Should regulators always be transparent? A bank run experiment*

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Abstract

We study, using laboratory experiments, the extent to which disclosure policies about the financial health of a bank affect the likelihood of a bank run. We consider two disclosure regimes, full disclosure and no disclosure, under two scenarios: one in which the bank is on average financially solvent and another in which the bank is on average insolvent. When the bank is on average insolvent, the full disclosure regime reduces the expected likelihood of runs. In contrast, when the bank is on average solvent, the full disclosure regime increases the expected likelihood of runs. We also find that disclosing identical information when depositors' expectations are low versus high (good versus bad news) leads to behavioural differences only indirectly through their beliefs about the other depositor's actions. Our findings show that instituting a policy of greater banking transparency is not always beneficial.

JEL Codes: C92, G21, C72, G18.

Keywords: Bank runs, Banking crises, Public policy, Information disclosure.

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1 Introduction

The stability of financial systems has been at the top of policy agendas after the 2007-2008 financial crisis. In reaction, there has been a growing consensus for increased transparency about the health of financial institutions.[1,2] Since 2015, the Basel Committee on Banking Supervision has continued its recommendations toward increased disclosure by banks about their financial state (see the BCBS report for 2015 and 2018). Currently, the Bank of England has a statutory duty to reveal when a financial institution applies for emergency funding. However, such a policy is not adopted everywhere. Most notably, the US Federal Reserve has a policy of not publicly disclosing its CAMELS ratings.[3]

In this paper, we present an experiment to better understand how information disclosure about the health of financial institutions, such as a bank, can affect runs. We use the design to help regulators discern the following question.

Research question 1 *(RQ1). Should regulators commit themselves to always revealing the health of the banks?*[4]

Whilst we recognise that runs on financial institutions can sometimes be optimal for depositors (see Alonso, 1996), such events are nevertheless undesirable for regulators.

In some economies, regulators may already be committed (by legal or constitutional rules) to high degrees of transparency about the banks' health. The disclosed information about the banks by regulators can be expected to influence depositors' withdrawal behaviour. What is less obvious is whether depositors' withdrawal behaviour is also influenced by the *affective* content of the disclosed information, such as whether a bank's health turns out to be better (*Good* news) or worse (*Bad* news) than expected. Indeed, some insights on this matter can help regulators better pre-

[1]One of the main recommendations from the "Squam Lake Report" (French et al., 2010) is for regulators to increase the dissemination of collected information about financial institutions to the private sector.

[2]The Dodd-Frank Wall Street Reform and Consumer Protection Act of 2010 mandates the Federal Reserve to conduct supervisory "stress tests" on large financial institutions and publicly disclose the results by June 30th of the calendar year. However, it is not obvious as to whether such disclosure is necessarily beneficial (see Goldstein and Sapra, 2014).

[3]Supporting this contrasting view of non-disclosure, Gorton (2009) argues that the creation of the ABX.HE index precipitated the run on subprime bonds, by revealing information about beliefs concerning the riskiness of those assets.

[4]In this study, we restrict our attention to scenarios where regulators (credibly) commit themselves to be fully transparent or opaque about the banks' health. The analysis is more complicated when regulators can choose when to be transparent or opaque as the lack of information may itself convey information.

pare for the consequences of information disclosure. This leads us to our second research question.[5]

Research question 2 *(RQ2). Does the likelihood of bank runs depend on whether the revealed information about the bank's financial health is better (good news) or worse (bad news) than expected?*

We base our experimental design on the Diamond and Dybvig (1983) model where a bank faces short-term liquidity constraints and uncertainty about its long-term health.[6] We consider two economic outlooks, *weak* and *strong*, differing in the distribution of the bank's long-term returns, which proxy for the bank's long-term health. For both types of outlooks, the distribution of the bank's long-term returns includes values for which it is a dominant strategy for depositors to run (i.e., the prisoner's dilemma), as well as values for which the no run equilibrium is feasible as in the standard Diamond and Dybvig model. The former case we refer to as an insolvent bank, while the latter case we refer to as a solvent bank.[7] There is a higher chance for depositors to face the prisoner's dilemma (an insolvent bank) when the outlook is weak relative to when it is strong and, in fact, a bank with a return equal to the expected outlook-contingent return would be insolvent in the weak outlook and solvent in the strong outlook.

To study the role of information disclosure on bank runs (RQ1), we implement two regimes differing on whether depositors are informed of the bank's long-term returns. In the first regime, there is a no disclosure policy in which depositors must decide whether or not to withdraw their deposits knowing only the distribution of the long-term returns. In the second regime, there is a full disclosure policy in which depositors know the actual long-term returns before making their withdrawal decisions. For each outlook (e.g., weak, strong) we compare runs under the no disclosure and full disclosure policies. The influence of information disclosure on bank runs is non-trivial due to the existence of multiple equilibria when the bank is solvent. This task is therefore well suited to laboratory experiments where the confounding forces such as beliefs and experiences can be carefully controlled.

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[5]For example, the run on the Northern Rock bank in 2007 may have been precipitated by the Bank of England announcement that Northern Rock had applied for emergency liquidity support (see Shin, 2009). In preparation for the announcement, the Bank of England may benefit (e.g., better resource allocation decisions) if they knew whether depositors' reaction will differ depending on whether the liquidity support provided to Northern Rock is larger or smaller than most market participants had expected.

[6]The Diamond-Dybvig model is also used to study currency attacks (e.g., Obstfeld, 1995) and rollover risk (e.g., He and Xiong, 2012; Martin et al., 2014).

[7]Hence, a run on a solvent bank is a liquidity problem rather than a solvency problem in that if all depositors delay withdrawing, then they would each receive more than they could today.

In our design, the long-term returns of the weak and strong outlook banks will intersect at a range of values. At this intersection, the returns will be either better (good news) or worse (bad news) than expected given the depositors' prior when outlooks are weak or strong, respectively.[8] We therefore compare depositors' behaviour under the full disclosure weak outlook and full disclosure strong outlook to better understand the influence of good and bad news on bank runs (RQ2).[9]

Research finds that the affective content of information can influence economic behaviour. For example, asset price movements (e.g., Conrad et al., 2002; Leippold et al., 2008), beliefs formation (e.g., Eil and Rao, 2011) and public opinion (e.g., Soroka, 2006) respond differently to good and bad news. Depositors' behaviour in the Diamond-Dybvig bank run paradigm may not only be affected by good and bad news directly as in the above examples but may additionally be affected by their beliefs about other depositors' reactions to the news. The laboratory environment enables us to study both channels of influences on bank runs—with non-experimental data, the lack of the counterfactual implies that it is difficult to judge whether bank runs would have been any worse or better depending on the affective content of news.

Our experiment shows that information disclosure is a double-edged sword. When the outlook is weak, the no disclosure policy leads to more runs than the full disclosure policy. The opposite is true when the outlook is strong: the full disclosure policy leads to more runs than the no disclosure policy. In both cases, results are driven by behaviour at the extremes of the distribution of returns: full disclosure is beneficial when the outlook is weak because it informs depositors in the rare event that it is rational not to run. In contrast, no disclosure under a strong outlook prevents runs in the rare event that returns are too low and running on the bank is a dominant strategy. Essentially, when the outlook is strong, it is beneficial to hide bad information within overall good information. When the outlook is weak, it is beneficial to allow good information to be revealed against a backdrop of overall bad information. As a whole, our results show that disclosure rules can have significant influence on bank runs.

Turning our attention to the full disclosure treatments, we find that the affective content of information influences depositors' strategic belief formation: depositors believe that other depositors are more likely to trigger a bank run when the disclosed news about the bank is bad relative to good. This is despite the fact that depositors

[8] Here, good or bad news is always relative to depositors' ex-ante expectations.

[9] In an interesting study, Mian and Sankaraguruswamy (2012) find that the sensitivity of stock price movements to good (resp. bad) news is higher (resp. lower) during periods of high relative to low market "sentiments". The notion of high and low market sentiments is similar to our concept of strong and weak outlooks, respectively.

themselves do not seem to exhibit any non-strategic behavioural responses to good and bad news. Finally, whilst we also find the likelihood of runs to be higher when depositors receive bad relative to good news, the differences are not significant.[10]

To summarise, our results suggest that it may not always be optimal for regulators to commit themselves to be fully transparent about the financial health of banks. In fact, it is sometimes beneficial for regulators to "keep secrets" or in some circumstances, be as ambiguous as possible—see also the theoretical work by Gorton (1985), Chari and Jagannathan (1988), Kaplan (2006), Dang et al. (2017) and Ebert et al. (2018). Indeed, Alan Greenspan, the former chairman of the Federal Open Market Committee, famously remarked in 1987: "Since I've become a central banker, I've learned to mumble with great incoherence. If I seem unduly clear to you, you must have misunderstood what I said."

Our experiment also finds that whilst the affective content of information can affect depositors' beliefs about the behaviour of others, the influence on their withdrawal behaviour is fairly limited. This suggests that if regulators have to reveal that a bank's financial health is worse than can be expected, strategies that seek to manage depositors' beliefs about the behaviour of others may be successful in mitigating the likelihood of runs.

In a closely related paper, Bouvard et al. (2015) use the global games (e.g., Morris and Shin, 1998, 2002) paradigm to theoretically show that full disclosure about the health of banks by regulators can enhance the stability of the financial system during times of crises (i.e., weak outlook) and destabilise the system in normal times (i.e., strong outlook).[11,12] In this study, we show that same conclusions can be reached in the Diamond and Dybvig (1983) framework.

Banerjee and Maier (2016) use the global games paradigm to investigate the granularity of the public signal on bank runs.[13] Their experiment finds that the effect of information transparency, a more granular public signal, depends on whether the

[10]Depositors' withdrawal decisions are correlated to their strategic beliefs about the behaviour of others. However, the correlation is not perfect. Hence, it is possible for the affective content of information to have significant influence on beliefs but not withdrawal decisions.

[11]In global games, a continuum of players each receive a private noisy signal and a common public signal about the true state of nature. See Goldstein and Pauzner (2005) for an application of global games to bank runs.

[12]The authors chose to use global games, as opposed to the Diamond and Dybvig (1983) setup, to resolve the multiple equilibria issues that will arise with the latter. They go on to show that if the regulators can strategically choose when to pursue disclosure or opacity, a welfare reducing commitment problem will arise.

[13]Their design involved five banks. Depositors receive noisy private information about the health of each bank. The experiment manipulates the public information: *aggregated* (i.e., aggregated information over all five banks) signal treatment versus *granular* (i.e., noisy information for each bank) signal treatment.

public signal is "pessimistic" or "optimistic". Here, pessimistic and optimistic are defined as public signal values that are below and above, respectively, a specific *threshold* at which withdrawal behaviour is theoretically independent of the type of public signal. More specifically, greater transparency increases the likelihood of coordination failure (i.e., bank runs) when the public signal is pessimistic and reduces the likelihood of coordination failure when the public signal is optimistic.

In our study, the equivalent thresholds correspond to the point where the revealed long-term returns in the full disclosure treatments are equal to the expected long-term returns in the no disclosure treatments. Consistent with Banerjee and Maier (2016) results, we also find that greater transparency, such as with the full disclosure policy, will decrease (resp. increase) the likelihood of bank runs when the long-terms returns are revealed to be above (resp. below) the threshold—this holds for the weak and strong outlooks. However, we go on to show that the net effects of information disclosure on bank runs differ between the weak and strong outlooks. When the outlook is weak, information disclosure decreases bank runs to a greater extent than it increases them. In contrast when the outlook is strong, information disclosure increases bank runs to a greater extent than it decreases.[14]

Finally, we contribute to the broader discussions about transparency in the banking system (see Landier and Thesmar, 2011; Goldstein and Sapra, 2013). Briefly, proponents for greater transparency often argue that transparency by regulators can help to promote market discipline and allocative efficiency (e.g., French et al., 2010). However, whilst greater transparency can be *ex-post* efficient, it can sometimes also be *ex-ante* inefficient. For example, greater transparency may result in lower quality information as banks become less willing to share information with regulators (e.g., Prescott, 2008; Leitner et al., 2014). Also, public information by regulators may crowd out the private incentives to seek quality information which in the long-run may affect the market signals that regulators rely on to judge the health of banks (e.g., Bond and Goldstein, 2015). Depositors may overweight the public information relative to their own noisy information (e.g., Morris and Shin, 2002). Finally, the ability for banks to pool and share risk is fundamental to its operations (e.g., Allen and Gale, 2000). In this respect, the "Hirshleifer effect" (Hirshleifer, 1971) posits that greater transparency may limit banks' risk sharing opportunities. Together with Bouvard et al. (2015), we show that the outlook of the economy is also important when considering the benefits or cost of greater transparency in the banking sector.

[14]In a recent study, König-Kersting et al. (2020) also showed using the Diamond and Dybvig paradigm that information disclosure can increase and decrease the likelihood of bank runs when the health of the bank is revealed to be weak and strong, respectively. However, they did not consider the net effects of information disclosure.

The rest of the paper is organised as follows. Section 2 details our experiment design. Section 3 details the experimental procedures. Section 4 reports the experimental results. Finally, Section 5 concludes.

2 Experiment Design

We consider a simple two-player bank run game that is inspired by the Diamond and Dybvig (1983) model. In order to focus on the role of information disclosure, we use a two-player game so as to minimise the difficulty in evaluating the strategic uncertainty of other players.[15]

Bank Run game. The game is summarised in Figure 1. There are two depositors, each with 400 deposited in a bank. Each depositor decides (simultaneously) to withdraw his money *early* (e) or *late* (l). The bank faces short-term liquidity constraints and uncertainty about its long-term fundamentals. To model the long-term fundamentals, we assume that nature determines the bank to be one of eleven possible types, $\theta \in \Theta = \{\theta_1, \dots \theta_{11}\}$, with equal probability of each type. The bank collapses if any depositor withdraws early and the bank is only worth its liquidation value of 400, which is equally shared among all depositors who withdrew early. If both depositors withdraw late, the payoffs to each depositor is $R^j(\theta) \geq 0$, where $j = S, W$ denotes the long-term economic outlook that can either be *weak* (W) or *strong* (S).[16] Here, $R^j(\theta)$ is the type θ bank long-term returns. The outlook, whether it is weak or strong, is known to both depositors (not necessarily the bank's type).

The first two rows of Panels A and B of Table 1 detail the corresponding $R^j(\theta)$ for each type when the outlook is weak and strong, respectively. For example, if the outlook is weak (resp. strong) and both depositors withdraw late, each depositor receives 250 (resp. 550) when the bank's type is θ_6. Bank runs can be efficient when $R^j(\theta) \leq 200$ and are inefficient when $R^j(\theta) > 200$. Depositors face the prisoner's dilemma when $200 < R^j(\theta) < 400$ and the coordination game when $R^j(\theta) \geq 400$. When both depositors withdraw late, there is a 8/11 (resp. 2/11) chance of receiving less than their deposited amount when the outlook is weak (resp. strong).

Orthogonal to the above, we also consider two information regimes: *full infor-*

[15] When there are $n > 2$ players in the bank run game, each player must not only form beliefs about other players' actions but also beliefs about how correlated these actions may be.

[16] We are neutral as to the interpretation of types. One possibility is for θ to correspond to the probability that the bank will collapse in the long-run, even if all depositors withdrew late. In this case, $R^j(\theta) = X(1-p^j(\theta))$ where $p^j(\theta) \in [0,1]$ is the type θ's probability of collapsing in outlook j and $X > 0$ is the payoff to the depositor if the bank does not collapse.

	Withdraw Early (e)	Withdraw Late (l)
Withdraw Early (e)	200, 200	400, 0
Withdraw Late (l)	0, 400	$R^j(\theta)$, $R^j(\theta)$

Note. The values in each cell denote the payoffs to the row (Depositor 1) and column (Depositor 2) players, respectively. The variable $R^j(\theta) \geq 0$ depends on the bank's outlook $j = W, S$ and the bank's type θ. When the outlook is weak (W), $R^W(\theta)$ can take the values 0, 50, 100, ..., 500 with equal probability of each. When the outlook is strong, $R^S(\theta)$ can take the values 300, 350, ..., 800 with equal probability of each.

Figure 1: Bank run game.

Panel A: The weak outlook (*FW* game).											
Type	θ_1	θ_2	θ_3	θ_4	θ_5	θ_6	θ_7	θ_8	θ_9	θ_{10}	θ_{11}
$R^W(\theta)$	0	50	100	150	200	250	300	350	400	450	500
[i]Pure-Strategy eq.	ee	ee	ee	ee	ee	ee	ee	ee	$ee^{\square}$ $ll_{\perp}$	$ee^{\square}$ $ll_{\perp}$	$ee^{\square}$ $ll_{\perp}$
[ii]Mixed-Strategy eq.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.20	0.33

Panel B: The strong outlook (*FS* game).											
Type	θ_1	θ_2	θ_3	θ_4	θ_5	θ_6	θ_7	θ_8	θ_9	θ_{10}	θ_{11}
$R^S(\theta)$	300	350	400	450	500	550	600*	650	700	750	800
[i]Pure-Strategy eq.	ee	ee	$ee^{\square}$ $ll_{\perp}$	$ee^{\square}$ $ll_{\perp}$	$ee^{\square}$ $ll_{\perp}$	$ee^{\square}$ $ll_{\perp}$	$ee^{\square}$ $ll_{\perp}^{\square}$	ee $ll_{\perp}^{\square}$	ee $ll_{\perp}^{\square}$	ee $ll_{\perp}^{\square}$	ee $ll_{\perp}^{\square}$
[ii]Mixed-Strategy eq.	1.00	1.00	0.00	0.20	0.33	0.43	0.50	0.56	0.60	0.64	0.67

Note. The shaded columns in Panels A and B denote the equilibria in the *NW* and *NS* games, respectively, if the depositors are risk-neutral.

[i] Here, ee and ll denote the outcomes where both depositors withdraw early and late, respectively. Where relevant, the $\square$ and $\perp$ denote the *risk dominant* and *payoff dominant* equilibria, respectively.

[ii] The mixed-strategy refers to the probability of withdrawing early.

Table 1: Payoff parameters and pure strategy equilibria.

mation and *no information*. In the full information regime, depositors observe the bank's type, and consequently the long-term returns, before they make their withdrawal decisions. In contrast, depositors in the no information regime do not observe the bank's type before making decisions—they know whether the outlook is weak or strong. The full and no information conditions are analogous to a setting where a regulator is committed to always revealing and never revealing the bank's type, respectively.

Experiment Design. The above considerations result in a 2×2 design with the following four games: *FW* game (full information; weak outlook), *NW* game (no information; weak outlook), *FS* game (full information; strong outlook) and *NS* game (no information; strong outlook).[17] Depositors in the full information treatments receive *good* and *bad* news when informed that $R^j(\theta)$ is *larger* and *smaller*, respectively, than the expected long-term returns—assumed to be 250 and 550 in the *FW* and *FS* games, respectively, under risk-neutrality—given their prior over the possible states of the world.[18] Hence, when the returns are 300, 350, 400, 450 and 500, the revealed information is better and worse than expected for depositors in the *FW* and *FS* treatments, respectively.

To study RQ1, we consider each outlook separately to better understand how information disclosure about the bank's type (i.e., full information vs. no information), affects the *expected likelihood* of bank runs, that is, the ex-ante probability of a bank run before θ is resolved by nature. To study RQ2, we compare behaviour across the full information treatments when $R^j(\theta)$ are 300, 350, 400, 450 and 500 to better understand the influence of good (i.e., *FW* treatment) and bad (i.e., *FS* treatment) news on bank runs.

Equilibrium analysis. Panels A and B of Table 1 also detail the equilibrium (pure-strategy and mixed-strategy) given each type θ in the *FW* and *FS* games, respectively. The shaded columns detail the equilibrium in the *NW* and *NS* games.[19] The pure-strategy risk dominant and payoff dominant (Harsanyi and Selten, 1988) equilibria are denoted by the "□" and "⊥" symbols, respectively.

[17] Depositors in the *NW* and *NS* games face both strategic uncertainties as to the decisions of their peer and fundamental uncertainties as to the bank's type. In contrast, depositors in the *FW* and *FS* games only face strategic uncertainties.

[18] For example, learning that the bank's long-term returns is 400 will be good (resp. bad) news for a depositor in the *FW* (resp. *FS*) treatment.

[19] The behaviour in such games may resemble risk-neutral play which is identical to when the bank's type is known to be θ_6.

2.1 The impact of information disclosure (RQ1)

To study the impact of information disclosure when the outlook is weak (resp. strong) we focus on the *NW* and *FW* (resp. *NS* and *FS*) games, assuming risk-neutral depositors. The equilibrium analysis predicts that if depositors play the mixed-strategy equilibria or coordinate on the payoff dominant equilibrium, information disclosure will reduce and increase the expected likelihood of a bank run when the outlooks are weak and strong, respectively.[20] In contrast, information disclosure decreases the expected likelihood of bank runs when the outlook is strong and depositors coordinate on the risk dominant equilibrium; there is no influence of information disclosure in the weak outlook.

Experimental research with the stag-hunt game suggests that whether people coordinate on the risk or payoff dominant equilibria, if at all, can depend on the matching protocol or payoff parameters (see Devetag and Ortmann, 2007; Van-Huyck, 2008, for surveys). In general, people tend to pick the payoff dominant strategy more often as the *basin of attraction* of the risk dominant equilibria (Van-Huyck, 2008) decreases. In other words when $R^j(\theta) \geq 400$ (i.e., coordination game), depositors in the full information games are expected to withdraw early less frequently as $R^j(\theta)$ increases—this may possibly also hold for the prisoner's dilemma ($200 < R^j(\theta) < 400$) range.[21]

Importantly, the above suggests that information disclosure will have mixed effects in the bank run game. Namely, relative to the j outlook no information game, revealing the bank's type in the j outlook full information game can either increase or decrease the frequencies of bank runs for values of $R^j(\theta)$ depending upon whether the values are lower or higher than the expected long-term returns for depositors in the relevant no information game. Hence, the impact of information disclosure on the expected likelihood of bank runs will depend on whether disclosing the bank's type increases the frequencies of runs to a greater extent than it decreases, or vice-versa. For these reasons, it is difficult to draw an *a priori* hypothesis even with the wealth of experimental research on coordination games.

2.2 Good and bad news (RQ2)

The equilibrium analysis predicts that behaviour in the full information games only depends on $R^j(\theta)$ and not on whether $R^j(\theta)$ is revealed to be better (good news)

[20] The mixed-strategy equilibria in the *NW* and *FW* (resp. *NS* and *FS*) games are for depositors' expected probability of withdrawing early to be 1.00 and 0.78 (resp. 0.43 and 0.53), respectively. However, the mixed-strategy equilibria may not be stable in finitely repeated games (e.g., Echenique and Edlin, 2004).

[21] Such an outcome is inconsistent with the mixed-strategy equilibrium which predicts that depositors in the coordination game range are more likely to withdraw early as $R^j(\theta)$ increases.

or worse (bad news) than expected. In applications, the *FS* and *FW* treatments could trigger different *non-strategic* behavioural responses when the long-term returns are revealed to be 400, 450 and 500.[22] For example, a depositor may interpret the situation as choosing between the safe choice of withdrawing early and the risky choice of withdrawing late. After receiving good news, a depositor may be more optimistic and hence more likely to choose the risky option as compared to receiving bad news and choosing the safe option.

Depositors may believe that other depositors are susceptible to the above non-strategic behavioural responses to good and bad news even if they themselves do not exhibit the same responses. This influences their *strategic* belief formation: depositors believe that others are less (resp. more) likely to withdraw early when they receive good (resp. bad) news.[23] In the Diamond-Dybvig spirit, such beliefs induce a "self-fulfilling prophecy" where depositors themselves are less (resp. more) likely to withdraw early when they too receive the good (resp. bad) news. Hence, risk-neutral depositors will withdraw early less frequently in the *FW* game (good news scenario) relative to the *FS* game (bad news scenario) when the bank's long-term returns are 400, 450 and 500—its not obvious whether the differences in behaviour should extend to instances where $R^j(\theta)$ are 300 and 350 given that it remains a dominant strategy for depositors to withdraw early.[24]

3 Procedures

The *NW* (72 subjects), *FW* (78 subjects), *NS* (74 subjects) and *FS* (80 subjects) treatments were conducted in 2016, recruiting from the student cohort at University of Erlangen-Nuremberg—see Table A1 of the Appendix for details about the experimental sessions. Subjects were recruited on a first come basis through ORSEE (Greiner, 2015). The sessions were ran in a computer network; the experimental software was z-Tree (Fischbacher, 2007).

Each experimental session consisted of parts A and B—both parts are identical. In part A (resp. B), subjects played 19 (resp. 17) rounds of the corresponding games with random matching at each round and one experimental round was randomly chosen for payment—we pool data from both parts for the analysis. When subjects

[22]The 300 and 350 cases are less obvious since depositors face the prisoner's dilemma.

[23]It is difficult to see why depositors might instead believe that good and bad news will induce the other depositors to increase and reduce, respectively, their likelihood of withdrawing early.

[24]The effects of risk-aversion on the between-game differences is non-trivial since it will also depend on depositors' beliefs about the risk-aversion of other depositors.

received the instructions for part A, they were unaware of part B's design.[25] In each round, we also used an incentive compatible mechanism to elicit subjects' beliefs about their opponents likelihood of withdrawing early.[26] Subjects received feedback at the end of each round as to their payoffs and the bank's type—payoffs were denoted in the currency ECU. For efficient comparisons, we pre-generated four sequences of θ and applied them accordingly to the respective sessions. In addition to a €4 show-up payment, subjects' payoffs from parts A and B were converted to cash at the exchange rate of 75 ECU to €1. Mean earnings in the *NW*, *FW*, *NS* and *FS* treatments were €11.86, €12.11, €16.39 and €17.96, respectively.

4 Results

For the ease of exposition, we will use the short-hand R to denote a bank's type, and consequently, its long-term returns—each type θ maps uniquely to the long-term returns $R^j(\theta)$ under outlook j. Also, we refer to a depositor's *beliefs* as his incentive compatible guess about the likelihood of his opponent withdrawing early.[27]

4.1 Results: Preliminaries

We start by using the fixed-effects regression model to first study how R and *beliefs* affect depositors' behaviour— estimates are reported in Table B1 of Appendix B.1. Depositors in all treatments are significantly more likely to withdraw early as *beliefs* increases ($p < 0.001$). Also, subjects in the full information treatments are significantly less likely to withdraw early as R decreases ($p < 0.001$).

However, the extent to which beliefs affect withdrawal decisions in the full information treatments depend on R. More specifically, the correlation between *beliefs* and withdrawal decisions is significantly ($p < 0.001$, *FW* and *FS* treatments) smaller when R is within the prisoner's dilemma ($200 < R < 400$) range than in the coordination game ($R \geq 400$) range. Similarly, the correlation is significantly smaller ($p < 0.001$, *FW* treatment) when R is within the dominated ($R \leq 200$) range than when within the prisoner's dilemma range. This dichotomy is expected since beliefs

[25] The instructions are provided in the Appendix A. The two-part design allowed us to see if experience mattered as well as collect more data with the same number of subjects. We did not find an effect of experience so thus pooled the data.

[26] Each subject submits a "guess" $g = 0, 5, .., 100$ as to how likely his opponent will withdraw late. The payoffs from this task are $100 - 0.01g^2$ and $2g - 0.01g^2$ if the opponent withdraws early and late, respectively. These symmetric penalties ensure that subjects have an incentive to submit their truthful beliefs about their opponent's action.

[27] By construction, the variable *beliefs* is bounded between 0 and 100, where a higher value indicates greater probability of withdrawing early.

should determine behaviour for values of R within the coordination game range but not the dominated range.[28] As for the prisoner's dilemma range, while it may be a dominant strategy for a self-interested depositor to withdraw early, the same is not the case for subjects who exhibit social preferences (see Charness and Rabin, 2002; Chakravarty et al., 2016).

We next consider a more dynamic model, where depositors respond, in an adaptive manner, to past behaviour—fixed-effects regression model estimates are reported in Table B2 of Appendix B.1. In the no information treatments, depositors are significantly more likely to withdraw early if they ($p < 0.001$) or their opponents ($p < 0.001$) withdrew early in the previous round. The former correlation indicates a temporal persistence interpretation; the latter indicates a degree of social learning, in that interacting with an opponent who withdrew early may lead to an update on the beliefs about the population of players—recall that our experimental design had random matching in every round. In contrast, the previous opponent's withdrawal decision does not significantly ($p \geq 0.457$) influence the behaviour of depositors in the *FW* and *FS* treatments. Finally, conditional on withdrawing early in the previous round, depositors in the *FW* are significantly ($p < 0.001$) less likely to withdraw early when R is in the dominated and prisoner's dilemma ranges relative to the coordination game range—the same finding applies to the *FS* treatment.

The above findings are summarised with the following observation.

Observation 1 *Early withdrawal decisions are strongly correlated with depositors' past behaviour, the level of R, and their beliefs about their current opponent's action. They are not consistently or strongly correlated with past behaviour of other depositors.*

4.2 Results: The impact of information disclosure (RQ1)

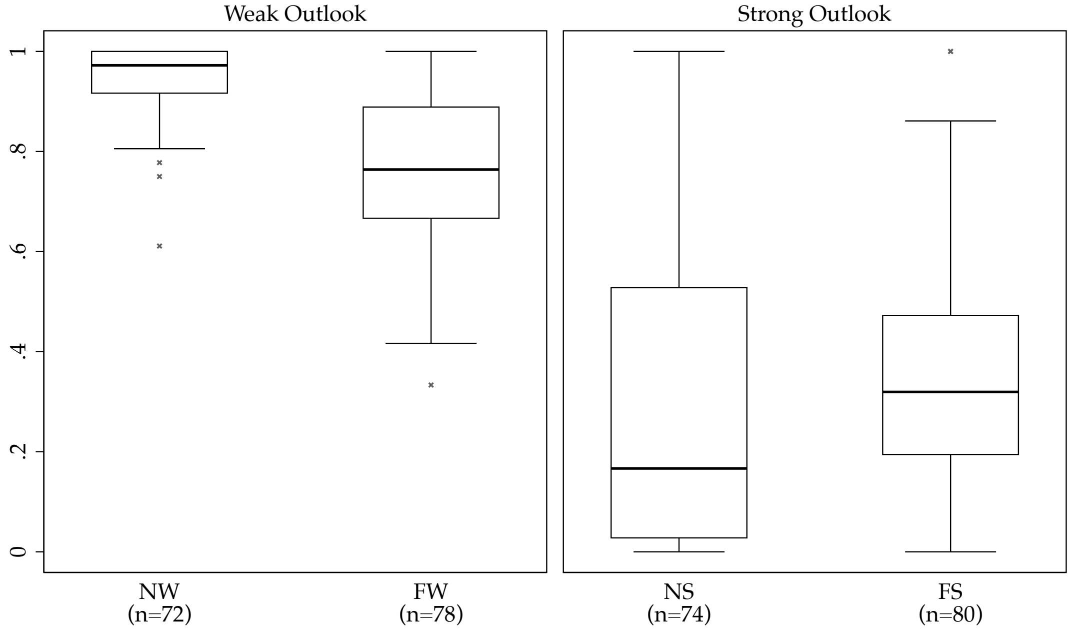
Since a bank run occurs whenever a depositor withdraws early, the analysis needs to only focus on the depositors' propensity to withdraw early. For each depositor, we define f_e as his relative frequency of withdrawing early.[29,30]

Figure 2 reports the Boxplot distribution f_e in all treatments. The median f_e for the *NW* and *NS* treatments are 0.97 and 0.17, respectively. These observations suggest that when uninformed of the bank's type, most depositors chose to withdraw

[28] In the *FW* treatment, we still observe a significant and positive correlation of behaviour and *beliefs* when R is within the dominated range. This shows that beliefs may even affect behaviour when runs are efficient.

[29] For example, $f_e = 0.5$ implies that the subject withdrew early in half of all his experimental rounds.

[30] For each subject, we do not find the realised frequencies of each bank's type to be significantly different (Wilcoxon Signrank, $p \geq 0.86$) from the theoretical frequencies (i.e., equal chance for each type).



Note. The left and right panels detail the boxplot distribution of f_e (i.e., a depositor's observed frequency of withdrawing early) when the outlooks are weak and strong, respectively.

Figure 2: Boxplot distribution of f_e in the *NW*, *FW*, *NS* and *FS* treatments.

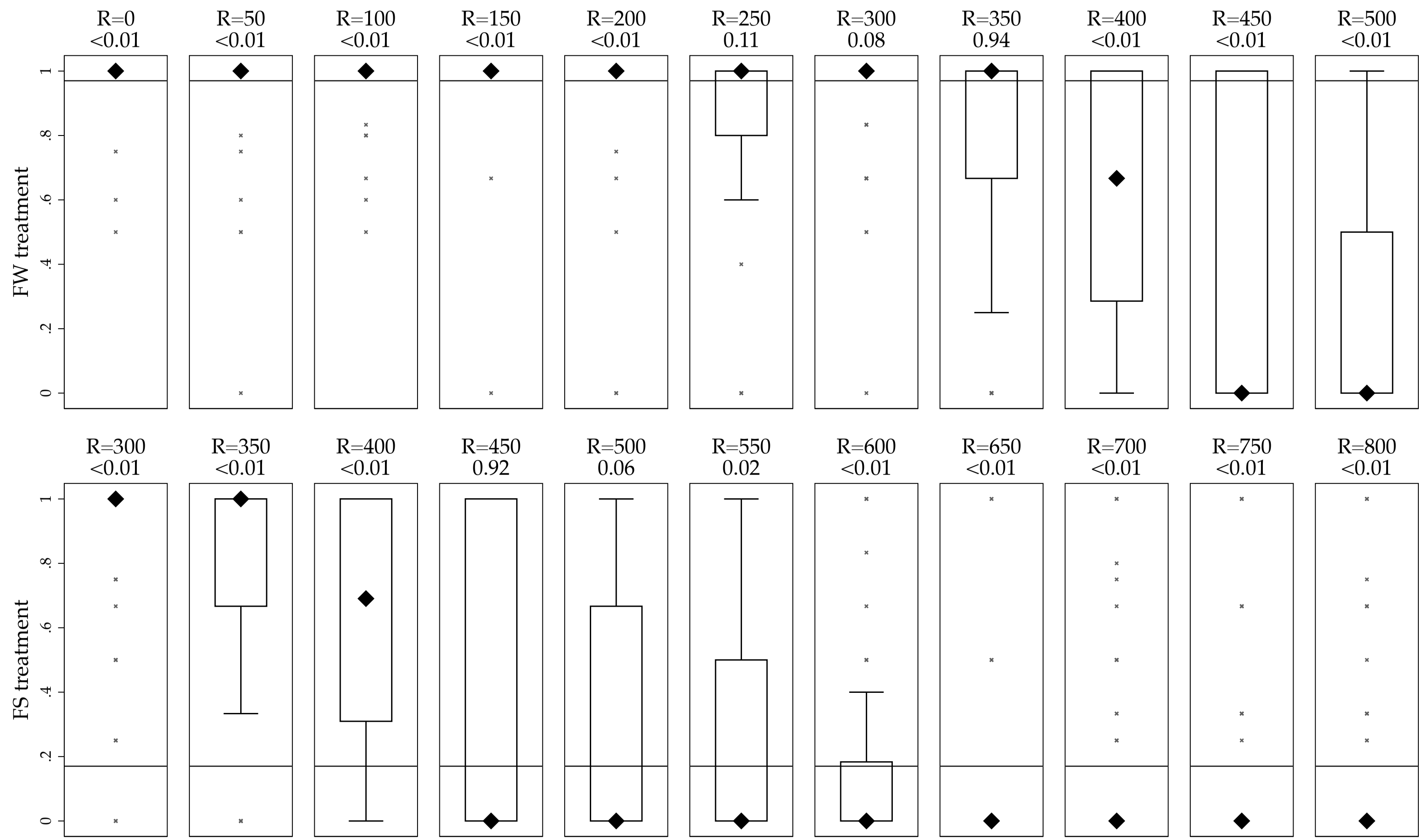
early when the outlook is weak and late when the outlook is strong. To see the influence of information disclosure on the *expected likelihood* of bank runs, we compare f_e in the *NW* and *FW* treatments as well as f_e in the *NS* and *FS* treatments. We find f_e to be significantly higher in the *NW* relative to *FW* treatment (two-tailed Mann-Whitney (MW), $p < 0.001$). In contrast, we find f_e to be significantly lower in the *NS* relative to *FS* treatment (MW, $p = 0.003$). These findings lead us to our first two results.

Result 1 *Information disclosure (revealing the bank's type) when the outlook is weak significantly reduces the expected likelihood of bank runs.*

Result 2 *Information disclosure (revealing the bank's type) when the outlook is strong significantly increases the expected likelihood of bank runs.*

To better understand the above results, we compare depositors' behaviour in the full information regime when the bank's type is θ, against behaviour in the no information regime where the bank's type is unknown. To do so, we define $f_e(R)$ as a depositor's frequency of withdrawing early when the bank's long-term returns is revealed to be R.

Figure 3 details the Boxplot of $f_e(R)$ in the *FW* (top row) and *FS* (bottom row) treatments. We also report the median f_e in the *NW* and *NS* treatments. Intuitively,



Note. Each column details the boxplot distribution of early withdrawal frequency $f_e(R)$ in the *FW* (top row) and *FS* (bottom row) treatments for a given R value. The horizontal line in each panel details the median early withdrawal frequency f_e in the *NW* (top row) and *NS* (bottom row) treatments. The header of each panel also details the two-tailed Mann-Whitney test p-value for the comparisons between the $f_e(R)$ in the full information treatment and f_e in the no information treatment.

Figure 3: Boxplot distribution of $f_e(R)$ in the *FW* and *FS* treatments.

comparisons between the f_e of the no information treatments and $f_e(R)$ of the full information treatments should shed light on the influence of information disclosure at each R.

Relative to f_e in the *NW* treatment we find $f_e(R)$ in the *FW* treatment to be significantly (MW, $p < 0.001$) higher when $R \leq 200$ and significantly (MW, $p < 0.001$) lower when $R \geq 400$. Relative to f_e in the *NS* treatment, we find $f_e(R)$ in the *FS* treatment to be significantly (MW, $p < 0.001$) higher when $R \leq 400$ and significantly (MW, $p \leq 0.02$) lower when $R \geq 550$. These findings lead us to our next result.

Result 3 *Information disclosure (revealing the bank's type) has mixed effects on the depositors' withdrawal decisions. In particular, information disclosure significantly increases the likelihood of bank runs for lower type banks and significantly decreases the likelihood of bank runs for higher type banks.*

Building on Result 3, we partition the state space (i.e., the bank's type) in the *FW* and *FS* treatments into the *plus-run*, *minus-run* and *neutral-run* regions where relative to their no information counterparts, information disclosure significantly increases, significantly decreases and has no significant influence on the likelihood of bank runs, respectively.[31] The proportion of instances in the *FW* treatment where depositors in the plus-run, minus-run and neutral-run regions withdrew early are 97%, 38% and 86%, respectively. For the *FS* treatment, the corresponding proportions are 77%, 14% and 31%, respectively. Finally, the proportion of instances in the *NW* and *NS* treatments where depositors withdrew early are 95% and 30%, respectively. We make the following observation.

Observation 2 *The extent to which information disclosure "mitigates" and "exacerbates" the likelihood of bank runs depends on the outlook. When the outlook is weak, information disclosure mitigates in the minus-run region to a greater extent than it exacerbates in the plus-run. When the outlook is strong, information disclosure mitigates in the minus-run region to a lesser extent than it exacerbates in the plus-run region.*

As a consequence, information disclosure significantly reduces and increases the *expected* likelihood of bank runs when the outlook is weak and strong, respectively. Finally, the above results also hold when we consider a depositor's frequency of withdrawing early weighted by the theoretical frequencies of each possible bank types.[32]

[31] In the *FW* (resp. *FS*) treatment, the plus-run region corresponds to the types where $R \leq 200$ (resp. $R \leq 400$) and the minus-run region corresponds to the types where $R \geq 400$ (resp. $R \geq 550$) – the remaining types correspond to the neutral-run region.

[32] In doing so, we control for the distribution of types realised by depositors in the experiment better.

We also draw similar findings when the analysis focuses on depositors' beliefs as to their opponents' likelihood of withdrawing early.

4.3 Results: Good and Bad news (RQ2)

To study whether depositors' behaviour varies depending on good and bad news, we focus on observations from the full information treatments where the bank's long-term returns are revealed to be 300, 350, 400, 450 and 500. Here, R is better (good news) and worse (bad news) than can be expected by depositors in the *FW* and *FS* treatments, respectively.

We first consider the effects of good and bad news on depositors' strategic beliefs. To do so, define $b(R)$ as a depositor's average *belief* about the chance (in percentage) of the other depositor withdrawing early when the bank's long-term return is revealed to be R. Panel A of Table 2 details the mean and standard deviation (in parenthesis) of $b(R)$ for depositors in the *FW* and *FS* treatments. In line with our conjecture in Section 4.3, we see that the affective content of information has significant influence on depositors' strategic beliefs: $b(R)$ is significantly higher in the *FS* relative to *FW* treatments when depositors face the coordination game ($R = 400$, MW $p = 0.024$; $R = 450$, MW $p = 0.016$; $R = 500$, MW $p = 0.067$)—there are no significant between treatment differences when depositors face the prisoner's dilemma ($R = 300$, MW $p = 0.374$; $R = 350$, MW $p = 0.627$).[33] In other words, depositors believe that the other depositors are more likely to withdraw early when news about R is bad relative to good.

The affective content of information clearly affects depositors' beliefs about the behaviour of others. But does it also influence their own behaviour? To see this, we use the random effects logit model to study depositors' withdrawal decisions, controlling for their beliefs. In the model specification, we interact the treatment variable (i.e., *FS* vs. *FW*) with R and beliefs—this allows the correlation between *beliefs* and withdrawal decision to vary by treatment and R.[34] We plot the regression model's predicted likelihood of withdrawing early on Figure 4—the corresponding regression estimates are reported in Table B3 of Appendix B.2. For all possible beliefs, there are no discernible between-treatment differences in the predicted probabilities of withdrawing early when the long-term returns are 350, 400, 450 and 500. When $R = 300$, we find the early withdrawal probabilities to be significantly higher (5% level) in the *FS* relative to *FW* treatments but only when depositors believe that the other deposi-

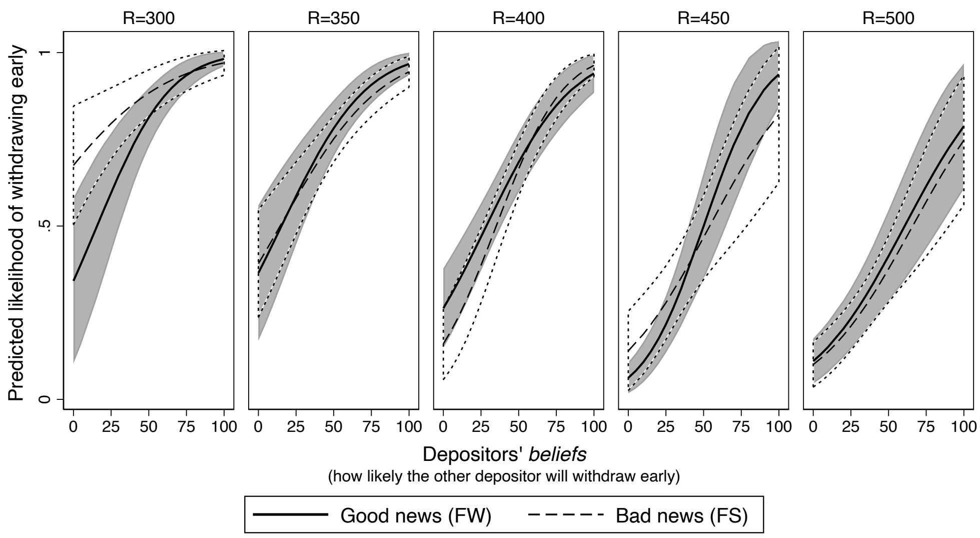
[33]The null difference in the prisoner's dilemma range can be expected since it remains a dominant strategy for depositors to withdraw early.

[34]The conclusions in this analysis hold even when a more parsimonious model is used.

	Prisoner's dilemma		Coordination game		
Long-term Returns	300	350	400	450	500
PANEL A: Mean and standard deviations of beliefs $b(R)$ of early withdrawal					
Good news (*FW*)	75.20 (18.13)	63.26 (28.24)	42.73 (28.76)	27.78 (29.70)	23.66 (27.91)
Bad news (*FS*)	70.24 (25.29)	66.93 (22.93)	51.69 (23.45)	42.30 (33.22)	29.83 (22.03)
Mann-Whitney (p-value)	0.374	0.627	0.024	0.016	0.067
PANEL B: Mean and standard deviations of early withdrawal frequency $f_e(R)$					
Good news (*FS*)	0.91 (0.19)	0.78 (0.36)	0.58 (0.38)	0.32 (0.43)	0.26 (0.37)
Bad news (*FW*)	0.89 (0.26)	0.80 (0.31)	0.62 (0.38)	0.44 (0.48)	0.30 (0.34)
Mann-Whitney (p-value)	0.653	0.576	0.531	0.293	0.588

Note. Each cell reports the mean value and the standard deviation in parenthesis. The last row of each column reports the p-value for the Mann-Whitney U-test between treatment comparison.

Table 2: The effects of good and bad news on $b(R)$ and $f_e(R)$.



Note. The solid (resp. dashed) thick lines detail the predicted probabilities of withdrawing early for depositors in the *FW* (resp. *FS*) with the 95% confidence interval denoted by the grey (resp. transparent) region.

Figure 4: Predicted likelihood of withdrawing early.

tors are unlikely to withdraw early (i.e., beliefs less than 50). We summarise the above findings with the following result.

Result 4 *Depositors believe that other depositors are less likely to withdraw early when the revealed information about the bank's long-term returns is better (good news) relative to worse (bad news) than expected. This holds despite the fact that good and bad news does not seem to affect depositors' own non-strategic behavioural responses.*

We now turn our attention to withdrawal decisions across treatments. Panel B of Table 2 details the mean and standard deviation (in parenthesis) of $f_e(R)$ for depositors in the *FS* and *FW* treatments. As can be expected given their *beliefs*, $f_e(R)$ are often higher in the *FS* relative to *FW* treatments when the long-term returns are 400 (MW, $p = 0.531$), 450 (MW, $p = 0.293$) and 500 (MW, $p = 0.588$). However, the differences are not significant. This leads us to our final result.

Result 5 *The effects of good and bad news on the likelihood of bank runs are in the predicted direction, i.e., runs are more frequent when depositors receive relatively bad news. However, the differences are very small in economic magnitude and statistically insignificant.*

5 Conclusion

We add to the discussion of information disclosure in financial institutions by providing experimental evidence in the context of a bank run game about how depositors respond to public information about the solvency of the bank. We show that the effects of information provision are highly dependent on the distribution of the underlying state of the world. Information provision affects behaviour at the extremes of the distribution of outcomes. That is to say, it affects behaviour in rare events (that is, bank insolvency in good times, or bank solvency in bad times).

We find that less transparency results in more runs when the expected health of the bank is fragile and less runs when the expected health of the bank is strong. In the former scenario, without information the subjects will coordinate on the run action. So if the policy maker's objective is to avoid failing banks, then clearly having a full disclosure policy would be better when the economy is weak.

We find that the affective content of the revealed information about the bank's health, and consequently its long-term returns, only affects depositors' withdrawal decisions through a belief mechanism. Good (resp. bad) news mean that depositors believe others are less (resp. more) likely to withdraw and therefore makes them less (reps. more) likely to withdraw. They have no direct effect on withdrawal behaviour through a "sentiment" channel.

Naturally, we contribute to the body of experimental literature that studies bank runs in the spirit of the Diamond and Dybvig model (see Dufwenberg, 2015, for a survey of the literature). In particular, there are a number of studies that examine the influence of external information on depositors' withdrawal decisions. In Arifovic and Jiang (2019), the depositors observe an external signal, a random public announcement stating the "predicted" deposit withdrawals. They find that depositors are more likely to follow the unconnected external signals when parameters are such that there is high strategic uncertainty as to which equilibrium will form. Chakravarty et al. (2014) and Brown et al. (2017) look at the possibility of bank run contagions in the sense that a publicly visible run on one bank triggers a run on another. Both papers find evidence of bank run contagions when the fundamentals of two banks are linked. Consistent with the findings of Arifovic and Jiang (2019), Chakravarty et al. (2014) also find that depositors may get influenced by external information when the fundamentals are not linked.[35] Finally, there is also theoretical work on the role of announcements regarding the health of bank on bank runs (e.g., Gorton, 1985; Chari and Jagannathan, 1988; Kaplan, 2006; Dang et al., 2017; Ebert et al., 2018).

While our experiment has two depositors in each bank, which allowed for a large number of observations, we might ask what can be expected if we increase the number of depositors? Clearly, this would depend on the *threshold* proportion of early withdrawers amongst the $n > 2$ depositors that the bank can sustain before going insolvent (and not being able to pay the late withdrawers). In the extreme case, where the threshold proportion is $1/n$, such as when an early withdrawal by one of the n depositors can collapse the bank, the $R > 400$ bank run game is somewhat similar to the "minimum effort" game. Van Huyck et al. (1990) find that behaviour in the minimum effort game converges to the inferior equilibrium (i.e., all depositors withdrawing early) as the group size increases. However, when the threshold is less extreme, Heinemann et al. (2009) find that group size does not significantly affect behaviour in coordination games. More recently, bank run experiments by Arifovic et al. (2018) also find that group size may not affect withdrawal behaviour—the authors compared group size of 10 with group size of 70-90 and find that group size does not affect withdrawal decisions when "waiting" (i.e., withdrawing late) is perceived to be relatively safe. Taken together these previous experiments suggest that Results 1 and

[35]There is also bank run literature about depositors observing withdrawals in their own bank (e.g., Schotter and Yorulmazer, 2009; Garratt and Keister, 2009; Kiss et al., 2012).

2 may possibly hold for larger group sizes.

There is a related strand of experimental literature that uses the global games (e.g., Carlsson and van Damme, 1993; Morris and Shin, 2002) paradigm to study the effects of public information on coordination failures. The relevant experiments look at how people use public information and how the accuracy or transparency of public information affects behaviour.

For example, Cornand and Heinemann (2014) experimentally find that people tend to overweight the public information (i.e., relative to their own noisy private information).[36] In a related experiment, Baeriswyl and Cornand (2014) show that people overweight the public information to a lesser extent when the information is only revealed to a fraction of players or when the public information is sufficiently ambiguous.

On the issue of public information transparency, Anctil et al. (2004, 2010) find that changes to transparency, modelled by the precision of players' private information, can affect coordination failures.[37] Heinemann et al. (2004) experimentally study the role of public information in global games framed as currency attacks. They consider two treatments, one where the true state is fully revealed by the public signal and the other where the true state is not revealed (i.e., players receive noisy private signals). They find that public information reduces coordination failures and increases the success likelihood of currency attacks.

A promising line of future work is to expand the ability of the regulator to communicate in two ways. First, we can make the regulator a player in the game. Our current setup is equivalent to forcing the regulator to have full commitment to either always commit to fully reveal his information or to always conceal his information. Second, we can alter these levels of commitment to either restricting the regulator to always send the truth, but not restricted to which truth (a form of verifiability) or even no commitment at all (say anything even if it is lying).

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[36]Arifovic and Jiang (2019) find that public information such as "sunspots" can also help people coordinate.

[37]In general, they find that increasing the precision of player's private information increases coordination on *risk dominant* (Harsanyi and Selten, 1988) equilibria.

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APPENDIX

A Instructions

Table A1 details the number of participants in each session. There were two parts to the experiment, Part A (19 rounds) and Part B (17 rounds). The instructions to the relevant parts were only distributed at the start of the part. Both parts are identical.

Session	Date (Time)	Treatment	No. of subjects
1	03.06.2016 (0930)	*FS*	20
2	03.06.2016 (1130)	*FW*	20
3	01.07.2016 (0930)	*NS*	20
4	01.07.2016 (1130)	*NW*	20
5	07.07.2016 (0930)	*FS*	20
6	07.07.2016 (1100)	*FW*	20
7	07.07.2016 (1230)	*NS*	20
8	07.07.2016 (1445)	*NW*	18
9	24.10.2016 (1100)	*FS*	20
10	24.10.2016 (1330)	*FW*	20
11	26.10.2016 (0930)	*NS*	20
12	26.10.2016 (1300)	*NW*	18
13	07.11.2016 (0945)	*FS*	20
14	07.11.2016 (1130)	*FW*	18
15	09.11.2016 (1000)	*NS*	14
16	09.11.2016 (1130)	*NW*	16

Table A1: Details of experimental sessions.

The experiment was conducted in English. The following details the instructions for the FW (full information; weak outlook) treatment. Sentences which are unique to the strong outlook treatments will be marked in "text". Sentences which are unique to the no information treatments will be marked in "text".

A.1 Instructions: Introduction

Welcome to the experiment. Please read these instructions carefully. Your payment in this experiment will depend on your decisions and the decisions made by other people; it is therefore important you understand the rules of the experiment. In this experiment, your decisions will earn Experimental Currency Units (ECU).

75 ECU are worth €1.

At the end of the experiment, we will calculate your total ECU and convert it into euros. In addition, you will also receive a €4 show up payment.

The experiment will consist of two parts (Part-A and Part-B). The experimental design for Part-A is detailed below. We will inform you about the experimental design for Part-B once we have completed the Part-A experiment.

A.2 Instructions: Part-A

The Part-A experiment consists of at least 15 rounds. The actual number will be randomly determined by the computer but you will not know this number. At the end of Part-A, the computer will randomly choose your payoffs from one of the rounds and convert it into cash.

A.2.1 The Start of Each Round

At the start of each round, the computer will randomly match you with another player in this session. In addition, the computer will randomly generate a value for the variable R. Here, R can be any number between 0 and 500 300 and 800 in steps of 50, with each value being equally likely. The below table (Table A2) clarifies the possible values for R and the chance for each value.

Value of R	0 300	50 350	100 400	150 450	200 500	250 550	300 600	350 650	400 700	450 750	500 800
Chance	1/11	1/11	1/11	1/11	1/11	1/11	1/11	1/11	1/11	1/11	1/11

Table A2: Value of R.

- Both players will observe the value for R. Both players will NOT observe the value for R.
- Each player also has a saving account in a Bank worth 400 ECU.

Given the above, each player will perform two tasks. Your payoff from each task will depend on your decision and the decision of the other player. Your payoff for the round will be a combination of the payoffs from both tasks.

Task-A. Your first task is to decide whether you want to withdraw your money TODAY or wait until TOMORROW. The below table (Figure A1) describes how your payoff from the task will be computed.

- If both players withdraw today, you get 200 ECU (other player gets 200 ECU).

	Other Player withdraws Today	Other Player withdraws Tomorrow
You withdraw Today	200	400
You Withdraw Tomorrow	0	R

Figure A1: Task-A.

- If both players withdraw tomorrow, you get R ECU (other player gets R ECU).
- If you withdraw today and the other player tomorrow, you get 400 ECU (other player gets 0 ECU).
- If you withdraw tomorrow and the other player today, you get 0 ECU (other player gets 400 ECU).

Task-B. Your second task is to submit your guess as to how likely the other player will withdraw Tomorrow. To do so, you will submit a number between 0 and 100, in increments of 5 (i.e., 0, 5, 10, 15,...,95, 100). Here, a low number implies that it is highly unlikely for the other player to withdraw tomorrow. A high number implies that it is highly likely for the other player to withdraw tomorrow. Depending on your submitted guess and the withdrawal decision of the other player, your payoffs will be computed as follow:

For example, if your guess is 25 and the other player withdraws today, you will receive 93.75 ECU. If your guess is 90 and the other player withdraws tomorrow, you will receive 99 ECU.

Final Payoffs for the Round. Once both players have completed Task-A and Task-B, we will compute your payoffs.

$$\text{Payoffs for the Round} = \text{Payoffs Task-A} + \text{Payoffs Task-B}$$

A.2.2 Control questions

Here are some questions that examines your understanding of Part-A design. Please submit your answers in the computer screen.

1. There are at least 15 rounds in Part-A. (<u>True</u>/false)

Your guess	Other player withdraws today	Other player withdraws tomorrow
0	100	0
5	99.75	9.75
10	99	19
15	97.75	27.75
20	96	26
25	93.75	43.75
30	91	51
35	87.75	57.75
40	84	64
45	79.95	69.75
50	75	75
55	69.75	79.75
60	64	84
65	57.75	87.75
70	51	91
75	43.75	93.75
80	36	96
85	27.75	97.75
90	19	99
95	9.75	99.75
100	0	100

Table A3: Task-B.

2. You had chosen to withdraw today and the other player had chosen to withdraw tomorrow. Your Payoffs from Task-A will be ___. (0 ECU; 200 ECU; 400 ECU; R ECU)

3. You had chosen to withdraw tomorrow and the other player had chosen to withdraw tomorrow. Your Payoffs from Task-A will be ___. (0 ECU; 200 ECU; 400 ECU; R ECU)

4. You had chosen to withdraw tomorrow and the other player had chosen to withdraw today. Your Payoffs from Task-A will be ___. (0 ECU; 200 ECU; 400 ECU; R ECU)

5. You submit a Guess of 45 and the other player withdraws today. Your Payoffs from Task-B will be ___

6. Both Players will observe R. (True/false)

A.2.3 Other information

Please be reminded that the experiment in Part-A will consist of at least 15 rounds. We will inform you about the Part-B experiment was we have completed Part-A. After Part-B is completed, we will require you to complete a simple survey form. Please raise your hands if there are any questions and the experimenter will answer your questions in private.

A.3 Instructions: Part-B

Part-B of the experiment is identical to Part A.

Reminders

- The Part-B experiment consists of at least 15 rounds. The actual number will be randomly determined by the computer but you will not know this number. At the end of Part-B, the computer will randomly choose your payoffs from one of the rounds and convert it into cash.
- Both players will observe the value for R. Both players will NOT observe the value for R.
- Each player will perform two tasks (Task-A and Task-B). Your payoff from each task will depend on your decision and the decision of the other player. Your payoff for the round will be a combination of the payoffs from both tasks.

B Econometrics

B.1 Determinants for withdrawal beehaviour

In the full information treatments there are three relevant ranges of R for which beliefs play (potentially) different roles.

- *Dominated* (DOM) range. When $R \leq 200$ it is both individually and collectively rational to withdraw early—beliefs should not play any role in decision-making.

- *Prisoner's Dilemma* (PD) range. When $200 < R < 400$, subjects are playing a prisoner's dilemma; while it is a dominant strategy for a self-interested subject to withdraw early, the same is not the case for subjects who exhibit social preferences (see Charness and Rabin, 2002; Chakravarty et al., 2016).

- *Coordination Game* (COOR) range. When $R \geq 400$, we have a coordination game, in which beliefs about the other's action is critical to determining which equilibrium should be played.

Table B1 details the estimates for the linear probability fixed effects GLS model of the decision to withdraw early on dummies for the relevant ranges of R (i.e., DOM, PD or COOR), as well as their interaction with a measure of belief about the probability of the other depositor withdrawing early for the treatments with full information.[38] Here, each column details the regression estimates for a treatment. For example, column 1 reports the estimates for the *NW* treatment. In the no information treatments, we only used beliefs as the sole regressor since subjects do not observe R.

We next consider instead a more dynamic model, where subjects respond, in an adaptive mode, to past behaviour. We therefore use early withdrawal decisions (subjects' own and opponent's) in the previous period as the main regressor, interacted whenever appropriate with the relevant ranges of R. Table B2 reports the results.

B.2 Good and bad news

On table B3 we report the random-effects logit estimates focusing on observations in the *FW* and *FS* treatments where the long-terms returns are revealed to be 300, 350, ..., 500.

[38]We report cluster-robust standard errors at the session level.

Dependent variable: Early withdrawal				
Treatment	*NW*	*FW*	*NS*	*FS*
DOM		0.596^{***} (0.0385)		
PD		0.345^{***} (0.0299)		0.452^{***} (0.0364)
beliefs	0.004^{***} (0.0002)	0.009^{***} (0.0003)	0.006^{***} (0.0003)	0.008^{***} (0.0004)
beliefs × DOM		-0.006^{***} (0.0005)		
beliefs × PD		-0.003^{***} (0.0004)		-0.003^{***} (0.0005)
Constant	0.588^{***} 0.0188	0.124^{***} 0.0122	0.091^{***} 0.0105	0.044^{***} 0.009
Number of observations	2,592	2,808	2,664	2,880
Number of subjects	72	78	74	80
R^2	0.12	0.58	0.27	0.47

Note. Robust standard errors in parentheses. The "DOM" and "PD" dummy covariates refer to observations where $R \leq 200$ and $200 < R < 400$, respectively—the omitted category is the COOR range. We do not have any DOM range observations in the strong outlook treatments. The *beliefs* variable refers to the subjects' belief that their opponents will withdraw early.
*** indicate $p < 0.01$.

Table B1: Fixed-effects GLS estimates of the role of beliefs.

Dependent variable: Early withdrawal				
Treatment	*NW*	*FW*	*NS*	*FS*
DOM		0.767^{***} (0.0321)		
PD		0.623^{***} (0.0370)		0.587^{***} (0.0258)
Subject withdraws early in t-1	0.268^{***} (0.0181)	0.164^{***} (0.0282)	0.341^{***} (0.0181)	0.034^{*} (0.0195)
Subject withdraws early in t-1 × DOM		-0.247^{***} (0.0366)		
Subject withdraws early in t-1 × PD		-1.172^{***} (0.0407)		-0.156^{***} (0.0436)
Opponent withdraws early in t-1	0.090^{***} (0.0173)	0.012 (0.0276)	0.139^{***} (0.0141)	0.014 (0.0186)
Opponent withdraws early in t-1 × DOM		0.010 (0.0367)		
Opponent withdraws early in t-1 × PD		0.001 (0.0406)		0.161^{***} (0.0437)
Constant	0.612^{***} (0.0234)	0.255^{***} (0.0253)	0.152^{***} (0.0090)	0.239^{***} (0.0108)
Number of observations	2,520	2,730	2,590	2,800
Number of subjects	72	78	74	80
R^2	0.15	0.40	0.52	0.24

Note. Robust standard errors in parentheses. The DOM and PD dummy covariates refer to observations where $R \leq 200$ and $200 < R < 400$, respectively—the omitted category is the COOR range. We do not have any DOM range observations in the strong outlook treatments.
*** and * indicate $p < 0.01$ and $p < 0.10$, respectively.

Table B2: Fixed-effects GLS model estimates of the determinants of early withdrawal.

Dependent variable: Early withdrawal			
	β	Robust SE	pvalue
FS	2.040	0.986	0.039
$R = 350$	0.146	0.929	0.875
$R = 400$	-0.542	0.700	0.439
$R = 450$	-2.761	0.779	0.000
$R = 500$	-1.978	0.829	0.017
$R = 350 \times FS$	-1.873	1.205	0.120
$R = 400 \times FS$	-2.905	0.961	0.003
$R = 450 \times FS$	-0.901	1.119	0.421
$R = 500 \times FS$	-2.173	1.099	0.048
belief	0.061	0.009	0.000
beliefs $\times$ *FS*	-0.025	0.015	0.103
beliefs $\times R = 350$	-0.008	0 .014	0.558
beliefs $\times R = 400$	-0.009	0.012	0.465
beliefs $\times R = 450$	0.012	0.015	0.425
beliefs $\times R = 500$	-0.013	0.014	0.375
beliefs $\times FS \times R = 350$	0.017	0.018	0.340
beliefs $\times FS \times R = 400$	0.040	0.016	0.012
beliefs $\times FS \times R = 450$	-0.001	0.022	0.978
beliefs $\times FS \times R = 500$	0.024	0.020	0.242
Constant	-0.965	0.788	0.220
n		2670	
♯ of subjects		158	

Note. The *beliefs* variable refers to the subjects' belief that their opponents will withdraw early. Where relevant, the reference group is the *FW* treatment or $R = 300$ case.

Table B3: Random-effects model estimates.