Bank instability: Interbank linkages and the role of disclosure

Christian König-Kersting, Stefan T. Trautmann, Razvan Vlahu

Department of Banking and Finance, University of Innsbruck, Universitätsstraße 15, Innsbruck 6020, Austria
Alfred-Weber-Institute for Economics, University of Heidelberg, Bergheimer Strasse 58, Heidelberg 69115, Germany
Economics and Research, De Nederlandsche Bank, Westeinde 1, Amsterdam 1000AB, the Netherlands

ARTICLE INFO
Article history:
Received 28 October 2021
Accepted 28 October 2021
Available online 31 October 2021
JEL classification:
DB1
G31
G28
Keywords:
Disclosure
Banks
Interbank linkages
Coordination
Beliefs

ABSTRACT
We study the impact of disclosure about bank fundamentals on depositors' behavior in the presence (and absence) of economic linkages between financial institutions. Using a controlled laboratory environment, we identify under which conditions disclosure is conducive to bank stability. We find that bank deposits are sensitive to perceived bank performance. While banks with strong fundamentals benefit from more precise disclosure, an opposite effect is present for solvent banks with weaker fundamentals. Depositors take information about economic linkages into account and correctly identify when disclosure about one institution conveys meaningful information for others. Our findings suggest potential costs of bank transparency and that disclosure may not always be stability-enhancing.

1. Introduction
In the aftermath of the financial crisis, greater regulation and efforts to increase the transparency of the banking industry have been at the forefront of the policy debate. Rigorous stress testing has been introduced as a key method for assessing the financial sector’s ability to withstand large-scale correlated shocks to multiple (macro-)economic factors. With the rise of these regular tests of risk-bearing ability and capital adequacy of financial institutions on both sides of the Atlantic, the questions of whether or not to release results publicly and at what level of detail have been discussed by politicians, researchers and the media alike.

The reason for the observed attention can be understood by looking at the trade-off between market discipline and financial stability. On the one hand, it is clearly in depositors’ and investors’ interest to know the state of their financial institutions to make well-informed financial decisions. Increased public awareness of bank risks may enhance market discipline, penalizing financial institutions for excessive risk taking. At the same time, it is also clear that insolvent financial institutions need to be identified and resolved quickly to prevent subsequent adverse ripple effects on other institutions, potentially endangering the whole banking system. As evidence from the Global Financial Crisis suggests, the lack of disclosure might impede financial activity. Increased uncertainty about which banks have incurred losses led to situations in which banks were unable to raise additional funds to withstand liquidity demand because of a market freeze.1 On the other hand, disclosing stress test results to the public may also have self-fulfilling effects in the sense that knowledge of an institution’s subpar, yet not in itself a dangerous result, may still lead to strong depositors' reactions and a dramatic tightening of liquidity. Such a liquidity squeeze might then lead to a bank failure, regardless of whether the bank is solvent in the long run or not.

Furthermore, stress tests usually cover only a subsample of all financial institutions, leaving depositors of untested banks in the dark even if results are published for others. This aspect highlights the potential importance of knowledge about economic linkages.

1 Potential lenders were unable to assess the solvency of individual banks due to balance sheet opacity, and as a result, fearing information asymmetries, they were reluctant to lend.

https://doi.org/10.1016/j.jbankfin.2021.106353
0378-4266/© 2021 Elsevier B.V. All rights reserved.
between financial institutions. How similar are different banks in their capital adequacy? Are various banks exposed to the same levels and types of risk? Knowledge of such linkages can be crucial in understanding if and how disclosed information about certain institutions might lead to panic behavior among depositors with the potential to spread to other institutions subsequently in a contagious fashion.

In our study, we focus on a direct information-based mechanism. Depositors obtain factual information of varying precision through public communication rather than observation of others’ behavior. We can find real-world justification for this approach in the stylized sequence of events in bank runs. Significant reductions of bank deposits through wire transfers often preceded the more easily observable depositor run at bank counters. Statistical information about deposit levels is usually published with a lag of multiple months, precluding timely observation of withdrawals through channels other than actual cash withdrawals. One example of a depositor run following this sequence is Greece, where deposit levels had fallen tremendously after the elections of 2014 (the information event). Yet the more easily observable depositor run by retail customers only started about half a year later (European Central Bank, 2015).

The theoretical literature provides valuable insights on the underlying mechanisms of bank runs, information disclosure, and contagion effects. However, there is little empirical work on the impact that information precision about bank’s fundamentals, and the simultaneous consideration of both disclosure about fundamentals of individual banks and information about economic linkages across banks, might have on depositors’ behavior and the stability of solvent banks. Bank runs occur infrequently, and perceptions of the precision of information about bank fundamentals, and beliefs about linkages between banks, are hard to observe in empirical data. To understand the fundamental mechanisms underlying disclosure effects on depositors, we need tighter control over the decision situation and cleaner treatment manipulation than would be possible based on empirical data and natural experiments. We, therefore, study these mechanisms in a laboratory experiment, complementing evidence from case studies in the field with qualitative insights from a more controlled but abstract setting that aims to capture the main structural principles of the real-world setting of interest.

The approach offers us the opportunity to study the effects of information disclosure on depositors’ behavior in the presence (and absence) of economic linkages (modeled here as exposure to correlated assets) between financial institutions in a unified setting. Our experiment is based on the Diamond and Dybvig (1983) framework, which treats bank runs as coordination games with inherent strategic uncertainty. In this setup, we first examine how different degrees of information precision about a bank’s fundamentals create conditions for bank runs. We find that more precise information about banks with strong fundamentals (in terms of liquidity and profitability) reduces the propensity for deposit withdrawals. This effect is reversed for banks with weaker fundamentals, as they are confronted with an increased incidence of withdrawals. Second, we study if noisy information about interbank linkages combined with transparency over the fundamentals of one bank can trigger a run at another bank for which there is no disclosure. While we find that disclosure about one institution affects withdrawal rates at another in the presence of noisy information about their interbank linkages, this is not the case in the absence of linkages.

Our paper contributes to several strands of literature. First, it is related to the literature examining the effects of information disclosure and, more specifically, the debate on the publication of bank stress test results. Second, it complements the bank-run literature in general and the experimental bank-run literature in particular. We discuss the existing evidence, both theoretical and empirical, regarding the effects of disclosure policies on bank stability and contagion in Section 2. The discussion motivates our experimental approach and hypotheses presented in the following sections. Section 3 offers the stylized banking setting for our experiment and introduces the depositors’ coordination problem and the experimental design and procedures. This section also discusses the issue of the external validity of the laboratory experimental approach. Section 4 formulates our hypotheses. Results on depositor behavior are in Section 5, and results on beliefs are in Section 6. Section 7 considers variations in beliefs and confidence. Section 8 concludes.

2. Disclosure and bank stability: theoretical and empirical insights

2.1. Financial disclosure

Morris and Shin (2002) highlight the potential for adverse effects of publicly releasing information. They argue that public disclosure comprises information about fundamentals and has the potential to serve as a coordination device by creating incentives for market participants to disregard their private information (cf. Angeletos and Pavan, 2007). The coordination aspect of public information might render disclosure “too effective” (Morris and Shin, 2002, p. 1522) in influencing market participants’ behavior, as they tend to overreact to the information provided. Publicly released information is hardly a perfect, but rather a noisy signal. Given the overreaction of agents to public information, the amplification of noise in their private signals may affect their behavior and deteriorate market outcomes. But some papers caution that the relationship between disclosure and financial stability is more complex.

Bouvard et al. (2015) argue that the effect of information disclosure is context-dependent: disclosing bank-specific information enhances the stability of the financial system during crises but is having a contrary effect in normal times. Goldstein and Leitner (2018) show that when regulators have information about banks’ ability to overcome future liquidity shocks, partial disclosure is optimal during times of distress, while not disclosing any information is beneficial in non-crisis times. Our experimental design models differences between normal times and times of distress implicitly through the existence of banks with stronger and weaker fundamentals. This setup allows us to test these theoretical predictions empirically.

Apart from this more general literature on the disclosure of financial information, there is also research directly concerned with the publication of stress test results. Several papers provide theoretical costs and benefits perspective on stress tests (Faria-e Castro et al., 2017; Goldstein et al., 2014; Leitner, 2014; Orlov et al., 2020; Prescott, 2008; Quigley and Walther, 2015; Shapiro and Skeie, 2015; Spargoli, 2012). Some conclude that disclosure of stress test results promotes financial stability. In contrast, others highlight potential harmful effects, such as banks with weaker fundamentals potentially suffering from increased disclosure due to

---

2 Our results add to the empirical evidence on the link between transparency, market discipline, and financial stability (Jordan et al., 1999; Nier, 2005; Nier and Baumann, 2006).

3 Unwarranted public news or false disclosure are examples of public information noise (Morris and Shin, 2002).

4 See Goldstein and Yang (2019) for a discussion of the channels through which financial disclosure works in financial markets.
market participants’ overreaction. We test this prediction and find empirical support for it in our paper.

2.2. Bank run experiments

Arifovic et al. (2013) study bank runs as phenomena of pure coordination failure. Building on Temzelides (1997), they focus on the coordination parameter, i.e., the share of depositors that need to refrain from running the bank for not-withdrawing to yield higher payoffs than withdrawing. They show that the coordination outcomes are difficult to predict for specific values of the coordination parameter, although depositors' behavior exhibits path dependence.

Garratt and Keister (2009) show how beliefs about the other depositors' behavior affect individual withdrawal behavior. Arifovic and Jiang (2014) find that uninformative public announcements are effective sunspot coordination devices, particularly in times of high uncertainty. Heggin (2015) studies the effects of disclosure on investors' sensitivity to bad signals about bank fundamentals in a global-game setting (cf. Carlson and van Damme, 1993). He finds that noisier information positively correlates with the prevalence of banking crises and that individual characteristics (e.g., risk preferences, past experience) are important determinants of withdrawal behavior. Similar results concerning past experiences and loss aversion are reported in Trautmann and Vlahu (2013). They also find that weaker banks (in the sense of risk dominance of the withdrawal equilibrium) experience more runs. In the current paper, we test whether the noisy revelation of bank weakness similarly increases the incidence of runs.

Beside bank-run experiments with simultaneously moving depositors, some papers treat bank runs as a phenomenon of sequentially deciding agents. Kiss et al. (2012) find that the effectiveness of deposit insurance in reducing the occurrence of bank runs depends on the degree of observability of depositors' actions. Peia and Vranceanu (2019) study depositor behavior in presence of partial deposit insurance. Kiss et al. (2014a, 2014b) show that depositors who are being observed are less likely to run and that depositors observing others condition their withdrawal decision on the action they observe. Kiss et al. (2016) argue that higher cognitive abilities reduce the frequency of withdrawals, while Kiss et al. (2018) link the occurrence of pure panic runs to an overestimation of the withdrawal probability. Schotter and Yorulmazer (2009) and Davis and Reilly (2016) focus on the dynamics and severity of bank runs rather than their occurrence. They find that informed insiders are less likely to withdraw than uninformed depositors, and study the impact of re-contracting conditions, respectively.

2.3. Financial contagion

Our paper adds to the literature on financial contagion. Iyer and Peydro (2011) and De Graeve and Karas (2014) highlight the joint relevance of information about banks’ fundamentals and economic linkages between banks for depositors’ decisions. These authors argue that weaker banks face more significant contagion effects with strong interbank connections leading to larger deposit withdrawals.

Few papers succeed in studying financial contagion using real-world data. Individual depositors’ behavior is hard to identify. Chakravarty et al. (2014) study financial contagion using experimental coordination games and find evidence for contagion between two banks, regardless of interbank linkages. Brown et al. (2017) identify pessimistic beliefs triggered by observing a depositor run elsewhere as a cause of own withdrawals. In contrast to Chakravarty et al. (2014), they only find contagion evidence in the presence of economic linkages between financial institutions. The results of Brown et al. (2017) are consistent with Cipriani et al. (2018), who find evidence for contagion between two markets, but only when asset fundamentals are correlated.

Trevino (2020) identifies two financial contagion channels: a fundamental channel and a social learning channel. She argues that participants in the experiment suffer from an overreaction bias. They put too much emphasis on others' behavior (the social channel) and fail to disregard the social signal even if it is completely uninformative. Similarly, Glasserman and Young (2016) argue that changes in market perceptions about the intermediaries’ creditworthiness and their assets’ value may trigger information contagion. Our experiment enables us to test for the existence of this purely psychological contagion effect.

In notable contrast to most experiments on the occurrence of bank runs, the studies on financial contagion mentioned earlier involve sequentially moving depositors who can observe other depositors’ behavior from another bank. In our experimental design, all depositors move simultaneously. They cannot observe other depositors’ behavior. This design allows us to study financial contagion in the same framework predominantly used to study bank runs.

While our experimental framework shares several common features with the literature on experimental bank runs and the more recent literature on experimental financial contagion, the focus of our analysis is different from other papers in this literature. We study how depositors respond to different precision of disclosure in the presence of uncertainty about the banks’ quality and the linkages between banks. Our novel approach that combines the analysis of a bank run and potential contagion effects allows us to highlight the complex role of disclosure on the financial sector’s stability. We show how disclosure may affect the likelihood of an individual bank run, and more importantly, how it may create spillover effects within the banking system.

3. Banking setting and experimental design

3.1. Banking setting

We start with a general description of the experimental banking setting we use to study the effect of information disclosure and the role of economic linkages. We consider an economy with three dates (0, 1, 2) and no discounting. A bank operating in this economy takes deposits at date 0 and invests in assets that produce profits at date 2. Bank deposits are uninsured and costly. The creditors are repaid (with interest) at date 2 if their bank is solvent. Solvency depends on the bank's assets portfolio and depositors' actions. With respect to the former, we make assumptions about banks’ fundamentals (e.g., liquidity position, quality of assets). With respect to the latter, depositors face uncertainty about the quality of banks’ assets and may choose to withdraw their money before maturity, at date 1. In order to meet its payment obligations at date 1, the bank may be forced to liquidate (some of) its assets. Conditional on the liquidity and quality of a bank’s assets at date 1, liquidation may be possible at a substantial discount. When the discount is too large, the bank may not be able to pay the remaining depositors at date 2, effectively rendering the bank insolvent. In this case, the bank is liquidated at date 1 and the liquidation value of its assets is distributed among those depositors who choose to withdraw. Upon bank bankruptcy, patient depositors (i.e., those without withdrawal claims at date 1) lose their deposits.
Information about the banking system is conveyed to market participants through disclosure. Two types of disclosure may affect bank stability in this framework. First, there is transparency about the quality and liquidity of bank’s assets, which is arguably of highest importance to market participants. Such enhanced information about the bank’s exposure to potential liquidity shocks may prevent (or, conditional on the type of information conveyed to the market, precipitate) individual bank runs as well as contagion effects across banks. Naturally, this type of disclosure may vary in its informativeness to depositors. Specifically, as we discuss in detail in Section 3.2, we consider various scenarios in which disclosed information about the banks’ ability to withstand liquidity shocks is either non-informative, partially informative, or fully informative. We assume that disclosed information is common knowledge among all depositors of a bank. More explicitly, all depositors receive the same information simultaneously and no depositor has an advantage over the other depositors in reacting to it.

Second, the quality of information about the interbank linkages may contribute to the fragility of the banking sector. Common assets exposure is one important form of interbank linkages (Chen, 1999; Ahnert and Georg, 2018). Our experimental design captures this specific form. There are other forms of interbank linkages (e.g., interbank lending), but we abstract from them in this paper. Depositors typically face uncertainty about the existence of such linkages across different financial institutions. At one extreme, depositors might face maximum uncertainty when they are not aware of any explicit interbank linkages between their bank and other banks in the system. Rationally then, information disclosed about the capacity of another bank to withstand liquidity shocks is not informative about the liquidity position of their own bank. At the other extreme, depositors may be aware that their bank has an identical asset portfolio as other banks. In this case, information about one bank is informative about the fundamentals of another bank. In reality, the precision of information about the interbank linkages generates various potential scenarios between these two extreme cases. We deliberately abstract away from different aspects of similarity and instead model similarity as the probability of being identical. As we discuss in the next section, we consider various scenarios in which disclosed information about the interbank linkages is either non-informative or partially informative.

3.2. Experimental design

3.2.1. Banks and depositors

We model banks as one-shot, three-player coordination games with Pareto-ranked run and no-run equilibria in pure strategies. Each bank has three depositors who can individually choose between withdrawing and not withdrawing their money. All depositors act simultaneously and without knowing other depositors’ decisions. To model banks with different risk exposures and allow financial disclosure to provide meaningful information to depositors about bank fundamentals, we consider three types of banks: Good, Medium, and Weak. The banks differ with respect to their payoffs to depositors in case of early liquidation as well as in the case of no liquidation. To put it differently, our design allows us to differentiate the banks in terms of profitability and liquidity (i.e., how fragile a bank is to mass withdrawals). While these payoffs are fixed payments in the experiment, we interpret these payoffs as the certainty equivalent of a stochastic return on deposit to capture the role of uncertainty about expected returns on deposits on withdrawal decisions.7 That implies that stronger banks offer higher returns and are more liquid (i.e., less fragile when it comes to withdrawals). We offer a rationalization for this structure after introducing the exact payoffs below. Note further that under these conditions, all the banks in our experiment are solvent in expectation: there is no exogenous shock to their asset portfolios, and all the banks, regardless of their type, can repay depositors in full if none of them withdraws before maturity. Put differently, forced liquidation of bank assets triggered by deposit withdrawal is the sole cause of bank failure.

Good banks have the strongest fundamentals. They are the least fragile to liquidity shocks and fail only if two or more of their depositors withdraw. These banks offer the highest payoffs to depositors regardless the number of withdrawals. If all depositors keep their money in the bank, the bank does not have to liquidate any investments and all depositors receive a payoff $R_G$. If one depositor withdraws, the bank can repay him $R_{GW}$, with $R_{GW} < R_G$, thus the early depositor forgoes some of the potential future return. When at least two depositors withdraw, the bank is liquidated and the liquidation value $L_C$ is shared among early depositors. In the case of bank liquidation, the depositor (if any) who decides to keep money in the bank receives zero.

Medium banks are more fragile than good banks and fail if at least one depositor withdraws. In terms of payoffs, they are identical to good banks in case of no liquidation, i.e., when nobody withdraws, each depositor receives $R_C$. However, they have a lower liquidation value $L_M$, with $L_M < L_C$. This lower liquidation value reflects the fact that the Medium banks have a less liquid portfolio. When subject to an unexpected liquidity demand from depositors, a Medium bank is forced to liquidate (all of) its assets at a loss, reflecting the liquidity-induced premium. As with Good banks, in liquidation, the depositors withdrawing from a failed bank share the available funds among themselves leaving nothing to the other depositors.

Finally, the Weak banks are identical with Medium banks in terms of fragility (i.e., they fail if at least one depositor withdraws) and payoffs upon liquidation (i.e., liquidation value is $L_M$). However, they are less profitable than Medium banks and therefore pay less to their depositors in case of no liquidation: $R_{WY}$, with $R_{WY} < R_G$. Thus, in our design, a Weak bank has the poorest fundamentals both in terms of profitability and liquidity.

Table 1 presents the payoff matrix for this three-person coordination game (as used in the experiment; payments are in experimental currency units, 1 ECU = 0.01 EUR). The payoff structure can be rationalized as follows: banks may get exposure at date 0 to the same asset class (e.g., real estate). Yet, the individual bank’s specific investments are not observable. Ex-ante, all types of banks have identical expected returns and face a similar cost of funding. This is due to the fact that the market does not have detailed information about individual banks’ portfolios, but only aggregate information about the sectors in which the banks are investing. However, after the investment is made and before the returns are realized,

<table>
<thead>
<tr>
<th>Bank type and own decision</th>
<th>Number of other depositors withdrawing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Good withdraw</td>
<td>$R_G = 210$</td>
</tr>
<tr>
<td>Medium withdraw</td>
<td>$R_{GW} = 85$</td>
</tr>
<tr>
<td>Medium not withdraw</td>
<td>$R_G = 210$</td>
</tr>
<tr>
<td>Weak withdraw</td>
<td>$R_{WY} = 150$</td>
</tr>
<tr>
<td>Weak not withdraw</td>
<td>$R_{WY} = 150$</td>
</tr>
</tbody>
</table>

Notes: Payoffs are given in experimental currency units. Exchange rate: 1 ECU = 0.01 EUR.
banks' depositors may receive some information about the quality (i.e., profitability and liquidity) of banks' assets. Upon receiving such information (via mandatory or voluntary bank disclosure), depositors may find out that some banks have more valuable/liquid assets than other banks. For example, one bank may turn out to have a larger exposure to the prime real estate sector than another bank, which is heavily exposed to the subprime sector. This revelation may affect not only banks' valuation but also their perceived capacity to withstand depositors' withdrawals. Exposure to the subprime market may be associated with illiquidity: banks investing in this real estate segment, when forced to liquidate their investments, are able to do so only at significant discounts. This increases their vulnerability in face of depositors' demand for liquidity. Our payoff structure with ex-post different expected returns is motivated by the idea of capturing the role of disclosure in offering additional information to banks' depositors about the quality of banks' assets at a certain point in time after the initial investment. This approach shares similar features with the theoretical bank-run models of Chen and Hasan (2006) and Moreno and Takalo (2016) that study the role of bank creditors' information at an interim stage.

Note that in our framework, there is no choice of banks according to expected returns. Ex-ante, there is type uncertainty, and upon disclosure, the depositors decide whether to withdraw or keep their deposits. As discussed in Section 2, the distinction between stronger and weaker banks can also be interpreted from a temporal perspective as fundamentals resulting in normal times with higher expected returns, and in times of distress with lower expected returns.

### 3.2.2. Treatments

The aim of our study is to examine whether different degrees of information, and the simultaneous consideration of both disclosure about fundamentals of individual banks and information about interbank linkages, affect depositors' behavior and thus financial stability. The degree of disclosure about individual banks and interbank linkages varies between groups of participants. This variation allows us to observe the outcomes of their coordination games and to identify the conditions that make coordination failure (i.e., a bank run) most likely.

The first dimension of interest is disclosure about an individual bank (Bank A, hereafter). Participants take on the role of depositors of Bank A and receive information on Bank A's fundamentals. Depositors are aware of the payoff as shown in Table 1, and this is common knowledge among depositors. All depositors of a Bank A receive a signal of the form:

**Bank A has [Type] fundamentals.**

*This statement is correct with probability [p].*

Type describes the quality of Bank A's fundamentals (i.e., Good, Medium, or Weak). Each group of three depositors that form a Bank A is shown only one of these potential values. Systematically varying the value of p across disclosure treatment conditions allows us to effectively implement three levels of disclosure for Bank A: (1) No-disclosure, in which the signal is non-informative (p = 33%), meaning that it is equally likely for Bank A to be Good, Medium, or Weak; (2) Partial-disclosure, in which the signal is partially-informative (p = 66%) and reveals the most likely type;9 and (3) Full-disclosure, in which the signal is fully-informative (p = 100%) and does not leave any room for uncertainty about Bank A's fundamentals. It is common knowledge that all members of a depositor group receive the same signal about their respective Bank A and decide simultaneously on whether to withdraw or not.

The second dimension we are interested in concerns the linkages (in the form of assets commonality) between Bank A and a second bank (Bank B, hereafter), for which there is no explicit disclosure. Each participant in the experiment is a depositor at both banks and plays once the three-person coordination game with each bank (i.e., first with Bank A, and then with Bank B). Moreover, depositors know that they play the Bank B coordination game with a new group of 3 players. Depositors receive the following information regarding their respective Bank B:

**With probability [q], Bank B has the same fundamentals as Bank A.**

*This statement is always correct.*

We vary the value of q to implement two distinct levels of information about interbank linkages between the two banks: (1) No-linkages (q = 33%), in which the type of Bank B is completely independent of the type of Bank A since disclosure about Bank A fundamentals provides no information about fundamentals of Bank B; and (2) Partial-linkages (q = 66%), in which the two banks share the same type of fundamentals in two-thirds of the cases.10 Participants know that all depositors in their respective Bank B have received the same linkage information. Importantly, it is also common knowledge that their fellow Bank B depositors have received the same signal about Bank A, both concerning the type of fundamentals and level of disclosure. When depositors take the withdrawal decision for Bank B, the uncertainty about the fate of Bank A (i.e., how many depositors have withdrawn and whether the bank has failed or not) has not yet been resolved. However, Bank B depositors are reminded about the specific type of signal they received for Bank A on the decision screen.

Our treatments allow us to simultaneously study the behavioral effects of different types of information on depositor behavior, as well as potentially resulting contagion effects from Bank A to Bank B in a unified setting. To this end, we systematically vary the degree of disclosure about Bank A's fundamentals and about the linkages between Bank A and Bank B (i.e., the degree to which information about the financial health of Bank A is relevant for assessing the health of Bank B) in different treatment groups. Our novel approach that combines the analysis of a bank run (Bank A) and potential contagion effects (on Bank B) allows us to highlight the complex role of disclosure on the financial sector's stability. As we will discuss in more detail in Section 4, disclosure may affect both the likelihood of an individual bank run and more importantly, it may create spillover effects within the banking system. Our design is consistent with evidence on consumers' preference for maintaining multiple banking relationships and can be rationalized by assuming that depositors in Bank B already have some prior information about Bank A's fundamentals before receiving additional information about the potential linkages between these two banks. More importantly, abstracting from the laboratory setting, a more general interpretation is as follows: imagine that depositors from a bank have no information about their bank's fundamentals because of balance sheet opacity. Yet, they all have identical information about another bank's fundamentals (information that has been obtained via publication of stress tests results or another public source). In addition to that, they receive identical details on

---

9 For the type signals for Bank A, if the types of the two banks do not match, the other types are equally likely. We explain the implementation of the linkage treatments in Appendix A.

10 Appendix A describes in detail the matching procedure used to implement this feature in the experiment.
the existing linkages between the banks. Both types of information may then influence their decisions regarding their own bank. The individual participants playing two coordination games in the experiment would thus represent a group of consumers with identical information about two banks, but holding deposits at only one bank.

3.2.3. Procedures and supplementary data

The experiment was programmed and conducted using z-Tree (Fischbacher, 2007). A total of 432 participants were recruited using both hroot (Bock et al., 2014) and ORSEE (Greiner, 2015).1 One half of the experimental sessions were conducted at AWI Lab in Heidelberg, the other half at mLab in Mannheim. We conducted 24 sessions with 18 participants taking part in each session.2 Each session was structured as follows: first, participants received general information about the session and the payoff modalities. They learned that they would be paid for two parts of the experiment and receive further instructions at the beginning of each task. Participants proceeded to part one, the bank-run game. They were first given the instructions on the screen and received a paper handout summarizing bank payoffs. Participants were asked to answer comprehension questions on the instructions and only continue with the experiment after correctly answering all of them. They received feedback on the correctness of their answers, were allowed to refer back to the instructions, and could correct their answers. They could also ask for assistance from the experimenters, although hardly anyone did. After the comprehension questions, participants subsequently took the withdrawal decisions for Banks A and B on two separate screens.

For the purpose of the bank run game, each participant was randomized into two separate groups of three players each. One group represented the depositors of Bank A; the other one represented those of Bank B. Our protocol ensured that the group composition always differed between Bank A and Bank B in at least one participant.3 Participants were matched in a way that ensured that all depositors of the same Bank, i.e., members of a group, received identical information about their two banks. Both coordination games, i.e., the one for Bank A and the one for Bank B, were payoff relevant.

To get insights into the channels through which bank disclosure affects behavior in the bank-run game in the absence (or presence) of interbank linkages, we also elicited participants’ beliefs. For both banks, we asked participants to indicate their beliefs about how many of the other depositors (i.e., none, one, two) they thought would choose to withdraw and how confident (0–100%) they were in this judgment. We ask for confidence to get an individual level estimate for the perceived strategic uncertainty in the decision situation. For Bank B, we additionally asked participants to indicate their beliefs about how likely (0–100%) it was for Bank B to be of the type indicated by the signal about Bank A. To be least intrusive, yet as close to participants’ thought processes as possible, the non-incentivized belief elicitation questions appeared on the same screens and at the same time as the payoff-relevant withdrawal decisions. We opted to “just ask” for beliefs, based on Rutström and Wilcox’s (2009) finding that common, incentivized scoring rule elicitation procedures can affect play in strategic games, while simple, non-incentivized questions do not show this propensity. As Trautmann and van de Kuilen (2015) show, the accuracy of beliefs concerning the other players’ behavior is not negatively affected by relying on introspection compared to more sophisticated, incentivized elicitation procedures.

In part two, we also assess participants’ attitudes towards losses. Loss aversion has been reported to affect behavior in coordination games (see Trautmann and Vlahu, 2013). We implement Gächter et al.’s (2010) incentivized lottery choice task to elicit individual loss attitudes. The loss attitude elicitation followed immediately after the withdrawal decisions for the two banks. Participants received their payment for the loss aversion task in addition to the payoffs from the bank-run game in part one.

Finally, at the end of each session, we collected demographics (age, gender, field of studies) and information on banking habits (number of bank accounts, relationship with multiple banks, owning a savings account). Our participants are on average 22.6 years old, 52.4% are female, and 27.9% study economics. In terms of banking relationships, participants, on average, have 2.2 bank accounts, with 70.9% owning a savings account. 61.7% of our participants hold accounts at more than one bank.

Participants’ payment consisted of a show-up fee, payoffs for the bank-run game, and the payoff for the loss aversion task. On average, participants earned EUR 8.02 and the sessions lasted approximately 40 min.

3.3. External validity of the experimental setting

Two aspects of the experiment warrant closer discussion concerning their external validity. First, our experiment does not consider deposit insurance. However, we believe that the findings are also relevant beyond uninsured retail or wholesale depositors because deposit insurance is by no means a silver bullet. Flannery (1998) reports that insured depositors are concerned about the solvency of their bank and that of the deposit insurer. In addition, the coverage of the deposit insurance funds is limited (Demirguc-Kunt et al., 2005, 2015; Demirguc-Kunt and Laeven, 2013), and it has been argued that retail depositors in developed economies often have very limited knowledge about deposit insurance (Sträter et al., 2008; Bartiloro, 2011). Deposit insurance with extensive coverage and under government management has been associated with bank instability (Demirguc-Kunt and Detragiache, 2002; Demirguc-Kunt and Huizinga, 2004; Hoggarth et al., 2005). Relatedly, even if depositors are aware of being insured, they may not deem the insurance scheme credible (Martinez Peria and Schmukler, 2001; Prean and Stix, 2011). This can explain why insured depositors might still withdraw deposits from distressed banks (Iyer and Puri, 2012; Karas et al., 2013). Furthermore, depositors’ beliefs about the protection of their deposits may change during periods of widespread financial distress when concerns about the liquidity facility of central banks or government support arise. Such swift shifts in perception have been documented not only in emerging (Ennis and Keister, 2009), but also in developed economies. For example, during the European sovereign debt crisis, uncertainty about the coverage of deposit insurance triggered large withdrawals from solvent banks perceived as being less protected in Portugal (Bonfim and Santos, 2017), Germany (Fecht et al., 2019), and Denmark (Iyer et al., 2016a). While bank runs can occur, liquidity support by central banks may prevent bank failures. However, when it is difficult to disentangle liquidity from solvency shocks, emergency liquidity assistance can create moral hazard and give banks incentives to take excessive risk. Because of that, regulatory interventions are limited to instances when the systemic risk is at stake, and they are less likely in case of individual bank problems. Our paper relates to studies analyzing deposit withdrawals from stable banks and shows how

11 Two participants requested their data to be deleted after the experiment, leaving us with data from 430 participants. In two sessions data from the final demographic questionnaire was not correctly saved to disk. A total of 18 questionnaires could be restored from z-Tree Gamesafe files. No behavioral data was lost.
12 The dataset, as well as the complete script of the experiment, are available at https://osf.io/x34k7/.
13 Appendix A shows group assignments for both bank types.
they may become unstable without changes in their fundamen-
tals. The experimental method allows studying depositor behav-
ior before adverse events materialize and for a counterfactual in-
stitutional setting.

Second, our participants are recruited from a student popul-
ation in a Western industrialized country. Does the observed be-
havior reflect that of real-life depositors whose savings are at
stake if a bank collapses, and does it generalize beyond developed
economies? There are certainly limits to generalizing the findings
in a lab experiment on bank runs, as is true for any empirical
study in a specific institutional setting. However, our goal is not
the prediction of quantitative effects in a particular banking juris-
diction. Instead, we aim to understand better the general mecha-
nisms underlying the impact of information disclosure on decision
makers’ behavior in the presence of strategic uncertainty. The evi-
dence suggests that such qualitative behavioral mechanisms iden-
tified in the lab with student populations generalize to general
non-student populations (Huck and Müller, 2012; Noussair et al.,
2014) and even professionals (cf. Fréchette, 2015; Beyer et al., 2018;
Weitzel et al., 2020). Similarly, while there is international vari-
tion in the behavior in experimental tasks, differences do not typi-
cally obtain along with the division between developed and devel-
oping economies (Falk et al., 2018). As Dufwenberg (2015) argues
in his survey of banking experiments, people are people, and fun-
damental behaviors typically apply broadly across different popu-
lations.

4. Hypotheses

Hypothesis 1 (Individual bank disclosure). Conditional on the
underlying bank type (i.e., Good, Medium, Weak), increased preci-
sion of disclosure about Bank A’s fundamentals reduces the
propensity of deposit withdrawal for banks with stronger funda-
mentals (i.e., Good and Medium banks). Conversely, increased preci-
sion of disclosure about Bank A’s fundamentals increases the
propensity of bank withdrawal for banks with poor fundamentals
(i.e., Weak banks).

This prediction derives from the literature on the optimal bank
transparency that reports differential effects of financial informa-
tion disclosure depending on the economic context (Bouvard et al.,
2015; Leitner, 2014; Moreno and Takalo, 2016; Nier, 2005). In
this literature, the closest paper to our design is Moreno and
Takalo (2016) which study the effects of bank transparency on wel-
fare, bank risk-taking, and rollover risk. These authors show that
increasing the precision of information about bank fundamentals
fosters efficient liquidity by increasing the likelihood of a run
from banks with poor fundamentals. Following from this theore-
tical prediction we expect that reducing the uncertainty about a
bank’s type from full uncertainty (as is the case of No-disclosure
 treatment, when \( p = 33\% \)) to none (as is the case of Full-disclosure
 treatment, when \( p = 100\% \)), leads to more coordination and is
beneficial for Good and Medium banks, but aggravates the coor-
dination problem for Weak banks. Arguably, we consider the Good
and Medium banks as entities with stronger fundamentals as they
dominate the Weak banks in at least one dimension (i.e., profitabil-
ity and/or liquidity).15

14 Recent contributions include Iyer and Puri (2012), Egan et al. (2017) and
Artavanis et al. (2019).

15 If we consider the notion of the expected payoff in the case of no disclosure,
Table 1 shows that the expected payoff will be unambiguously higher than that
of the Weak bank, and lower than that of the Good bank. For the Medium bank,
the effect is ambiguous, with both cases possible depending on beliefs regarding
the number of withdrawals by other depositors, as well as potential risk aversion.
Therefore, it is conceivable that disclosure has ambiguous effects on the Medium
bank, or the Medium bank is treated as an average bank with no impact of disclo-
sure.

The following channel may be at work here: when disclosure
reduces the uncertainty about a bank’s type, it also affects the be-
\( \)liefs about the other bank’s depositors’ behavior. For those banks
with solid fundamentals, more precise information about a bank’s
strength may increase the belief that the other depositors will keep
the money in the bank. This, in turn, will reduce the propensity of
withdrawing. The reverse holds for the banks with poor fundamen-
tals.

Hypothesis 2 (Absence of interbank linkages). When the disclo-
sure about interbank linkages is non-informative, the withdrawal
decisions of Bank B’s depositors are independent of their informa-
tion about Bank A’s type and the precision of that information.

Hypothesis 3 (Partial interbank linkages). When the disclosure
about interbank linkages is informative, the withdrawal decisions
of Bank B’s depositors are positively correlated with the with-
drawal decisions of Bank A’s depositors across banks’ types. The
 correlation is stronger for higher precision of disclosure about Bank
A’s type.

These predictions derive from the literature on the spillover ef-
ects of information disclosure.16 Our design shares several features
with the banking model of Chen and Hasan (2006) which studies
the role of transparency in generating panic and information-based
bank runs. Chen and Hasan (2006) show that depositors in one
bank have stronger incentives to react to information about other
banks’ fundamentals. Their reactions are stronger when the infor-
mation about the other banks is more precise and depend on the
degree of asset commonality (i.e., the correlation between banks’
portfolios).

Our prediction from hypothesis 2 relates to the fact that the
type of Bank B is entirely independent of the type of Bank A. In
this framework, the disclosure about Bank A’s fundamentals does
not provide any information about the fundamentals of Bank B.
Thus, we expect that Bank B’s withdrawal rates will not exhibit
significant variation conditional on the signal about Bank A’s type
and the precision of that signal: there is no purely psychological
contagion.

In what concerns the prediction following from hypothesis 3,
we first have to observe that in the presence of (partial) interbank
linkages, disclosure about the types of Bank A provides a (noisy)
signal about the type of Bank B. As a result, Bank B depositors can
learn about their bank’s type from the disclosure about Bank A.
Thus, we expect that on the one hand, when the signal about Bank
A’s type is non-informative, the withdrawal rates from Bank B will
not exhibit significant variation across different signals about Bank
A’s type. On the other hand, as the precision about Bank A’s type
increases, the strength of bank fundamentals leads to more coor-
dination towards repayment for Good and Medium banks than for
Weak banks.

We conjecture the following channel: when disclosure about
Bank A’s type is non-informative, it has no effect on the beliefs
about Bank B’s type or on the beliefs about the behavior of other
Bank B depositors. Thus, the pattern for withdrawals across banks’
types is similar to that for Bank A in absence of disclosure. How-
ever, as the disclosure about Bank A’s type becomes more precise,
it affects the beliefs of Bank B’s depositors about their bank’s type,
as well as the beliefs about other depositors’ behavior. When more
precise information about Bank A’s type reveal that Bank A has
strong fundamentals, information about partial linkages between
Bank A and Bank B increases the belief that Bank B also has strong
fundamentals while reducing the belief that the other Bank B de-
positors withdraw their money. These changes in beliefs, in turn,
reduce the propensity of withdrawing.

16 Admati and Pfleiderer (2000) argue that information disclosure by one firm can
be used by investors to evaluate other firms, thus generating spillover effects.
5. Results: behavioral outcomes

5.1. Individual bank disclosure

Treatment comparisons of withdrawal behavior show that most variation happens when moving from no information (no disclosure) to at least some information (partial or full disclosure), as shown in Table B.1 in Appendix B. Thus, we pool the data from both disclosure treatments and compare it to the No-disclosure condition. The results are reported in Table 2. Despite all three banks being solvent in all conditions, we find statistically significant differences in withdrawal rates across disclosure levels and bank type signals. We observe that disclosure of any kind significantly reduces withdrawals from banks with a Good type signal and significantly increases withdrawals from banks with a Weak type signal compared to the No-disclosure conditions. The differences in withdrawal rates for depositors who receive a Medium type signal are not significantly different between the No-disclosure and Disclosure conditions ($p = 0.39$). That is, disclosure works to reduce withdrawals from banks believed to have strong fundamentals but aggravates the situation for those believed to have weak fundamentals. Medium banks seem to be perceived as average banks compared to expectations, with no apparent disclosure effects. These results are confirmed in a multivariate analysis with controls (Appendix B): increased precision is good for strong banks, but has an overall negative effect on weak banks, with insignificant effects on the medium banks.

The results for Bank A are generally consistent with Hypothesis 1 and confirm the theoretical predictions from the banking literature (e.g., Moreno and Takalo, 2016). Our results speak to the literature on the role of disclosure in achieving financial stability. As regulators would like to minimize the expected losses in the banking system (Goldstein and Leitner, 2018) and reduce the incidence of bank runs (Bouvard et al., 2015), our results suggest that the disclosure policy’s efficiency is context-dependent. During normal times, disclosing information may not be desirable, because it can lead to bank runs from solvent banks with bad fundamentals. Conversely, during crises, disclosure may be desirable, because it can prevent some runs (e.g., from banks with the solid fundamentals).

An interesting observation concerns the substantially lower withdrawal rates for the Good bank under No-disclosure. Below we will see that a similar effect emerges for Bank B in the case of linkages with Bank A, but not absent linkages. The effect implies that the mere wording of the signal (which in this instance contains no statistical information – one third likelihood of each bank type), affects behavior. This might be due to a psychological anchoring effect. However, we observe that the effect does not monotonically follow the valence of the signal’s name. We, therefore, conjecture that the impact may result from the uninformative Good signal providing a coordination “sunspot.” Arifovic and Jiang (2014) show the existence of such sunspots (using uninformative random messages as in the current No-disclosure condition) and how they depend on the coordination problem. It seems that the Good signal for Bank A becomes such a coordination sunspot.

5.2. Interbank linkages disclosure

Next, we analyze the behavior of depositors in Bank B. This allows us to identify the impact of disclosure about Bank A’s type on their withdrawal decisions, both in the absence and presence of interbank linkages between the two banks. First, we focus on the No-linkages condition, for which all depositors know that the probability of both banks having the same type is 33%.

The columns in Table 3 show depositors’ withdrawal rates from Bank B contingent on different signals about Bank A’s type. Having realized in the previous section that the distinction between partial and full disclosure is of minor importance to depositors, we pool both treatments to analyze withdrawals from Bank B. Neither in the No-disclosure nor in the Disclosure setting there are any statistically significant differences in pairwise proportions testing of the withdrawal rates from Bank B across Bank A’s type (comparing along the rows, within the two disclosure conditions). At the same time, we also do not find any statistically significant differences in the withdrawal rates from Bank B across disclosure conditions, holding the signal about Bank A constant (i.e., comparing along the columns). In the absence of interbank linkages between the two banks, depositors do not seem to (inadequately) transfer information disclosed about Bank A to Bank B, i.e., we do not find any evidence for purely psychological financial contagion in the absence of interbank linkages. This result is in line with our Hypothesis 2, and consistent with findings in Brown et al. (2017) that contagion is not just occurring arbitrarily in the absence of economic linkages between banks.

Next, we report the Partial-linkages condition results, for which withdrawal rates from Bank B are depicted in Table 4. We first compare withdrawal rates along the rows. When depositors know that there is a two-thirds probability for Bank B having the same type as Bank A, but they do not have any information about the latter type (No-disclosure), withdrawal rates from Banks B do not differ statistically significantly across the three types of signals. In contrast, when depositors do receive valuable information about Bank A, they also take the presence of interbank linkages between

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Withdrawals from Bank A with pooled disclosure conditions.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bank A Type signal</td>
<td>Good</td>
</tr>
<tr>
<td>No-disclosure</td>
<td>12.5%</td>
</tr>
<tr>
<td>Disclosure</td>
<td>1.0%</td>
</tr>
</tbody>
</table>

Notes: The table shows the percentage of participants in each condition that chose to withdraw. N = 48 for No-disclosure, N = 94–96 for Disclosure.

<table>
<thead>
<tr>
<th>Table 3</th>
<th>Withdrawals from Bank B (No-linkages).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bank A Type signal</td>
<td>Good</td>
</tr>
<tr>
<td>No-disclosure</td>
<td>33.3%</td>
</tr>
<tr>
<td>Disclosure</td>
<td>31.3%</td>
</tr>
</tbody>
</table>

Notes: The table shows the percentage of participants in each condition that chose to withdraw. N = 24 per group in No-disclosure, N = 48 per group in Disclosure.

<table>
<thead>
<tr>
<th>Table 4</th>
<th>Withdrawals from Bank B (Partial-linkages).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bank A Type Signal</td>
<td>Good</td>
</tr>
<tr>
<td>No-disclosure</td>
<td>16.7%</td>
</tr>
<tr>
<td>Disclosure</td>
<td>12.5%</td>
</tr>
</tbody>
</table>

Notes: The table shows the percentage of participants in each condition that chose to withdraw. N = 24 per group in No-disclosure, N = 46–48 per group in Disclosure.
the two banks into account when making their withdrawal decision for Bank B. In the presence of interbank linkages and meaningful disclosure about Bank A, the withdrawal rates from Bank B are statistically significantly lower if the signal for Bank A is Good rather than Weak. The difference in withdrawals from Bank B when the signal about Bank A’s type reveals Good rather than Medium fundamentals remains marginally statistically significant. However, there is no statistically significant difference in withdrawals from Bank B between Medium and Weak type signals ($p = 0.45$). These observations are consistent with our third hypothesis (i.e., information disclosed about Bank A is used for Bank B only when it is meaningful) and confirm the theoretical predictions from the banking literature (e.g., Chen and Hasan (2006)).

Again, it is also possible to compare withdrawal rates from Bank B in the Partial-linkages condition along the columns. That is, we can hold the type signal for Bank A constant and compare withdrawal rates from Bank B between No-disclosure and Disclosure conditions. Disclosure seems to reduce withdrawals from banks that are believed to have strong fundamentals (i.e., Good and Medium banks) and increase the rates for those believed to have poor fundamentals (i.e., Weak banks). However, none of the pairwise t-tests reveals statistically significant differences in withdrawal rates across treatments (all $p$-values $> 0.6$). Multivariate analyses with controls confirm the result (Appendix B, Tables B.2 and B.3). This effect is presumably driven by the weaker, indirect effect of Bank A signals on Bank B under partial linkages, in the presence of the above-discussed sunspot effect leading to already lower withdrawals for Good signals under No-Disclosure.

### 5.3. Bank failures

Apart from looking at individuals’ withdrawal behavior, we also examine expected outcomes of the bank-run coordination games. We consider expected coordination outcomes rather than the actual outcomes in our experiments because our total number of banks is relatively low, and coordination outcomes depend on each bank’s random depositor composition.\(^\text{17}\) The focus on expected rates is better suited to uncover the fundamental mechanisms underlying bank failures in larger samples. The probability of a bank failure to occur depends directly on the probability that a randomly selected depositor withdraws. In turn, the probability of withdrawal is affected by the information a depositor has about their banks. In our setup, banks of Good type fail if two or more depositors withdraw. Banks of Medium or Weak type fail if at least one depositor withdraws. Thus, depositors’ withdrawal propensities translate into expected bank failures differently.\(^\text{18}\) Fig. 1 shows the relationship between the withdrawal probabilities and the probability of bank failure for the three types.

Bank failure probabilities help us to understand the effects different withdrawal rates have for the various bank types. For example, if one-third of the depositors of Good banks withdraw, this only leads to a probability of bank failure of 25.9%. In contrast, for Medium and Weak types in our setup, the same withdrawal probability translates into a 70.3% probability of bank failure (approx. 2.7 times as high). While individual depositors’ withdrawal behavior might not be of major interest to policymakers and regulators, bank failures clearly are. This is because of the large number of depositors potentially affected and the ripple effects bank failures can create in the financial system. The exercise of calculating bank failure probabilities from observed withdrawal decisions highlights how small changes in depositor behavior interact with the potentially unobservable fragility of financial institutions to produce large differences in economic outcomes.

In Table 5 we show the expected bank failure rates based on observed withdrawal rates in our experiment. Overall, the bank failure rates are high for all but the banks with signal Good. This happens even though all the banks in our setting are solvent (and thus they can meet their obligations as long as depositors do not withdraw). Note that these failure rates need to be interpreted within the context of the experimental calibration of parameters and cannot serve as a quantitative prediction outside the lab. The important qualitative insight is that less liquid banks experience more withdrawals and are also more affected by withdrawals, leading to an overall amplified failure risk compared to stronger banks.

### 6. Results: the role of beliefs

#### 6.1. Beliefs and actions

Having studied actual withdrawal behavior and observed significant differences in the probabilities for observing subsequent bank failure, we now look at the mechanisms underlying the behavioral effects. As hypothesized, differences in withdrawal behavior in response to our treatment conditions could result from changes in the beliefs of depositors about the type of their banks and the behavior of their fellow depositors. Different precision levels of the

---

\(^{17}\) As an example, consider 9 depositors in 3 banks of Weak type. If 3 of the 9 depositors withdraw, we could observe anywhere from one to three bank failures, depending on how depositors are randomized into groups. We present actual bank failure rates in Appendix B.

\(^{18}\) For Good types, the probability of bank failure $F_G$ depending on withdrawal rate $w$ is given by $F_G(w) = 3w^2 - 2w^3$. For Medium and Weak types, it is $F_{MW}(w) = 1 - (1 - w)^3$. 

![Fig. 1. Bank failure probabilities](image-url)

Notes: $F$ denotes the probability of bank failure, $w$ denotes the probability of withdrawal. Graph for Medium and Weak bank types with dashed line; graph for Good bank type with solid line.

<table>
<thead>
<tr>
<th>Type Signal</th>
<th>Good</th>
<th>Medium</th>
<th>Weak</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bank A</td>
<td>4.3%</td>
<td>67.6%</td>
<td>57.8%</td>
</tr>
<tr>
<td>Disclosure</td>
<td>0.03%</td>
<td>57.0%</td>
<td>82.3%</td>
</tr>
<tr>
<td>Bank B (No-linkages)</td>
<td>25.9%</td>
<td>50.3%</td>
<td>64.5%</td>
</tr>
<tr>
<td>Disclosure</td>
<td>23.3%</td>
<td>61.3%</td>
<td>46.5%</td>
</tr>
<tr>
<td>Bank B (Partial-linkages)</td>
<td>7.4%</td>
<td>64.5%</td>
<td>64.5%</td>
</tr>
<tr>
<td>Disclosure</td>
<td>4.3%</td>
<td>59.6%</td>
<td>70.3%</td>
</tr>
</tbody>
</table>

Notes: Columns Good/Medium/Weak show expected bank failure probabilities for each bank type signal. These are calculated by treating observed withdrawal rates as withdrawal probabilities.
Disclosure for Bank A directly inform participants about the likelihood of encountering each bank type. This should affect their belief about how many of the other depositors, who have received the same information, withdraw their money.

For both Bank A and Bank B, we asked participants to indicate how many other depositors they think would withdraw their money. For Bank B, we additionally asked how likely they consider Bank B to be of the same type as Bank A. Table 6 shows Probit regression results for both banks, separately by the type of Bank A signal. We make two observations. First, for both banks, a higher belief in withdrawals by other depositors is highly significantly associated with a higher likelihood of withdrawals by a depositor. Second, for Bank B, the belief in the Good type is associated with lower, and the belief in the Medium type is associated with a larger likelihood of withdrawal. These effects are very small in comparison to the impact of the belief about other depositors withdrawals.

A difficulty in interpreting these associations between withdrawal beliefs and behavior lies in the possibility of reverse causality. It is conceivable that depositors decide to withdraw upon reception of the signal and believe others will do the same. Two observations can be made that support an effect running from beliefs to behavior. First, for Bank A, we see that the negative impact of beliefs is present also for Good banks. We would expect no general intention to withdraw upon reception of the signal for Good banks, making the reverse-path unlikely. Second, for Bank B, we see that beliefs about the type of the bank do not have substantial direct effects on withdrawal behavior. For Weak banks, the direct effect is entirely absent, and for Good banks it points in the opposite direction than the belief about others. Thus, while it is difficult to unambiguously identify the causal link absent opposite manipulation of beliefs about type and others withdrawing, we think the data suggest an interpretation in terms of withdrawals reacting to beliefs about withdrawals by others.

6.2. Beliefs in Bank A

We observe a positive and statistically significant correlation between the type signal about Bank A (coded as 1 = Good, 2 = Medium, 3 = Weak) and the believed number of withdrawals by other depositors (withdrawals are 0, 1, 2, Spearman’s rho = 0.29, p < 0.01). That is, signals of lower bank quality are associated with a higher number of expected withdrawals. Depositors also take disclosure (type signal precision) into account when forming their beliefs about the behavior of others: in the No-disclosure treatment, in which the type signal is uninformative, the correlation between signal type and believed number of withdrawals is low and only marginally statistically significant (rho = 0.1621, p = 0.052). The correlation is much stronger and highly statistically significant in both treatments in which the signal is at least partially informative (Partial-disclosure: rho = 0.32, p < 0.01; Full-disclosure: rho = 0.40, p < 0.01). As expected, more precise type signals affect beliefs more strongly. The better the information available to depositors, the more they differentiate between the types.

We next turn to a multivariate regression framework, which also allows us to include additional control variables. In model (1), we regress the believed number of others’ withdrawals on the level of disclosure, the bank type signal, and their interaction using an ordered probit model. In model (2), we also add controls for age, gender, loss aversion, being an economist, owning a savings account, having multiple bank accounts, banking with multiple banks, and having participated in Mannheim rather than in Heidelberg. The estimation results are shown in Table 7. The regression results reveal that the main factors behind the beliefs about the number of withdrawals are Full-disclosure (reduces withdrawal beliefs), receiving a Weak signal (increases withdrawals), and the combination of both situations (increases withdrawal beliefs strongly). That is, while increased precision by full disclosure reduces beliefs about the propensity to withdraw of other depositors for strong banks, this is not the case for medium and weak banks (joint effect of the coefficient of disclosure and its interaction with the Medium or Weak signal). Exogenous variation in disclosure affects beliefs about other depositors. As argued above, beliefs seem to translate into withdrawal decisions.

10 Participants still seem to react to the different words used in the instructions (Good / Medium / Weak), even absent information content, as discussed in Section 5.1.

11 OLS regressions yield qualitatively similar results. The ordered probit model better fits the discrete dependent variable.

12 There are no systematically statistically significant effects for any of the controls.

Table 6
Withdrawals and beliefs.

<table>
<thead>
<tr>
<th></th>
<th>(1) Good</th>
<th>(2) Medium</th>
<th>(3) Weak</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Panel A</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Belief: One other withdraws</td>
<td>1.026***</td>
<td>2.232***</td>
<td>1.867***</td>
</tr>
<tr>
<td></td>
<td>(0.517)</td>
<td>(0.400)</td>
<td>(0.377)</td>
</tr>
<tr>
<td>Belief: Two others withdraw</td>
<td>2.145***</td>
<td>2.850***</td>
<td>3.484***</td>
</tr>
<tr>
<td></td>
<td>(0.953)</td>
<td>(0.498)</td>
<td>(0.462)</td>
</tr>
<tr>
<td><strong>Panel B</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Belief: Type B = Signal A</td>
<td>-0.016</td>
<td>0.020***</td>
<td>0.003</td>
</tr>
<tr>
<td></td>
<td>(0.008)</td>
<td>(0.009)</td>
<td>(0.007)</td>
</tr>
<tr>
<td>Belief: One other withdraws</td>
<td>1.047***</td>
<td>1.306***</td>
<td>1.592***</td>
</tr>
<tr>
<td></td>
<td>(0.324)</td>
<td>(0.343)</td>
<td>(0.331)</td>
</tr>
<tr>
<td>Belief: Two others withdraw</td>
<td>2.641***</td>
<td>2.801***</td>
<td>2.644***</td>
</tr>
<tr>
<td></td>
<td>(0.520)</td>
<td>(0.447)</td>
<td>(0.449)</td>
</tr>
<tr>
<td>Observations</td>
<td>144</td>
<td>142</td>
<td>142</td>
</tr>
</tbody>
</table>

Notes: Probit models. Standard errors in parentheses. Dependent variables: Panel A: Withdrawal decision from Bank A. Panel B: Withdrawal decision from Bank B. Base category: Belief: No other depositor withdraws. Regressions by type signal for Bank A with pooled disclosure conditions. Confidence is controlled for. ***/**/*** denote statistical significance at 0.05/0.01/0.001.

Table 7
Multivariate analysis of withdrawal beliefs for Bank A.

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Partial-disclosure</td>
<td>-0.220</td>
<td>-0.104</td>
</tr>
<tr>
<td></td>
<td>(0.265)</td>
<td>(0.273)</td>
</tr>
<tr>
<td>Full-disclosure</td>
<td>-1.010***</td>
<td>-0.869**</td>
</tr>
<tr>
<td></td>
<td>(0.338)</td>
<td>(0.353)</td>
</tr>
<tr>
<td>Medium signal</td>
<td>0.337</td>
<td>0.432**</td>
</tr>
<tr>
<td></td>
<td>(0.248)</td>
<td>(0.263)</td>
</tr>
<tr>
<td>Weak signal</td>
<td>0.494**</td>
<td>0.565**</td>
</tr>
<tr>
<td></td>
<td>(0.247)</td>
<td>(0.257)</td>
</tr>
<tr>
<td>Partial-disclosure x Medium signal</td>
<td>0.354</td>
<td>0.157</td>
</tr>
<tr>
<td></td>
<td>(0.355)</td>
<td>(0.374)</td>
</tr>
<tr>
<td>Partial-disclosure x Weak signal</td>
<td>0.549</td>
<td>0.442</td>
</tr>
<tr>
<td></td>
<td>(0.353)</td>
<td>(0.368)</td>
</tr>
<tr>
<td>Full-disclosure x Medium signal</td>
<td>0.373</td>
<td>0.033</td>
</tr>
<tr>
<td></td>
<td>(0.430)</td>
<td>(0.405)</td>
</tr>
<tr>
<td>Full-disclosure x Weak signal</td>
<td>1.178***</td>
<td>1.065**</td>
</tr>
<tr>
<td></td>
<td>(0.413)</td>
<td>(0.433)</td>
</tr>
<tr>
<td>Controls</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Observations</td>
<td>430</td>
<td>398</td>
</tr>
</tbody>
</table>

Notes: Ordered probit model. Standard errors in parentheses. Dependent variable: Belief about how many other depositors in the group will withdraw. Base categories: No-disclosure and Good type signal. Controls are age, female gender, loss aversion, being trained in economics, participating in Mannheim rather than Heidelberg, number of bank accounts, banking with more than one institution, and owning a savings account. ***/**/*** denote statistical significance at 0.05/0.01/0.001.
Table 8
Multivariate analysis of withdrawal beliefs for Bank B.

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No-linkages</td>
<td>No-linkages</td>
<td>Partial-linkages</td>
<td>Partial-linkages</td>
</tr>
<tr>
<td>Partial-disclosure</td>
<td>0.192</td>
<td>0.344</td>
<td>0.372</td>
<td>0.492</td>
</tr>
<tr>
<td></td>
<td>(0.323)</td>
<td>(0.333)</td>
<td>(0.336)</td>
<td>(0.356)</td>
</tr>
<tr>
<td>Full-disclosure</td>
<td>-0.089</td>
<td>-0.007</td>
<td>-0.070</td>
<td>0.004</td>
</tr>
<tr>
<td></td>
<td>(0.327)</td>
<td>(0.338)</td>
<td>(0.346)</td>
<td>(0.379)</td>
</tr>
<tr>
<td>Medium Signal</td>
<td>-0.150</td>
<td>-0.051</td>
<td>0.226</td>
<td>0.289</td>
</tr>
<tr>
<td></td>
<td>(0.330)</td>
<td>(0.340)</td>
<td>(0.339)</td>
<td>(0.372)</td>
</tr>
<tr>
<td>Weak Signal</td>
<td>-0.357</td>
<td>-0.233</td>
<td>0.138</td>
<td>0.216</td>
</tr>
<tr>
<td></td>
<td>(0.334)</td>
<td>(0.344)</td>
<td>(0.343)</td>
<td>(0.358)</td>
</tr>
<tr>
<td>Partial-disclosure x</td>
<td>0.0851</td>
<td>0.032</td>
<td>-0.105</td>
<td>-0.419</td>
</tr>
<tr>
<td>Medium</td>
<td>(0.461)</td>
<td>(0.482)</td>
<td>(0.471)</td>
<td>(0.512)</td>
</tr>
<tr>
<td>Partial-disclosure x</td>
<td>-0.275</td>
<td>-0.316</td>
<td>0.0570</td>
<td>0.023</td>
</tr>
<tr>
<td>Weak</td>
<td>(0.473)</td>
<td>(0.487)</td>
<td>(0.472)</td>
<td>(0.498)</td>
</tr>
<tr>
<td>Full-disclosure x</td>
<td>0.342</td>
<td>0.228</td>
<td>-0.596</td>
<td>-0.695</td>
</tr>
<tr>
<td>Medium</td>
<td>(0.465)</td>
<td>(0.487)</td>
<td>(0.507)</td>
<td>(0.565)</td>
</tr>
<tr>
<td>Full-disclosure x</td>
<td>0.419</td>
<td>0.303</td>
<td>0.148</td>
<td>-0.137</td>
</tr>
<tr>
<td>Weak</td>
<td>(0.468)</td>
<td>(0.481)</td>
<td>(0.484)</td>
<td>(0.544)</td>
</tr>
<tr>
<td>Controls</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Observations</td>
<td>216</td>
<td>207</td>
<td>214</td>
<td>191</td>
</tr>
</tbody>
</table>

Notes: Ordered probit model. Standard errors in parentheses. Dependent variable: Belief about how many other depositors in the group will withdraw. Base categories: No-disclosure and Good type signal. Controls are age, female gender, loss aversion, being trained in economics, participating in Mannheim rather than Hesdelberg, number of bank accounts, banking with more than one institution, and owning a savings account. ***/*** denote statistical significance at 10%/5%/1%.

It appears thus that one channel through which disclosure of information about bank fundamentals affects withdrawal behavior is through a change in beliefs about other depositors’ likely actions. This finding is in line with our first hypothesis.

6.3. Beliefs in Bank B

The picture changes if we turn towards Bank B. Beliefs about the number of withdrawals do not correlate statistically significantly with either the signal about Bank A or the level of disclosure. While this is expected in the absence of interbank linkages, it is surprising in the presence of linkages.

We probe these observations in a multivariate framework that tries to uncover potential interaction effects of type signal and the disclosure level. The model specifications follow those of Bank A. We estimate the models with and without our set of controls and separately for the case of No-linkages and Partial-linkages. Table 8 shows the ordered probit regression results. The belief about the number of other depositors withdrawing from the bank is not significantly affected (in either linkage condition) by either the level of disclosure or the signal about Bank A or their interaction. In stark contrast to the results for Bank A, we do not find a statistically significant influence of our treatments on the beliefs participants form about the number of other depositors withdrawing from Bank B. As established before, beliefs still translate into choices, but it is less clear how beliefs are formed for Bank B in the first place. Given that the link between banks A and B is partial at best, the signal that participants receive about the type of Bank B seems to be too noisy to induce a strong belief response.

7. Belief heterogeneity and confidence

Literature originating from Morris and Shin (1998) studies speculative attacks on currency pegs and builds on the global games approach of Carlsson and Van Damme (1993). In the currency attack game, agents independently choose whether to attack a currency or not. If fundamentals are common knowledge, these games have multiple equilibria. Morris and Shin (1998) show that introducing noise to agents’ private signals can collapse the set of equilibria to a unique one. Various studies on the effects of information disclosure and transparency are based on these models (Heinemann and Ilting, 2002; Morris and Shin, 2007; Szekpus and Trevino, 2015; Yang, 2015). An important difference between this line of research and our approach to studying financial disclosure is that we do not introduce noise in agents’ private signals nor limit information disclosure to a subset of all agents, but directly vary the precision of the publicly disclosed information. In our setting, all depositors possess the same (imprecise) information and know that all other depositors also have the same information. Yet, the question remains whether they react homogeneously to the information provided. If not, public disclosure would appear to induce a private noise component, after all.

Recall that in the No-disclosure conditions, each bank type is equally likely. The signal does not provide any additional information, as it just states that Bank A has Good, Medium, or Weak fundamentals with a 33% probability. Yet, for Bank A, variations in beliefs are much higher with signals mentioning the possibility of Weak or Medium fundamentals than with those mentioning the Good type. Clearly, participants process the signals differently, despite their identical information content. We see this as evidence for a heterogeneous private interpretation of identical public disclosure.

How strongly interpretations of the public signal differ also depend on their content: in the Partial- and Full-disclosure treatments, variances of beliefs about Bank A are inversely related to the quality of bank fundamentals. The better the fundamentals, the lower the variation of beliefs. However, in these treatments, the signals are informative and provide depositors with information about their most likely bank type. Larger variances with lower quality fundamentals may indicate that strategic uncertainty increases in the coordination problem. The uncertainty also carries over across banks: for Bank B, the variance in withdrawal beliefs is significantly affected in the presence of partial linkages with full disclosure. Yet, only the Weak type signal carries enough power to increase variances compared to other type signals.

In the next step, we hold bank type signals constant and compare variances of beliefs across disclosure conditions. For Bank A, the effects of different disclosure levels on the variation of depositors’ beliefs are not uniform but depend on the type signal. For Good signals, more precisely disclosed information serves to reduce variances in beliefs. There is no statistically significant effect for Weak signals, while for Medium signals the evidence is mixed. The differences do not systematically transfer to Bank B in either linkage condition.

We also elicited confidence in withdrawal beliefs for all decisions in our experiment. Participants were asked to indicate how confident they were in their assessment of how many other depositors would withdraw on a 0 to 100 scale. While variances of beliefs tell us how similar beliefs are between depositors, this provides us with an individual-level, self-reported measure of confidence. Two observations stand out: (i) Confidence is generally lower for Bank B than for Bank A; (ii) For both banks we find that depositors are most confident in their belief when they...

---

24 A closely related literature that studies coordination games with private and public information models decisions using linear quadratic Gaussian pay-off loss functions (Baeriswyl and Cornand, 2014; Cornand and Heinemann, 2008; Morris and Shin, 2002).

25 To keep the discussion brief, we only report the main findings in the text. The detailed analysis including all test statistics can be found in Appendix C.
dicate that either no other depositor or all other depositors will withdraw. Confidence in the belief that only one other depositor withdraws is significantly lower. In fact, this finding strongly resembles the predictions of the canonical, multi-equilibria model of Diamond and Dybvig (1983): either everyone withdraws, or nobody. Similar to our earlier analyses of withdrawals, we find that the confidence in beliefs about Bank B is only affected by the level of disclosure in the presence of economic linkages. In their absence, it is not.

Overall, our results show that in a setting with common, yet noisy, public signals, substantial belief heterogeneity emerges, which ultimately affects behavior. It appears that our unified setting, which incorporates public disclosure and models interbank linkages, reveals heterogeneity in the private interpretation of public signals. It thereby connects the predictions of classic bank runs as coordination games models with findings on the effects of heterogeneous private signals originating from the global games’ literature.

8. Conclusion

We study the fundamental mechanisms of information disclosure about the fragility of financial institutions. In line with our hypotheses and the theoretical literature, we find that the effects of increased precision in the information disclosed depend on the financial institutions’ fundamentals. If banks are believed to have solid fundamentals and thus a significant capacity to withstand liquidity shocks, more precise disclosure reduces the likelihood of bank runs (i.e., large deposit withdrawals before maturity are less likely). In contrast, banks that are solvent but believed to have weaker fundamentals in terms of liquidity are confronted with significantly larger early withdrawal rates when the signal about their fundamentals becomes more precise. Our belief data shows that disclosed information affects the beliefs about the number of depositors expected to withdraw and suggests that depositors react accordingly.

In addition, our results suggest that disclosing meaningful information compared to not releasing any information has significant effects on depositors’ withdrawal decisions. Revealing any information also seems to play a more critical role in shaping depositors’ actions than increasing the disclosed information’s precision.

Moreover, our results shed light on how and when the information disclosed about individual banks may affect the behavior of depositors from other banks. Notably, we study both the information disclosure about a particular bank and the transmission of information between banks in a unified setting that considers both the precision of disclosure about bank fundamentals and about interbank linkages. In the absence of interbank linkages, if the information disclosed about one bank were to systematically affect depositors’ likelihood of withdrawing their money from another bank, information would be inadequately applied to an unrelated entity. We do not find any evidence for this problematic form of purely psychological financial contagion in our experiment. This is consistent with findings in Brown et al. (2017).

However, in the presence of interbank linkages, we observe that information disclosed about one bank also affects the withdrawal behavior of depositors at the linked institution. In this case, the disclosed information about one bank provides a meaningful but noisy signal about the second bank’s fundamentals. Our results suggest that depositors identify when information is valuable for both institutions and act accordingly.

Trevino (2020, p. 298) writes: “…an experimental session cannot recreate exactly the decisions that investors face in financial markets. However, the tensions and trade-offs are qualitatively mirrored, so that we can interpret the behavior of experimental subjects as a qualitative guide to the type of behavior that financial market participants might exhibit.” Keeping this caveat in mind, our findings are relevant to the policy debate on the costs and benefits of publicly releasing bank stress tests results. Regulators need to consider the opposing effects that disclosure might have for banks with solid vs. fragile fundamentals, especially since selective reporting conditional on a positive outcome would not be strategically feasible. Our results suggest that the effect of information disclosure is context-dependent: disclosing bank-specific information enhances the stability of the financial system during crises (allowing banks with strong fundamentals to survive), but is having a contrary effect in normal times (by uncovering weaker banks and potentially triggering deposit outflows). The potential contagion effects within the banking sector also need to be considered. Stress test results published for a subsample of banks can affect other banks which are not covered in the stress tests. According to our results, such dynamic effects are relevant if, and only if, untested banks are considered similar to those stress-tested in terms of business models, portfolio exposures, or other forms of interbank linkages. That also implies that if tested banks are systematically different from untested banks, the risk of such contagion might be much lower.

Declaration of Competing Interest

None.

Appendix A

In each session, there were 18 participants. Participants were randomly assigned cubicles in the laboratory. The cubicles were always matched in the same way to ensure an equal number of banks of each type in all sessions and treatment conditions. There always were two Banks A of each type (Good, Medium, Weak) and

![Fig. A1. Cubicle to actual bank type matching.](image)

Notes: The first row only shows Banks A, the second shows Banks B. Each circle represents a bank, i.e. a depositor group in the coordination game. Green (Orange, Red) circles represent Good (Medium, Weak) type banks. Depositors are represented by cubicle numbers.
two Banks B of each type in each session. Fig. A.1 shows how cubicles, numbered from 1 to 18, were matched to bank types. Example: The first Bank A of type Good consists of participants sitting at cubicles 1 to 3. For depositors at cubicles 1 and 2, their Bank B is also of Good type. In Bank B, their third depositor is the participant in cubicle 12. Their fellow Bank A depositor in cubicle 3, however, is part of the fourth Bank B, which is of also of Good type. For each participant, Banks A and B never consist of the same set of depositors.

Note that the figure shows the actual bank types, which participants typically do not know for sure. The only case in which they can be certain of a bank’s type occurs in the Full Disclosure treatment, in which they know their Bank A’s type for sure. The way we implement group matching allows us to make truthful statements about the probabilities of banks A and B having the same types in our linkages treatment, while at the same time ensuring that we can implement all information disclosure precision levels for banks of type A.

Table A.1 shows the Bank A type signal each individual receives. It depends on a random draw, which is automatically conducted by the computer at the beginning of each session. This random draw determines which of the different sub-cases of each treatment condition is implemented. Each case (within a treatment condition) is equally likely. The random draws ensure that the probabilities of

Table A.1
Bank A – types and signals.

<table>
<thead>
<tr>
<th>Player</th>
<th>Bank A</th>
<th>Bank B</th>
<th>Type A</th>
<th>No-Disclosure</th>
<th>Signal A</th>
<th>Partial-Disclosure</th>
<th>Full-Disclosure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>G</td>
<td>c1</td>
<td>G</td>
<td>G</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>G</td>
<td>c2</td>
<td>G</td>
<td>G</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>W</td>
<td>c2</td>
<td>W</td>
<td>M</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>M</td>
<td>c3</td>
<td>M</td>
<td>W</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td>5</td>
<td>5</td>
<td>W</td>
<td>c3</td>
<td>W</td>
<td>M</td>
</tr>
<tr>
<td>6</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>M</td>
<td>c4</td>
<td>M</td>
<td>W</td>
</tr>
<tr>
<td>7</td>
<td>3</td>
<td>6</td>
<td>6</td>
<td>G</td>
<td>c4</td>
<td>G</td>
<td>W</td>
</tr>
<tr>
<td>8</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>G</td>
<td>c5</td>
<td>G</td>
<td>W</td>
</tr>
<tr>
<td>9</td>
<td>6</td>
<td>3</td>
<td>3</td>
<td>W</td>
<td>c6</td>
<td>W</td>
<td>G</td>
</tr>
</tbody>
</table>

Notes: G/M/W denote Good/Medium/Weak bank type. C1 to c6 denote cases 1 to 6.

Table A.2
Bank B – types.

<table>
<thead>
<tr>
<th>Player</th>
<th>Bank A</th>
<th>Bank B</th>
<th>Type A</th>
<th>No-Linkage</th>
<th>Partial-Linkage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>G</td>
<td>c1</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>G</td>
<td>c2</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>W</td>
<td>c2</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>M</td>
<td>c3</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td>5</td>
<td>5</td>
<td>W</td>
<td>c3</td>
</tr>
<tr>
<td>6</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>M</td>
<td>c4</td>
</tr>
<tr>
<td>7</td>
<td>3</td>
<td>6</td>
<td>6</td>
<td>W</td>
<td>c4</td>
</tr>
<tr>
<td>8</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>G</td>
<td>c5</td>
</tr>
<tr>
<td>9</td>
<td>6</td>
<td>3</td>
<td>3</td>
<td>W</td>
<td>c6</td>
</tr>
</tbody>
</table>

Notes: G/M/W denote Good/Medium/Weak bank type. C1 to c6 denote cases 1 to 6.
each signal being correct are truthful. Take the No-disclosure treatment as an example. Each one of the three cases is implemented with 1/3 probability. Depending on the case, the members of exactly one bank type (Good, Medium, or Weak) receive a signal that perfectly corresponds (in its type) to the actual bank’s type. As participants are randomized to player numbers (cubicles in the lab), there is a chance of exactly 1/3 that their bank actually has the type given by the signal. A similar argument holds for the Partial-disclosure treatment. In 2 out of 3 cases, participants receive a signal that matches their actual type of bank.

Table A.2 shows Bank B types for each participant. Again, a computerized random draw at the beginning of the session determines which of the cases is implemented. Note that the cases in this treatment directly determine the actual type of Bank B for each participant, rather than a signal about its type. This is the result of participants receiving a statement about the probability that their Bank B is of the same type as Bank A. In the No-linkages treatment and in each of its cases, the members of exactly one type of Bank A (Good, Medium, or Weak) face a Bank B which is of the same type as A. In the Partial-linkages treatment and in each of its cases, the depositors of two Bank A types face a Bank B which is of the same type as A.

Appendix B. Withdrawals Bank A

Bank Failures

Table B.2 Withdrawals from Bank A – multivariate analysis.

<table>
<thead>
<tr>
<th>(1)</th>
<th>(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disclosure</td>
<td>-1.161***</td>
</tr>
<tr>
<td>(0.441)</td>
<td>(0.474)</td>
</tr>
<tr>
<td>Medium signal</td>
<td>0.662*</td>
</tr>
<tr>
<td>(0.299)</td>
<td>(0.328)</td>
</tr>
<tr>
<td>Weak signal</td>
<td>0.476</td>
</tr>
<tr>
<td>(0.304)</td>
<td>(0.328)</td>
</tr>
<tr>
<td>Disclosure x Medium signal</td>
<td>0.958*</td>
</tr>
<tr>
<td>(0.500)</td>
<td>(0.540)</td>
</tr>
<tr>
<td>Disclosure x Weak signal</td>
<td>1.678***</td>
</tr>
<tr>
<td>(0.500)</td>
<td>(0.534)</td>
</tr>
<tr>
<td>Controls</td>
<td>No</td>
</tr>
<tr>
<td>Observations</td>
<td>430</td>
</tr>
</tbody>
</table>

Notes: Probit model. Standard errors in parentheses. Dependent variable: Withdrawal decision for Bank A. Base categories: No-disclosure and Good type signal. Controls are age, female gender, loss aversion, being trained in economics, participating in Mannheim rather than Heidelberg, number of bank accounts, banking with more than one institution, and owning a savings account. **/*** denote statistical significance at 10%/5%/1%.

Table B.3 Withdrawals from Bank B – multivariate analysis.

<table>
<thead>
<tr>
<th>(1)</th>
<th>(2)</th>
<th>(3) Partial-linkages</th>
<th>(4) Partial-linkages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disclosure</td>
<td>-0.585</td>
<td>-0.183</td>
<td>-0.217</td>
</tr>
<tr>
<td>(0.325)</td>
<td>(0.343)</td>
<td>(0.383)</td>
<td>(0.412)</td>
</tr>
<tr>
<td>Medium signal</td>
<td>-0.381</td>
<td>0.419</td>
<td>0.269</td>
</tr>
<tr>
<td>(0.407)</td>
<td>(0.407)</td>
<td>(0.450)</td>
<td></td>
</tr>
<tr>
<td>Weak Signal</td>
<td>-0.118</td>
<td>0.419</td>
<td>0.356</td>
</tr>
<tr>
<td>(0.378)</td>
<td>(0.395)</td>
<td>(0.407)</td>
<td>(0.435)</td>
</tr>
<tr>
<td>Disclosure x Medium</td>
<td>0.260</td>
<td>0.189</td>
<td>0.091</td>
</tr>
<tr>
<td>(0.476)</td>
<td>(0.500)</td>
<td>(0.509)</td>
<td>(0.558)</td>
</tr>
<tr>
<td>Disclosure x Weak</td>
<td>-0.281</td>
<td>-0.401</td>
<td>0.301</td>
</tr>
<tr>
<td>(0.472)</td>
<td>(0.493)</td>
<td>(0.505)</td>
<td>(0.547)</td>
</tr>
<tr>
<td>Controls</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Observations</td>
<td>216</td>
<td>207</td>
<td>214</td>
</tr>
</tbody>
</table>

Notes: Probit model. Standard errors in parentheses. Dependent variable: Withdrawal decision for Bank B. Base categories: No-disclosure and Good type signal. Controls are age, female gender, loss aversion, being trained in economics, participating in Mannheim rather than Heidelberg, number of bank accounts, banking with more than one institution, and owning a savings account. **/*** denote statistical significance at 10%/5%/1%.

Table B.4 Actual bank failure rates.

<table>
<thead>
<tr>
<th>Type Signal</th>
<th>Good</th>
<th>Medium</th>
<th>Weak</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bank A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No-disclosure</td>
<td>25.0%</td>
<td>43.8%</td>
<td>25.0%</td>
</tr>
<tr>
<td>Partial-disclosure</td>
<td>0.0%</td>
<td>75.0%</td>
<td>81.3%</td>
</tr>
<tr>
<td>Full-disclosure</td>
<td>0.0%</td>
<td>43.8%</td>
<td>75.0%</td>
</tr>
<tr>
<td>Bank B (No-linkages)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No-disclosure</td>
<td>37.5%</td>
<td>37.5%</td>
<td>75.0%</td>
</tr>
<tr>
<td>Disclosure</td>
<td>62.5%</td>
<td>62.5%</td>
<td>25.0%</td>
</tr>
<tr>
<td>Bank B (Partial-linkages)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No-disclosure</td>
<td>37.5%</td>
<td>50.0%</td>
<td>50.0%</td>
</tr>
<tr>
<td>Disclosure</td>
<td>12.5%</td>
<td>50.0%</td>
<td>56.3%</td>
</tr>
</tbody>
</table>

Notes: Columns Good/Medium/Weak show bank failure rates for each bank type signal.

Appendix C. Belief heterogeneity

Table C.1 shows the distribution of the believed number of withdrawals by other depositors separated by precision of the disclosed information and the type signal about Bank A. It also includes means and standard deviations of the distributions of beliefs. We observe that in all disclosure conditions, standard deviations of beliefs are significantly lower with Good signals than with Medium or Weak signals (pairwise Levene’s tests, No-disclosure: G/W: $p < 0.01$, G/M: $p < 0.05$; Partial-disclosure: G/W: $p < 0.01$).
Withdrawals

Table C.3 Withdrawal beliefs for Bank B (Partial-linkages).

<table>
<thead>
<tr>
<th>Withdrawals</th>
<th>0</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>No-disclosure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Good</td>
<td>58.3%</td>
<td>37.5%</td>
<td>4.2%</td>
</tr>
<tr>
<td>Medium</td>
<td>50.0%</td>
<td>41.7%</td>
<td>8.3%</td>
</tr>
<tr>
<td>Weak</td>
<td>58.3%</td>
<td>29.2%</td>
<td>12.5%</td>
</tr>
<tr>
<td>Partial-disclosure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Good</td>
<td>41.7%</td>
<td>50.0%</td>
<td>8.3%</td>
</tr>
<tr>
<td>Medium</td>
<td>45.8%</td>
<td>33.3%</td>
<td>20.8%</td>
</tr>
<tr>
<td>Weak</td>
<td>37.5%</td>
<td>45.8%</td>
<td>16.7%</td>
</tr>
<tr>
<td>Full-disclosure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Good</td>
<td>58.3%</td>
<td>41.7%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Medium</td>
<td>77.3%</td>
<td>18.2%</td>
<td>4.6%</td>
</tr>
<tr>
<td>Weak</td>
<td>54.2%</td>
<td>33.3%</td>
<td>12.5%</td>
</tr>
</tbody>
</table>

Notes: Columns 0/1/2 show the share of participants with the respective combination of type signal and belief about the number of withdrawals by other depositors withdrawing.

Table C.4 Confidence in beliefs for Bank A.

<table>
<thead>
<tr>
<th>Withdrawals</th>
<th>0</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>No-disclosure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Good</td>
<td>66.46%</td>
<td>44.31%</td>
<td>61.00%</td>
</tr>
<tr>
<td>Medium</td>
<td>66.78%</td>
<td>43.25%</td>
<td>82.20%</td>
</tr>
<tr>
<td>Weak</td>
<td>62.04%</td>
<td>55.86%</td>
<td>74.2%</td>
</tr>
<tr>
<td>Partial-disclosure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Good</td>
<td>80.25%</td>
<td>63.58%</td>
<td>–</td>
</tr>
<tr>
<td>Medium</td>
<td>66.13%</td>
<td>55.89%</td>
<td>75.17%</td>
</tr>
<tr>
<td>Weak</td>
<td>57.91%</td>
<td>62.67%</td>
<td>75.4%</td>
</tr>
<tr>
<td>Full-disclosure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Good</td>
<td>88.53%</td>
<td>62.67%</td>
<td>–</td>
</tr>
<tr>
<td>Medium</td>
<td>85.97%</td>
<td>61.86%</td>
<td>85.50%</td>
</tr>
<tr>
<td>Weak</td>
<td>71.73%</td>
<td>47.71%</td>
<td>82.47%</td>
</tr>
</tbody>
</table>

Notes: Columns 0/1/2 show the mean confidence in the respective combination of disclosure level, signal for Bank A and belief about the number of other depositors withdrawing.

We repeat the same analyses for the believed number of withdrawals by other depositors from Bank B and report the distributions in Tables C2 and C3. For our No-linkages condition, in which the type signal for the type of Bank A does not provide information about the fundamentals of Bank B, we do not find any statistical differences in the standard deviations of the belief distributions between the different type signals for any level of disclosure (pairwise Levene’s tests, all p > 0.3). The picture is different in the Partial-linkages condition. Statistically significant differences appear in the Full-disclosure case, in which participants know the type of Bank B for sure and know that Bank B is of equal type with a probability of 2/3. Even then, only the Weak signal seems to be strong enough to affect the variance in beliefs significantly (Full-disclosure, G/W: p = 0.032, G/M: p = 0.374, M/W: p = 0.035). We do not find any significant differences for the Partial- and No-disclosure cases (all p > 0.17).

Holding type signals constant and again comparing across disclosure conditions, we do not find any statistically significant differences for the No-linkages condition (pairwise Levene’s tests. All p > 0.42). For the Partial-linkages condition, we only observe a significantly lower standard deviation when comparing Partial- and Full-disclosure for the Medium type signal (Levene’s test: 0.79 vs. 0.55, p = 0.015). The other differences are not statistically significant.

Confidence

We report confidence values for Bank A in Table C4. We find confidence to be increasing in disclosure (rho = 0.36, p < 0.001) and decreasing in type signal (recall: higher signal is worse; rho = −0.16, p < 0.01). The confidence in the belief that one other depositor would withdraw is significantly lower than the confidence in both other beliefs (pair-wise t-tests: 0 vs. 1: means 73.97 vs. 54.19, p < 0.001; 1 vs. 2: means 54.19 vs. 77.42, p < 0.001). There is no significant difference in confidence be-
between zero and two withdrawals (t-test, means: 73.97 vs. 77.42, p = 0.281). Clearly, depositors are more confident in their belief when they indicate that either no other depositor or all other depositors will withdraw.

Tables C.5 and C.6 show confidence values for Bank B. Confidence in the beliefs is generally lower for Bank B than for Bank A (two-sided paired t-test, means: 69.66 vs. 55.67, p < 0.001). While in the No Links condition confidence is uncorrelated with the level of disclosure, we find a significant positive association in the presence of links (rho = 0.25, p < 0.001). As seen in the analysis of withdrawal decisions and beliefs, depositors are able to cleanly separate between the two banks if they are not connected by economic linkages. However, the type signal received for Bank A does not affect confidence in beliefs about the number of withdrawals from Bank B in either of the two linkages conditions. (No Links: rho = -0.06, p = 0.362; Partial Links: rho = -0.02, p = 0.794). Similar to the pattern of confidence observed for Bank A, we also find confidence in the belief that one other depositor will withdraw from Bank B to be significantly lower than the belief in zero or two others withdrawing (Pair-wise t-tests: No Links: 0 vs. 1: means 59.47 vs. 47.87, p < 0.01; 1 vs. 2: means 47.87 vs. 65.81, p < 0.01. Partial Links: 0 vs.1: means 59.23 vs. 49.05, p < 0.01; 1 vs. 2: means 49.05 vs. 58.95, p = 0.032).

References
Huck, S., Müller, W., 2012. Alias for all: revisiting the paradox in a large representative sample. J. Risk Uncertain. 44 (3), 261–293.