142	142
Adj./pseudo R-squared	0.314	0.227	0.240	0.189	0.174

Table 7
The non-linear effect of exposure on deposit withdrawals

Column 1 and 2 present the results of an OLS regression where the dependent variable is *deposit growth*. Column 3 and 4 present the results of a probit where the dependent variable is *large deposit withdrawals*. *Deposit growth* is log (D_t/D_{t-1}) where D_t is the level of deposits as on 31st of December 2001 and D_{t-1} is the level of deposits as on 31st of March 2001. *Large deposit withdrawals* is a dummy variable that takes the value of 1 if deposit growth is lower than or equal to -12.75% (which implies that 20% of the observations exhibit large deposit withdrawals). *High exposure* is equal to exposure minus 0.0921 if exposure is greater than or equal to 9.21% and is equal to zero if exposure is lower than 9.21% (average plus one standard deviation of exposure if exposure is positive). *Medium exposure* is equal to exposure minus 0.0383 if exposure is greater than or equal to 3.83% and lower than 9.21%; is equal to zero if exposure is lower than 3.83% (average of exposure if exposure is positive); and, is equal to 0.0921 if exposure is greater than or equal to 9.21%. *Low exposure* is equal to exposure if exposure is lower than 3.83%; is equal to zero if exposure is 0; and, is equal to 0.0383 if exposure is greater than or equal to 3.83%. *Dummy Zero Exposure* is a dummy variable that takes the value of 1 if exposure is equal to 0%. All the independent variables are described in the Appendix. All balance sheet variables are measured as on 31st of March 2000 unless otherwise stated. Heteroscedasticity-robust standard errors are in parentheses. Unless otherwise stated, regressions are estimated with constants, but the coefficients are not reported. *, **, *** denote statistical significance at the 10, 5 and 1% levels, respectively.

	OLS Deposit growth	OLS Deposit growth	Probit Large dep. withdrawals	Probit Large dep. withdrawals
	(1)	(2)	(3)	(4)
High exposure	-1.325**	-1.192*	21.734***	19.851***
	(0.628)	(0.637)	(7.124)	(6.820)
Medium exposure	-1.901*	-1.474	-5.873	-14.625
	(1.082)	(1.095)	(18.090)	(21.595)
Low exposure	0.615	1.250	0.371	-10.058
	(1.364)	(1.192)	(10.903)	(9.870)
Dummy zero exposure		0.056*		-1.332***
		(0.033)		(0.145)
Size	-0.161	-0.014	-0.049	-0.061
	(0.169)	(0.016)	(0.145)	(0.128)
Return on assets	3.260**	2.857**	-34.535**	-28.726
	(1.364)	(1.414)	(16.738)	(18.999)
Media	-0.190***	-0.195***	1.772***	2.073***
	(0.049)	(0.050)	(0.269)	(0.288)
Weak	-0.062	-0.063	0.883**	0.957**
	(0.038)	(0.039)	(0.361)	(0.381)
Credit to deposit ratio	-0.174**	-0.154**	1.212	0.820
	(0.085)	(0.077)	(0.895)	(0.926)
Capital ratio	-0.111	-0.125	1.028	0.112
	(0.259)	(0.252)	(2.707)	(3.104)
Correspondent relationship	0.016	0.027	-0.397	-0.539
	(0.020)	(0.020)	(0.316)	(0.347)
Distance			0.003*	0.002
			(0.001)	(0.001)
F test of equality of coefficients of high versus low exposure	2.43	3.83*	2.45	4.81**
District controls	yes	yes	no	no
Number of banks	142	142	142	142
Adj./pseudo R-squared	0.260	0.273	0.252	0.286

Table 8
The effect of exposure on deposit rate change

This table presents results of OLS regressions where dependent variable is *Deposit Rate change. Deposit Rate change* is defined as $(DR_t - DR_{t-1})/ DR_{t-1}$ where DR_t is the deposit rate (offered to depositors for a deposit of 1-year maturity) prevailing as on 31st of March 2002 and DR_{t-1} is deposit rate prevailing as on 31st of March 2001. *Exposure* is the credit outstanding of a bank with the failed bank divided by its total assets as on 13th of March 2001. *Dummy high exposure* is a dummy variable that takes the value of 1 if exposure is higher than or equal to 9.21% (average plus one standard deviation of exposure if exposure is positive). *Dummy medium exposure* is a dummy variable that takes the value of 1 if exposure is higher than or equal to 3.83% (average of exposure if exposure is positive) and lower than 9.21%. *Dummy low exposure* is a dummy variable that takes the value of 1 if exposure is lower than 3.83% and higher than 0%. All the independent variables are described in the Appendix. All balance sheet variables are measured as on 31st of March 2001 unless stated. Dummy variables take the value of zero otherwise. Heteroscedasticity-robust standard errors are in parentheses. Unless otherwise stated, regressions are estimated with constants, but the coefficients are not reported. *, **, *** denote statistical significance at the 10, 5 and 1% levels, respectively.

	OLS Deposit rate change		
	(1)	(2)	(3)
Exposure	0.124	-0.041	
	(0.271)	(0.305)	
Dummy high exposure			0.023
			(0.047)
Dummy medium exposure			0.016
			(0.039)
Dummy low exposure			0.032
			(0.030)
Size		-0.034*	-0.033*
		(0.019)	(0.018)
Return on assets		-1.700	-1.424
		(1.396)	(1.463)
Media		0.095	0.096
		(0.064)	(0.062)
Weak		-0.123*	-0.113**
		(0.049)	(0.049)
Credit to deposit ratio		-0.037	-0.031
		(0.081)	(0.089)
Capital ratio		0.770	0.738
		(0.576)	(0.603)
Correspondent relationship		0.008	0.0009
		(0.027)	(0.029)
Deposit growth (t-1)		0.169	0.180
		(0.175)	(0.182)
District controls	yes	yes	yes
Number of banks	70	70	70
Adj./pseudo R-squared	0.279	0.351	0.335

Table 9
The immediate effect of exposure on deposit growth

This table presents results of OLS regressions where the dependent variable is *Deposit growth (t-1)*. *Deposit growth (t-1)* is log (D_{t-1}/D_{t-2}) where D_{t-1} is the level of deposits as on 31st of March 2001 and D_{t-2} is the level of deposits as on 31st of March 2000. *Exposure* is the credit outstanding of a bank with the failed bank divided by its total assets as on 13th of March 2001. *Dummy High Exposure* is a dummy variable that takes the value of 1 if exposure is higher than or equal to 9.21%. *High exposure* is equal to exposure minus 0.0921 if exposure is greater than or equal to 9.21% and is equal to zero if exposure is lower than 9.21% (average plus one standard deviation of exposure if exposure is positive). *Medium exposure* is equal to exposure minus 0.0383 if exposure is greater than or equal to 3.83% and lower than 9.21%; is equal to zero if exposure is lower than 3.83% (average of exposure if exposure is positive); and, is equal to 0.0921 if exposure is greater than or equal to 9.21%. *Low exposure* is equal to exposure if exposure is lower than 3.83%; is equal to zero if exposure is 0; and, is equal to 0.0383 if exposure is greater than or equal to 3.83%. All the independent variables are described in the Appendix. All balance sheet variables are measured as on 31st of March 2000 unless otherwise stated. Heteroscedasticity- robust standard errors are in parentheses. Unless otherwise stated, regressions are estimated with constants, but the coefficients are not reported. *, **, *** denote statistical significance at the 10, 5 and 1% levels, respectively.

	OLS Deposit growth (t-1)		
	(1)	(2)	(3)
Exposure	-0.287**		
	(0.137)		
Dummy high exposure		-0.040**	
		(0.019)	
High exposure			-0.508*
			(0.264)
Medium exposure			0.417
			(1.040)
Low exposure			0.777
			(1.436)
Media	-0.118**	-0.136**	-0.135**
	(0.056)	(0.060)	(0.016)
Weak	-0.017	0.001	0.004
	(0.034)	(0.036)	(0.036)
Credit to deposit ratio 2000	0.214***	0.149***	0.152***
	(0.049)	(0.056)	(0.058)
Capital ratio 2000	-0.435**	-0.588**	-0.592**
	(0.191)	(0.229)	(0.242)
Return on assets 2000	2.895**	4.807***	4.733***
	(1.421)	(1.522)	(1.536)
Size 2000	-0.015	-0.018	-0.017
	(0.015)	(0.016)	(0.016)
Correspondent relationship	-0.019	0.0008	0.0007
	(0.019)	(0.019)	(0.019)
Distance	0.0002		
	(0.0001)		
District controls	no	yes	yes
Number of banks	141	141	141
Adj./pseudo R-squared	0.318	0.349	0.340

Table 10

Table 10
Instrumental variable approach

In this table, we use an instrument for exposure. The instrument is *dummy other interbank lending*, which is equal to 1 for banks that overall lend in the interbank market (excluding lending to the failed bank) as on 31st March 2001, 0 otherwise. Column 1 and 2 presents results of a treatment-effects model using a two-step consistent estimator for the period between March 31st 2000 and March 31st 2001. The endogenous variable in the first stage regression (column 1) is *dummy high exposure* which is a dummy variable that takes the value of 1 if exposure is higher than or equal to 9.21% (average plus one standard deviation of exposure if exposure is positive). In the second stage regression (column 2), we analyze the impact of the component of *dummy high exposure* predicted by the instrument on *deposit growth* for the period between March 31st 2000 and March 31st 2001. In column 3 and 4, we run a probit for the effect of *exposure* on *large deposit withdrawals* (for the period between 31st March 2001 and 31st December 2001). Column 3 presents the first stage regression where the dependent variable is *exposure*. In column 4, we analyze the impact of the component of *exposure* predicted by the instrument on *large deposit withdrawals*. All the variables are described in the Appendix. All balance sheet variables are measured as on 31st of March 2001 except in column 1 and 2 where some are measured as on 31st of March 2000. Heteroscedasticity- robust standard errors are in parentheses. Standard errors are clustered at the district level. Unless otherwise stated, regressions are estimated with constants, but the coefficients are not reported. *, **, *** denote statistical significance at the 10, 5 and 1% levels, respectively.

	Dummy high exposure	Deposit growth (t-1)	Exposure	Large deposit withdrawals
	(1)	(2)	(3)	(4)
Exposure				18.729**
				(9.531)
Dummy high exposure		-0.155***		
		(0.041)		
Dummy other interbank lending	0.916***		0.028***	
	(0.329)		(0.008)	
Size			-0.003	0.002
			(0.006)	(0.191)
Return on assets			-0.178	-34.263**
			(0.604)	(16.880)
Media		-0.123***	-0.003	1.478***
		(0.039)	(0.009)	(0.497)
Weak		-0.025	-0.016***	0.885***
		(0.026)	(0.005)	(0.285)
Credit to deposit ratio			-0.053***	1.758**
			(0.019)	(0.839)
Capital ratio			0.041	1.589
			(0.061)	(2.731)
Correspondent relationship		-0.020	0.022**	-0.564
		(0.017)	(0.009)	(0.466)
Distance		0.0002**	0.000	0.001
		(0.0001)	(0.000)	(0.002)
Size 2000		-0.008		
		(0.011)		
Return on assets 2000		3.024**		
		(1.353)		
Credit to deposit ratio 2000		0.242***		
		(0.042)		
Capital ratio 2000		-0.482***		
		(0.188)		
District controls	no	no	no	no
Number of banks	120	120	121	121
Inverse of Mills ratio		-0.068***	T-statistic of exclusion hypothesis is 3.46***	
Wald test of exogeneity		9.64***		

	Probit Information release	OLS Deposit growth	Probit Large dep. withdrawals
	(1)	(2)	(3)
Exposure	-5.659**	-0.741**	9.207***
	(2.735)	(0.347)	(2.873)
Size	0.480	-0.008	0.103
	(0.294)	(0.018)	(0.269)
Return on assets	-0.105	4.886***	-65.515
	(9.827)	(1.549)	(13.592)
Media	-1.365***	-0.184***	1.221***
	(0.418)	(0.051)	(0.348)
Weak	-0.234	-0.184	0.841*
	(0.422)	(0.051)	(0.470)
Credit to deposit ratio	-0.617	-0.224**	1.454**
	(0.772)	(0.111)	(0.635)
Capital ratio	-3.410	-0.106	2.296
	(3.742)	(0.302)	(4.104)
Correspondent relationship	1.038***	0.041*	-0.413
	(0.201)	(0.022)	(0.337)
Distance	-0.000		0.001
	(0.001)		(0.001)
District controls	no	yes	no
Number of banks	142	97	97
Adj./pseudo R-squared	0.180	0.280	0.225

Table 12
Interbank linkages (excluding the failed bank) among banks

Column 1, 2 and 5 presents results of an OLS regression where the dependent variable is *deposit growth*. Column 3 and 6 presents results of a probit where the dependent variable is *large deposit withdrawals*. Column 4 presents results of an OLS regression where the dependent variable is *interbank borrowing*. In column 5 and 6, the sample is limited to banks that have zero *interbank borrowing*. *Deposit growth* is log (D_t/D_{t-1}) where D_t is the level of deposits as on 31st of December 2001 and D_{t-1} is the level of deposits as on 31st of March 2001. *Large deposit withdrawals* is a dummy variable that takes the value of 1 if deposit growth is lower than or equal to -12.75% (which implies that 20% of the observations exhibit large deposit withdrawals). The main independent variables are *interbank borrowing*, *exposure* and an interaction variable of these two variables. *Interbank borrowing* is the ratio of deposits held by other co-operative banks to total deposits as on 31st of March 2001. *Exposure* is the credit outstanding of a bank with the failed bank divided by its total assets as on 13th of March 2001. *Interbank borrowing* x *Exposure* is the interaction of *interbank borrowing* and *Exposure*. All the independent variables are described in the Appendix. All balance sheet variables are measured as on 31st of March 2001 except in column 4. Heteroscedasticity- robust standard errors are in parentheses. In column 3 and 6 standard errors are clustered at the district level. Unless otherwise stated, regressions are estimated with constants, but the coefficients are not reported. *, **, *** denote statistical significance at the 10, 5 and 1% levels, respectively.

	OLS Deposit growth	OLS Deposit growth	Probit Large dep. withdrawals	OLS Interbank borrowing	OLS Deposit growth	Probit Large dep. withdrawals
	(1)	(2)	(3)	(4)	(5)	(6)
Exposure	-0.676**	-0.539*	9.642***	-0.053	-0.611*	9.959***
	(0.292)	(0.300)	(3.367)	(0.038)	(0.320)	(3.889)
Size	-0.007	-0.003	-0.104		0.021	-0.269
	(0.017)	(0.017)	(0.255)		(0.023)	(0.308)
Return on assets	3.167**	3.077*	-32.181*		4.046**	-33.715*
	(1.562)	(1.586)	(18.784)		(1.824)	(20.411)
Media	-0.169***	-0.172***	1.431***	0.022	-0.131*	0.781***
	(0.054)	(0.052)	(0.355)	(0.017)	(0.078)	(0.298)
Weak	-0.080	-0.087	1.088***	-0.004	-0.054	0.775
	(0.051)	(0.053)	(0.407)	(0.007)	(0.073)	(0.508)
Credit to deposit ratio	-0.115	-0.093	0.920		-0.072	1.056
	(0.071)	(0.069)	(0.816)		(0.079)	(0.827)
Capital ratio	0.027	0.057	3.081		-0.028	3.139
	(0.261)	(0.259)	(2.751)		(0.265)	(3.375)
Correspondent relationship	0.012	0.010	-0.259		0.004	-0.205
	(0.022)	(0.022)	(0.384)		(0.023)	(0.382)
Interbank borrowing	-0.436	-0.004	6.015			
	(0.478)	(0.403)	(3.821)			
Interbank borrowing x Exposure		-82.330***	715.68***			
		(22.310)	(155.03)			
Distance			0.002			0.001
			(0.001)			(0.001)
Size 2000				0.009		
				(0.004)		
Credit to deposit ratio 2000				0.003		
				(0.01)		
Capital ratio 2000				-0.016		
				(0.041)		
Return on assets 2000				-0.037		
				(0.253)		
District controls	yes	yes	no	yes	yes	no
Number of banks	124	124	124	123	96	96
Adj./pseudo R-squared	0.336	0.380	0.292	0.150	0.235	0.173

Table 13
Interaction effects of exposure with bank fundamentals

Column 1, 2 and 5 present results of a probit where the dependent variable is *large deposit withdrawals*. Column 3, 4 and 6 present results of the OLS regression where the dependent variable is *deposit growth*. *Deposit growth* is log (D_t/D_{t-1}) where D_t is the level of deposits as on 31st of December 2001 and D_{t-1} is the level of deposits as on 31st of March 2001. *Large deposit withdrawals* is a dummy variable that takes the value of 1 if deposit growth is lower than or equal to -12.75% (which implies that 20% of the observations exhibit large deposit withdrawals). The main independent variables are exposure and interaction variables of exposure with variables that proxy for bank fundamentals, where *exposure* is the credit outstanding of a bank with the failed bank divided by its total assets as on 13th of March 2001. All the independent variables are described in the Appendix. All balance sheet variables are measured as on 31st of March 2001 unless stated. Heteroscedasticity- robust standard errors are in parentheses. In column 1, 2 and 5 standard errors are clustered at the district level. The coefficient for *# of depositors* is scaled up by 100000. Unless otherwise stated, regressions are estimated with constants, but the coefficients are not reported. *, **, *** denote statistical significance at the 10, 5 and 1% levels, respectively.

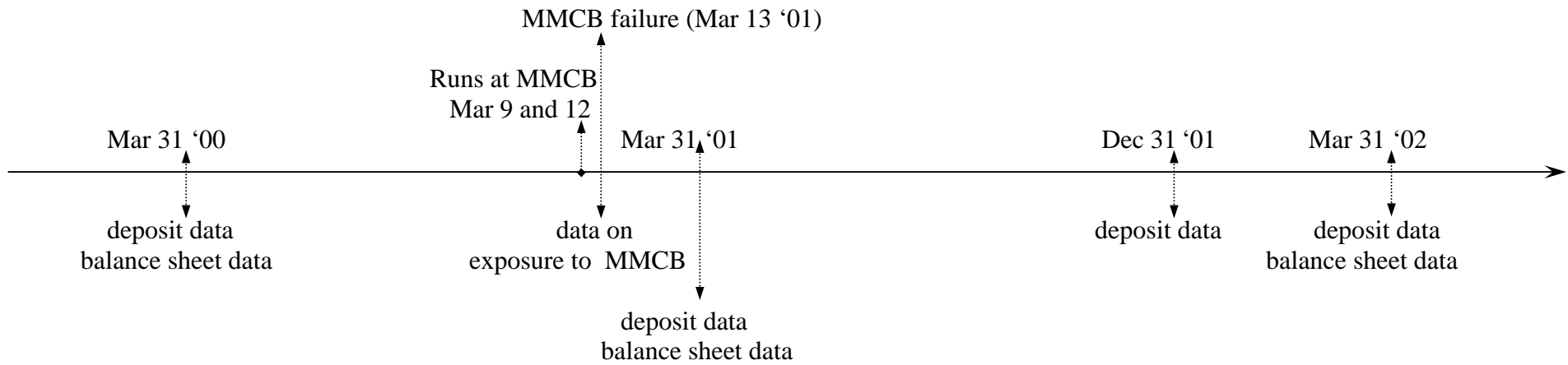|	Probit Large dep. withdrawals	Probit Large dep. withdrawals	OLS Deposit growth	OLS Deposit growth	Probit Large dep. withdrawals	OLS Deposit growth
	(1)	(2)	(3)	(4)	(5)	(6)
Exposure	7.620**	9.57**	-1.521***	-0.542*	99.505**	-1.039***
	(3.22)	(4.08)	(0.26)	(0.27)	(46.47)	(0.22)
Size	-0.100	-0.515**	0.100***	0.090**	-0.711***	0.094***
	(0.14)	(0.25)	(0.03)	(0.03)	(0.19)	(0.03)
Return on assets	-32.939**	-63.904***	4.439***	4.179**	-79.175***	4.327***
	(16.05)	(15.95)	(1.65)	(1.77)	(18.12)	(1.54)
Media	1.842***	2.128***	-0.136**	-0.135**	2.036***	-0.149**
	(0.33)	(0.40)	(0.06)	(0.06)	(0.46)	(0.05)
Weak	0.855**	1.149***	-0.299***	-0.057	33.880**	-0.306***
	(0.33)	(0.43)	(0.02)	(0.07)	(16.41)	(0.02)
Credit to deposit ratio	1.139	0.870	-0.064	-0.079	0.738	-0.047
	(0.76)	(0.63)	(0.06)	(0.07)	(0.83)	(0.05)
Capital ratio	0.362	2.052	0.049	0.177	-1.556	0.244
	(3.71)	(3.41)	(0.21)	(0.27)	(5.10)	(0.25)
Correspondent relationship	-0.255	-0.445	-0.011	-0.008	-0.186	-0.007
	(0.35)	(0.42)	(0.02)	(0.02)	(0.53)	(0.01)
Distance	0.003**	0.003*			0.002	
	(0.00)	(0.002)			(0.002)	
# of depositors		0.92	-0.17**	-0.19**	0.000	-0.13**
		(0.80)	(0.077)	(0.082)	(0.00)	(0.06)
Interbank borrowing			-0.615	-0.423	6.916	-0.117
			(0.45)	(0.41)	(6.08)	(0.35)
Interbank borrowing x Exposure					812.94***	-76.48***
					(299.35)	(18.04)
Capital ratio x Exposure	-0.392***				-0.569**	0.020
	(0.111)				(0.27)	(0.01)
# of depositors x Exposure		0.325**			0.523**	-0.037***
		(0.163)			(0.22)	(0.01)
Weak x Exposure			-0.152***		15.403**	-0.148***
			(0.01)		(7.62)	(0.01)
Size x Exposure				0.019	-0.343	0.058***
				(0.01)	(0.23)	(0.01)
District controls	no	no	yes	yes	no	yes
Number of banks	142	121	104	104	104	104
Adj./pseudo R-squared	0.240	0.287	0.471	0.339	0.445	0.576

Appendix
Definition of the variables

- *Deposit growth* is log (D_t/D_{t-1}) where D_t is the level of deposits as on 31st of December 2001 and D_{t-1} is the level of deposits as on 31st of March 2001.
- *Large deposit withdrawals* is a dummy variable that takes the value of 1 if deposit growth is lower than or equal to -12.75% (in effect 20% of the banks in our sample exhibit large deposit withdrawals).
- *Exposure* is the credit outstanding of a bank with the failed bank divided by its total assets as on 13th of March 2001.
- *Dummy high exposure* is a dummy variable that takes the value of 1 if exposure is higher than or equal to 9.21% (average plus one standard deviation of exposure if exposure is greater than zero).
- *Dummy medium exposure* is a dummy variable that takes the value of 1 if exposure is higher than or equal to 3.83% (average of exposure if exposure is greater than zero) and lower than 9.21%.
- *Dummy low exposure* is a dummy variable that takes the value of 1 if exposure is lower than 3.83% and higher than 0%.
- *Dummy zero exposure* is a dummy variable that takes the value of 1 if exposure is equal to 0%. All the dummy variables take the value of zero otherwise.
- *High exposure* is equal to exposure minus 0.0921 if exposure is greater than or equal to 9.21% and is equal to zero if exposure is lower than 9.21% (average plus one standard deviation of exposure if exposure is greater than zero).
- *Medium exposure* is equal to exposure minus 0.0383 if exposure is greater than or equal to 3.83% and lower than 9.21%; is equal to zero if exposure is lower than 3.83% (average of exposure if exposure is greater than zero); and, is equal to 0.0921 if exposure is greater or equal to 9.21%.
- *Low exposure* is equal to exposure if exposure is lower than 3.83%; is equal to zero if exposure is 0; and, is equal to 0.0383 if exposure is greater than or equal to 3.83%.
- *Return on assets* is the profits of the bank divided by its total assets as on 31st of March 2001.
- *Size* is the log of total assets of the bank as on 31st of March 2001.
- *Media* is a dummy variable that takes the value of 1 if a report about the bank appeared in newspapers in the period between 13th of March and 31st of March 2001, except for one bank.
- *Weak* is a dummy variable that takes the value 1 when a bank is classified as weak by the central bank as on 31st of March 2001.
- *Credit to deposit ratio* is the total loans of a bank divided by its total deposits as on 31st of March 2001.
- *Capital ratio* is the book value of shareholder equity plus reserves divided by total assets as on 31st of March 2001.
- *Deposit growth (t-1)* is log (D_{t-1}/D_{t-2}) where D_{t-1} is the level of deposits as on 31st of March 2001 and D_{t-2} is the level of deposits as on 31st of March 2000.
- *Correspondent relationship* is a dummy variable that equals one for banks that a have correspondent banking relationship with the failed bank.
- *Distance* refers to the physical distance (in Km) between the headquarter of a bank and the headquarter of the failed bank.
- *Interbank borrowing* is the ratio of deposits held by other co-operative banks to total deposits as on 31st of March 2001.
- *Other interbank lending* is the ratio of deposits held in other co-operative banks to total assets as on 31st of March 2001.
- *Dummy other interbank lending*, which is equal to 1 for banks that overall lend in the interbank market (excluding lending to the failed bank) as on 31st March 2001, 0 otherwise.
- *Deposit rate change* is defined as $(DR_t-DR_{t-1})/DR_{t-1}$ where DR_t is the deposit rate (offered to depositors for a deposit of 1-year maturity) prevailing as on 31st of March 2002 and DR_{t-1} is deposit rate prevailing as on 31st of March 2001.
- *Deposit rate 2001* is the rate prevailing as on 31st of March 2001 offered to depositors for a deposit of 1-year maturity.
- *Information release* is a dummy variable that takes the value of 1 if a bank released information on its exposure with the failed bank in its annual report for the year 2001 (the annual report is normally released between July and December).
- *# of depositors* is the number of depositors in the bank as on 31st of March 2000.
- *Credit to deposit ratio 2000* is the total loans of a bank divided by its total deposits as on 31st of March 2000.
- *Capital ratio 2000* is the book value of shareholder equity plus reserves divided by total assets as on 31st of March 2000.
- *Return on assets 2000* is the profits of the bank divided by its total assets as on 31st of March 2000.

Timeline of events and data

EVENTS

MMCB failure (Mar 13 '01)

Runs at MMCB
Mar 9 and 12

Mar 31 '00   Mar 31 '01   Dec 31 '01   Mar 31 '02

deposit data   data on   deposit data   deposit data
balance sheet data exposure to MMCB   balance sheet data

deposit data
balance sheet data

DATA