Financial Literacy and Bank Runs: An Experimental Analysis*

Eloisa Campioni†, Vittorio Larocca‡, Loredana Mirra§ and Luca Panaccione¶

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Abstract

We set up an experimental coordination game among bank depositors à la Diamond and Dybvig (1983). We elicit subjects' financial literacy and study the impact of revealing this information on the coordination problem typical of this game with multiple equilibria. We find that when no information is revealed the likelihood of runs increases with bank size, while when information on financial literacy is disclosed it increases in small banks and decreases in large ones. Over all banks' dimensions, the probability of coordinating on the inefficient equilibrium is lower when the average financial literacy revealed to the group is higher.

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†Department of Economics and Finance, Università di Roma "Tor Vergata", email: eloisa.campioni@uniroma2.it.

‡School of European Political Economy, Luiss Guido Carli, email: vlarocca@luiss.it.

§Department of Economics and Finance, Università di Roma "Tor Vergata", email: loredana.mirra@uniroma2.it.

¶Department of Economics and Finance, Università di Roma "Tor Vergata", email: luca.panaccione@uniroma2.it.

1 Introduction

Over the last decades the financial environment has become increasingly complex and active individual participation has been growing. Households who want to take part in financial markets need to access and elaborate sophisticated financial information.[1] The ability to process economic information and to make informed decisions about financial planning constitutes an individual's financial literacy (Lusardi and Mitchell, 2014). There is substantial evidence that financial literacy improves savings' and investments' choices at individual level,[2] and yet it appears to be still lacking even among households in developed economies.[3] The consequences of low financial literacy on the capacity to take sound financial decisions are of general concern for their impact not only on individual financial planning,[4] but also on the stability of financial systems. In fact, the provision of intermediation services may be jeopardised when too a large proportion of households takes inappropriate financial decisions, leading to financial crises.[5] These crises have been rationalized as undesirable outcomes of a coordination failure, as illustrated by Diamond and Dybvig (1983) for bank runs, or by Morris and Shin (1998) for currency attacks among others.

Whether one can establish a link between financial literacy and inefficient coordination outcomes is central to this work. We study whether there is any role for financial literacy in strategic settings, in which agents take decisions based on anticipations of the behaviour of their interacting partners. From a game-theoretic point of view, having information about the financial literacy of the interacting partners may be relevant in determining players' best responses. Two research questions therefore emerge: what is the role of financial literacy in strategic contexts? If players have information about their opponents' financial literacy, would they take different decisions?

Answering these questions requires to investigate both the role of own and others' financial literacy. To do so, we set up an experimental coordination game among bank depositors à la Diamond and Dybvig (1983) and analyse the relationships between the outcome of the game and depositors' financial literacy. In Diamond and Dybvig (1983) there is a fundamental coordination problem stemming from multiple equilibria. In one of these equilibria, all depositors withdraw according to their liquidity needs, the bank is solvent and the economy achieves a Pareto efficient allocation. In the other equilibrium, all depositors decide to prematurely withdraw supported by the belief that everyone else will do so, these behaviours induce a run on bank's deposits and yield an inefficient equilibrium outcome. Hence, we focus on the behaviour of groups of depositors, which constitute banks, and examine the equilibrium outcomes emerging from depositors' coordination.

[1] Rooij et al. (2011) and Christelis et al. (2010) report that individuals with greater numeracy and financial literacy are more likely to participate in financial markets.

[2] See, for example, Behrman et al. (2012) and Gustman et al. (2012) for an analysis on retirement and wealth accumulation; Rooij et al. (2011) and Christelis et al. (2010) for the effect on portfolio decisions and Lusardi and Mitchell (2014) for a survey on the importance of financial literacy in economic decisions.

[3] See the Health and Retirement Survey (2004) for the US, Lusardi and Mitchell (2011a) and Lusardi and Mitchell (2011b) among others.

[4] In the adverse economic conditions determined by 2007-2009 crisis, Guiso and Viviano (2015) and Klapper et al. (2013) document a positive effect of financial literacy on individual financial choices for the Italian and the Russian experiences, respectively.

[5] This concern emerges from an OECD survey distributed to 40 public institutions in 30 countries, including developed and developing ones, between late 2008 and early March 2009 (see OECD, 2009).

Within this experimental game à la Diamond and Dybvig (1983), we study whether the occurrence of a bank run is affected by group financial literacy. Given the welfare-enhancing effects of financial literacy on individual financial planning, this analysis tests whether it can also have a positive role in strategic interactions by mitigating the effect of strategic uncertainty. Specifically, we investigate whether banks formed by depositors with better financial skills coordinate less frequently on the inefficient equilibrium. Furthermore, we analyse whether giving to subjects information about the financial literacy of their group affects the outcome of the coordination game. Hence, we disentangle the role of financial literacy as an intrinsic characteristic of the group as opposed to its role as revealed information. To control for the qualitative content of the information received by the subjects, we replicate the analyses using information about group's general knowledge. Before playing the withdrawal game, we submit to each subject an incentivized multiple choice test containing questions on basic financial concepts and logical reasoning to elicit his financial literacy and general knowledge. The individual performances in the test are then aggregated to determine the group's characteristic in terms of the relevant variables. In our experiment, we also collect information about subjects' risk aversion by means of the Holt and Laury (2002) protocol. From the individual attitudes we then construct a measure of group risk aversion and test whether it is a relevant determinant of the probability of bank run. We study the same withdrawal game in groups of 5, 7 and 10 depositors controlling for the different information treatments,[6] to test whether and how bank size affects coordination.

To analyse the data of the experiment we first examine all the sessions in which subjects receive no information about the characteristics of the other depositors at their bank, controlling for frame effects due to the structure of the payoff table. This grouping (Grouping 1) allows to isolate the effects of group size from those of information revelation on the probability of a bank run. The analysis shows that larger groups more frequently coordinate on the inefficient equilibrium, that is increasing group dimension negatively affects coordination (*Result 1*). Similar results also emerge for other coordination games.[7] Furthermore, Result 1 reconciles the experimental evidences obtained in similar bank run settings, such as Garratt and Keister (2009) and Arifovic et al. (2013). In this no-information treatment, we find that group's financial literacy is irrelevant for the occurrence of a bank run (*Result 2*). That is, whether banks are formed by more or less financially literate depositors does not affect the coordination on bank run equilibrium. Hence, while financial literacy improves individual saving and investment decisions, it does not seem to be helpful for mitigating the effects of coordination failure.[8] Furthermore, we find that a more risk averse group of depositors has the same likelihood of experiencing a bank run than a less risk averse one, hence group's risk aversion does not affect the probability of bank run (*Result 3*). Determinants for the likelihood of a bank run in Grouping 1 are the experience that subjects mature throughout the repetitions of the game and the short run history, i.e. the information they get from the observed withdrawals of the previous interaction.

Subsequently, we examine the data of all the sessions with information treatments (Grouping

[6]For comparability purposes, the choice of the group sizes replicates those appearing in Garratt and Keister (2009) and Arifovic et al. (2013), who study a bank run game with 5- and 10-depositors banks, respectively.

[7]See Camerer (2009, Ch. 7) for a discussion of the role of group size in weak-link games.

[8]For this sample split, we find similar results when considering group's general knowledge.

2). In these treatments, before taking their decisions in the withdrawal game, subjects receive some summary statistics about the score of fellow depositors in financial and general questions, respectively. We analyse sessions in Grouping 2 by size and by type of information revealed. The size split allows to disentangle the impact of revealing information compared to the baseline in which subjects do not receive any information about their group, for banks of different dimensions. The information split captures possibly different behaviour in banks of different sizes due to the type of information revealed, financial vs general. Disclosing information about the group's financial literacy changes the results. Focusing on the size split, we find that providing information on financial literacy of the group has an opposite impact on bank run occurrence in 5-depositor relative to 10-depositor banks (*Result 4*). In particular, in small (large) groups it increases (decreases) the likelihood of bank run. In 7-depositor banks, providing information on financial literacy has no impact on bank run occurrence.[9] Additionally, for all sizes, group's risk aversion does not affect the probability of bank run, while experience and short run history increase it.

Focusing on the information split, we find that when financial information is disclosed the group average financial score is inversely related to the likelihood of a bank run (*Result 5*). That is, the probability of inefficient coordination reduces if depositors observe higher financial score in their group.[10] The intrinsic characteristic of the group, in terms of its average score in general knowledge, plays no role. When information on group general knowledge is disclosed, instead, neither the specific content of the information received nor the intrinsic financial competence are relevant to explain the coordination on bank run. Hence, subjects perceive general and financial information as qualitatively distinct. This interpretation is reinforced by the finding that the determinants of the bank run probability in the two information sub-samples are different. In particular, group's attitude toward risk plays no role in the financial information treatment, whereas it is very effective and augments the probability of run when subjects receive information about general knowledge (*Result 6*). Coordination on bank run equilibrium does not exhibit any substantial reaction to changes in bank's size when subjects are treated with financial information. On the contrary, it increases in large banks relative to small ones, when subjects are treated with general knowledge. Experience retains its importance while short run history has a weakly significant positive effect regardless the type of information provided.

The paper is organized as follows: Section 2 discussed the related literature, Section 3 presents the reference theoretical framework for the experiment, Section 4 illustrates the experimental design, Section 5 presents the econometric strategy and the results and Section 6 concludes.

2 Related Literature

Our paper contributes to the experimental analysis of bank runs in coordination games. This section briefly summarizes the main findings of the literature and highlights the issues mostly related to our analysis.

[9] In the same split, providing information on general knowledge reduces the probability of bank run in large banks, but it is less effective than its financial counterpart.

[10] We also tested for the heterogeneity of the group in terms of test scores, and it does not seem to matter.

There is robust evidence that runs emerge in experimental withdrawal games.[11] This finding is obtained under several specifications of the experimental protocols, featuring for example suspension of deposit convertibility (Madiès, 2006), the presence of (partial) deposit insurance (Madiès, 2006 and Schotter and Yorulmazer, 2009), or sequential withdrawals (Kiss et al., 2012, 2014).

In all these contributions, withdrawal decisions are frequent and subjects often coordinate on the inefficient equilibrium which corresponds to the bank run.[12] Among the contributions focused on identifying the determinants of bank run, Arifovic et al. (2013) investigate the relationship between the tightness of the coordination problem and bank runs. To do so they parameterize the withdrawal game to the threshold number of withdrawal choices that determines the switch in the best response of a depositor. This threshold determines the coordination parameter. By letting the coordination parameter vary, Arifovic et al. (2013) identify three regions in which the experimental economies stay close or converge to run, no-run equilibria, or deliver indeterminate predictions, respectively. They find that when the coordination parameter is tight, so that few withdrawals are sufficient to make withdrawal the preferred choice of a depositor, bank runs increase.

Our experiment is closely related to Arifovic et al. (2013), in that the withdrawal game is parameterized to a fixed value of the coordination parameter that would induce an indeterminate outcome in their game. This choice is motivated by our interest in studying the contribution of financial literacy to solve the indeterminacy problem due to multiple equilibria. For their analysis Arifovic et al. (2013) concentrate on large banks formed by a group of 10 depositors, which corresponds to the largest bank size that we consider.

Along the bank size dimension our design also encompasses that of Garratt and Keister (2009), in which banks are constituted by 5 depositors, the smallest size we consider. In their withdrawal game, the coordination problem is not too tight (withdraw is a best response when at least four out of five depositors choose it) and depositors' payoffs are stable.[13] In their baseline treatment no run occurs, hence they study whether multiple withdrawal opportunities and uncertainty about aggregate liquidity needs promote runs. Relative to their specification, we impose a tighter coordination requirement and higher variability in the payoffs associated to the no-withdrawal decision which makes strategic uncertainty more pronounced.

Our research is also related to literature dealing with information revelation in strategic settings. In decentralised systems, in which participants directly communicate with each others, early studies have investigated the possibility to rely on pre-play communication (see Cooper et al., 1990, and Cooper et al., 1994), more recently Chaudhuri et al. (2009) have extended this approach to overlapping generation settings. In centralised systems, on the other hand, subjects cannot exchange messages among themselves and, to deal with the indeterminacy due to multiple equilibria, communication has been introduced in different ways. For instance, in Van Huyck et al. (1992) and Brandts and Macleod (1995) the experimenter directly provides to participants recommendations

[11] For a detailed review of existing studies, we refer the reader to Dufwenberg (2016) and Duffy (2016).

[12] One way to eliminate the possibility of coordination failures is to modify the game according to the global game approach proposed by Carlsson and van Damme (1993). Goldstein and Pauzner (2005) apply this technique to the bank run setting and Klos and Sträter (2013) experimentally test its theoretical predictions, providing only limited support to its effectiveness in laboratory.

[13] Specifically, individual payoff depends on fellow depositors' choices only after the threshold number of withdrawals is reached.

on the actions to play, that is on a payoff-relevant variable. Whereas, following the theoretical approach initially proposed by Azariadis (1981) and Cass and Shell (1983) on sunspot equilibria, Arifovic and Jiang (2014) test whether a public announcement on a randomly generated forecast of withdrawals fosters coordination, investigating the impact of payoff irrelevant information on coordination. A common finding to previous studies is that, in general, communication enhances coordination on the efficient equilibrium (see Devetag and Ortmann, 2007). We design a centralised communication system that reveals to each subject information about fellow partners' characteristics in terms of financial literacy or general knowledge. Our set up differs from the aforementioned ones since this information is privately communicated to each participant. The aim is to test whether having information about the group's characteristics affects the outcome of the coordination game. In our design there are no linkages among banks, hence we do not investigate financial contagion.[14]

3 Theoretical Framework

Our theoretical reference is the Diamond and Dybvig (1983) approach to bank runs in which financial intermediaries provide essential liquidity services to consumers but are fragile with respect to runs on bank's deposits. They set up a three-period economy in which consumers are uncertain about their preferences over future consumption. At $t = 0$, each consumer has to decide on a portfolio allocation of her endowment. At $t = 1$, every consumer receives a private signal about her liquidity need (type). To transfer resources across time, agents can rely on a long-term productive technology which can be prematurely liquidated in $t = 1$ at a cost. Depositors can withdraw their money in $t = 1$ or $t = 2$. As long as individual liquidity shocks are not perfectly correlated, an intermediary collecting all available resources in the economy can guarantee to consumers a consumption profile that dominates the autarkic one. To provide these liquidity services, the intermediary uses demand deposit contracts which allow consumers to withdraw their money at any time.

When taking their withdrawal decisions depositors interact in a coordination game that features multiple equilibria, one of which corresponds to a run on bank deposits. The run equilibrium arises when depositors believe that a large number of withdrawals will occur: in this case, it is optimal to withdraw since there will be no resources left in the second period. The coordination issue triggering a bank run can be fully generated considering only consumers who would prefer to withdraw at $t = 2$. Therefore, in our experiment we do not introduce heterogeneity on preferences among subjects.

As a reference for the experiment, we consider a bank constituted by N depositors, each endowed with a unitary deposit account. The bank invests its resources (N) in an asset that guarantees a high return, $R > 1$, if liquidated at maturity ($t = 2$) and a liquidation value, $L < 1$, if prematurely liquidated at $t = 1$. Early liquidation also requires to pay a fixed liquidation cost $k > 0$. In $t = 1$ every depositor decides whether to withdraw or not. The bank promises to pay r_1 to depositors who withdraw, and r_2 in $t = 2$ to those who do not withdraw.

At $t = 1$ the bank receives the withdrawal requests and it has to (prematurely) liquidate its assets to comply with them. The residual resources are equally shared in $t = 2$ among those depositors who chose not to withdraw at $t = 1$. In the experiment the bank can fulfil the promise to repay r_2

[14]For an analysis of contagion, see Corbae and Duffy (2008), Chakravarty et al. (2014) and Brown et al. (2016).

only if all depositors do not withdraw. If the number of withdrawal requests is too high r_1 may not be guaranteed, either. In the withdrawal game played at $t = 1$, a bank run equilibrium is the situation in which all depositors at a bank choose to withdraw.

The structure of the payoff matrix guarantees that the best response of any depositor has a unique switch determined by a threshold number of withdrawals. In particular, if the number of withdrawals at a bank is sufficiently low, the best response for any depositor consists of choosing not to withdraw. The threshold number of withdrawals corresponds to the coordination parameter in Arifovic et al. (2013), and measures the coordination requirement imposed on depositors. It is given by the fraction of non-withdrawing depositors which makes a depositor indifferent between the two alternatives. In particular, let N be the total deposits at a bank, we derive the coordination parameter using r_1, R and $k > 0$. Under our repayment rule, a depositor who does not withdraw receives:

$$c_2 = \begin{cases} R\dfrac{N - r_1\,(N - w)}{w} - k & \text{if} \quad 0 \leq w < N \\ R & \text{if} \quad w = N \end{cases} \tag{1}$$

in which w is the number of depositors who choose not to withdraw. That is, if none withdraws each depositor gets R, otherwise she gets a fraction w of the return R matured on the residual assets of the bank after having repaid those who withdraw, $N - r_1\,(N - w)$. Denote with w^* the number of non-withdrawing depositors that makes a depositor indifferent between withdrawing or not. By definition, it solves the following equation:

$$r_1 = R\frac{N - r_1\,(N - w^*)}{w^*} - k \Leftrightarrow w^* = \frac{N\,R(r_1 - 1)}{r_1(R - 1) - k} \tag{2}$$

The coordination parameter $\hat{w}^*$ is given by the ratio w^*/N.

Eventually, in all sessions we rely on the same coordination parameter $\hat{w}^*$, promised repayment r_1, liquidation cost k and investment return R. Specifically, we assume $\hat{w}^* = 0.65$, $r_1 = 122$, $R = 150$ and $k = 10$.

4 Design of the Experiment

Let us now illustrate the details of the experimental design.[15] The experiment is organized in sessions. Each session is independent and consists of three phases (Phase 1, Phase 2 and Phase 3) in which participants perform incentivized tasks. Feedback information is provided at the end of each task, while actual payments are determined at the end of the experiment. The experimental currency is denominated in Zed, which is converted in Euro at a predetermined and known exchange rate.[16]

Phase 1. The experiment starts with a multiple choice questionnaire aimed at eliciting subjects' financial literacy and general knowledge. Overall, the questionnaire contains thirteen questions with one correct answer and three wrong answers. To avoid demand effects, no explicit reference is made to financial literacy or general knowledge questions: those in the first group are referred to as even

[15] The Instructions are provided in Appendix B.

[16] The denomination of the currency is borrowed from OECD (2014).

questions and those in the latter as odd questions, consistently with the numbering used.[17]

Participants must answer each question in 90 seconds and obtain +1 point for correct choices and −0.5 point for wrong choices. If time expires, the question is recorded as unanswered with no reward nor penalization.[18]

To incentivize participants in this phase, the total score from the questionnaire is converted into the probability P of winning the high prize in a binary lottery whose prizes are 150 Zed and 50 Zed. P increases with the score and ranges from 5% if a participant obtains the minimum score (−6.5 points), to 95% if a participant obtains the maximum score (13 points). To avoid wealth effects that may distort participants' behavior in subsequent phases we use a binary lottery and leave some randomness even in case of best and worst scores in the questionnarie.

At the end of Phase 1, participants receive information on own total score, as well as on the partial scores for financial literacy and general knowledge questions. Eventually, they are asked to evaluate which of the following categories best fits the content of even and odd questions: Problem Solving, General Knowledge, Financial Education, Graphical Representation.

The random draw for the binary lottery associated to the first phase is postponed at the end of the experiment.

Phase 2. In this phase, participants interact within groups for a predetermined number of rounds. Repeated-game effects are accounted for by adopting a stranger protocol, although the design of the protocol does not exclude that two or more subjects are assigned to the same bank in different rounds. Groups are equally sized and, depending on the session, they are formed by 5, 7 or 10 participants. The interaction is repeated to yield a total of 20 rounds in sessions with small- and medium-size groups and of 25 rounds in sessions with large-size groups.

In each round, group members — referred to as depositors of an experimental bank — are assigned a deposit worth 100 Zed. Each depositor must decide in 30 seconds to withdraw or to leave the money deposited.[19]

Participants' payoff depends on own withdrawal decision as well as on the withdrawal decisions of all other depositors in the same bank, as described by Table 1 for a small bank.[20] Individual payoff amounts to 150 Zed if no one withdraws and to 98 Zed if everyone withdraws.[21] Furthermore, the payoff obtained by not withdrawing decreases as other participants' withdrawals increase.

At the end of each round, participants receive feedback information on own payoff and number of withdrawals in their bank. At the end of the experiment, one round is randomly selected for payment.

Phase 3. As a final step in the experiment, participants face an individual task to elicit risk

[17]Three of the financial literacy questions refer to the topics of inflation, shares and interest compounding and are adapted from the Basic and Advanced Literacy Questions in Rooij et al. (2011). One question on pricing of an asset is adapted from PISA 2012 Financial Literacy Questions and Answers, proposed by OECD (2012a). Two questions relate to portfolio decisions and to the inter-temporal budget constraint and are proposed in an original formulation. The seven general knowledge questions are adapted from the PISA released items on mathematics, problem solving and field trial cognitive abilities (see OECD, 2012c, OECD, 2012b and OECD, 2015).

[18]A sliding bar on the screen shows the remaining time.

[19]A sliding bar on the screen shows the remaining time.

[20]The corresponding payoff tables for medium and large banks share the same features, see Appendix A.

[21]Observe that these two outcomes correspond to the two pure-strategy equilibria of the withdrawal game.

Table 1: Payoff table for 5-depositor banks

	Payoff if you withdraw ○	Payoff if you do not withdraw ●
○ ○ ○ ○	98	7
● ○ ○ ○	122	90
● ● ○ ○	122	117
● ● ● ○	122	132
● ● ● ●	122	150

aversion according to the Holt and Laury (2002) protocol. Prizes for the safe lottery are 200 Zed and 160 Zed, while prizes for risky lottery are 385 Zed and 10 Zed so that the magnitudes are comparable with payoffs in the withdrawal game. The random draw that determines the prize from the selected lottery is postponed at the end of the experiment.

Payment for the experiment. The final payment for each subject is the sum of (*i*) the randomly selected prize of the (individual) binary lottery associated to Phase 1, (*ii*) the individual payoff of the commonly drawn round of Phase 2 and (*iii*) the randomly selected prize of the binary lottery from the Holt and Laury (2002) protocol in Phase 3. The random draw associated to the binary lotteries for Phase 1 and 3 is performed by the computer. The payment round from Phase 2 and the lottery pair from Phase 3 are randomly selected using a public device (bingo numbers).

4.1 Treatments

During the experiment, we perform treatments related to information revelation and to framing effects. Relative to the baseline interaction described above, we test the impact of unannounced information disclosure occurring before the withdrawal decision in Phase 2. We differentiate the information treatments devoting some sessions to the revelation of information on financial literacy and others to general knowledge, at group level. We are interested in comparing the impact of information revelation relative to the baseline and in verifying whether the type of information revealed makes any difference for subjects' behavior.

In the Financial Information treatment (FI), each participant privately receives the minimum, the maximum and the average score in the financial literacy questions obtained by depositors of the same bank. In the General Information treatment (GI), the same statistics on the group's score in the general knowledge questions are communicated to participants. To control for the effects of information disclosure, in the no-information treatment (NO) participants do not receive any information on the score obtained by fellow depositors in the questionnaire. Each information treatment is replicated for every group size, whence a total of nine sessions.

To control for the possibility of framing effects due to the specification of the payoff matrix of the withdrawal game, we construct an alternative payoff matrix in which the rows are turned upside-down.[22] Then, we test such specification for every group size. This gives us an additional no-information treatment with reversed table labelled NO_R which includes three sessions.

The overall 264 subjects in our experiment have been recruited with the Orsee (Greiner, 2004)

[22]A sample of the payoff matrices used for this treatment is provided in the Appendix A (Table 12).

platform. Table 2 summarizes all relevant information about the organization of the experiment. The experiment, fully computerized with z-Tree Fischbacher (2007) software, was conducted in the CESARE laboratory for experimental economics at Luiss Guido Carli (Rome, Italy) between November 2015 and March 2016. Among the participants, 47.73% were female, 65.91% from Economics, 21.59% from Law and 11.74% from Political Science. The average payment to each subject has been of 23 Euros.

Table 2: Sessions' overview

Session	Treatments	Bank size (# depositors)	Number of students	Rounds	Number of banks per round	Number of banks per session
1	NO_R	5	25	20	5	100
2	NO_R	7	21	20	3	60
3	NO_R	10	20	25	2	50
4	NO	5	25	20	5	100
5	NO	7	21	20	3	60
6	NO	10	20	25	2	50
7	FI	5	25	20	5	100
8	FI	7	21	20	3	60
9	FI	10	20	25	2	50
10	GI	5	25	20	5	100
11	GI	7	21	20	3	60
12	GI	10	20	25	2	50

5 Results

We discuss our results considering first all data relative to the no-information treatments (NO and NO_R) to assess the impact of group size on the coordination game, controlling for possible frame effects. Subsequently, we examine the data relative to the information treatments (NO, FI, GI) so to evaluate the role of information revelation as a determinant of the probability of bank run. Therefore, sessions 1–6 constitute Grouping 1 and sessions 4–12 constitute Grouping 2.

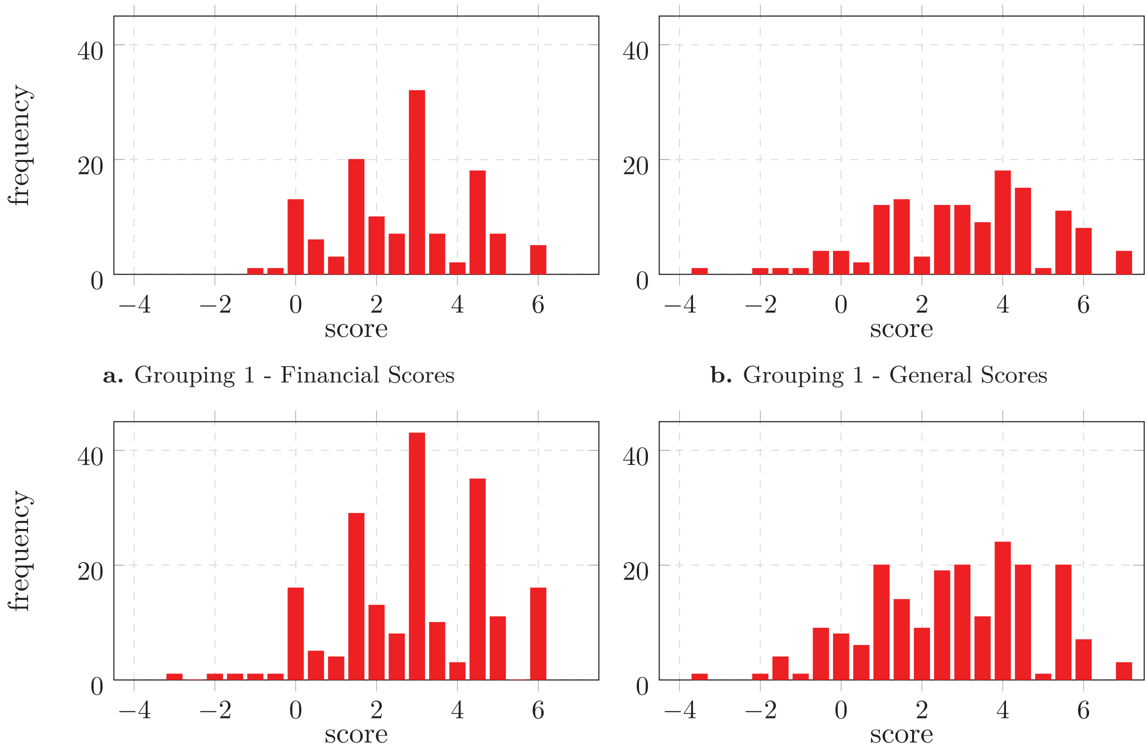
5.1 Descriptive statistics of the experimental data

We here provide the distribution of individual scores on financial literacy and general knowledge, and the distribution of individual attitude toward risk for both Groupings.[23] These statistics summarize subjects' characteristics that will be used in the econometric analysis.

Figure 1 reports the frequencies of these individual scores. Given the scoring rule and the number of questions in Phase 1, the score on financial literacy ranges between -3 and 6, and the score on general knowledge between -3.5 and 7. In Grouping 1 the minimum in financial questions is fairly distant from its lower bound and the distribution appears to be concentrated on positive values, with a single mode occurring at the score of 3. The scores in the general questions are concentrated on positive values too, however the distribution is more dispersed. We observe the same patterns for Grouping 2. Despite these similarities, the correlation between individual scores in the two groups

[23] Figure 6 in Appendix A displays the frequencies of individual total score of participants relative to Grouping 1 and Grouping 2.

Figure 1: Distribution of individual scores



a. Grouping 1 - Financial Scores

b. Grouping 1 - General Scores

c. Grouping 2 - Financial Scores

d. Grouping 2 - General Scores

of questions is very low (0.27), hence the information provided to subjects in FI and GI treatments refers to different abilities. Overall, the questionnaire is well suited to capture the financial literacy and general knowledge of the participants and reveals that subjects are more heterogeneous in terms of general than of financial knowledge.

Another key characteristic is subjects' attitude towards risk. Figure 2 shows the distribution of the individual safe choices elicited through the Holt and Laury (2002) protocol for Groupings 1 and 2, respectively. Relative to the theoretically predicted choices of a risk neutral agent represented by the dashed line, the percentage of safe choices remains steadily higher after the fifth decision, hence these subjects can be classified as risk averse. We are interested in investigating the role of these characteristics as determinants of the probability of bank run. In the econometric analysis, individual values will be aggregated at group level.

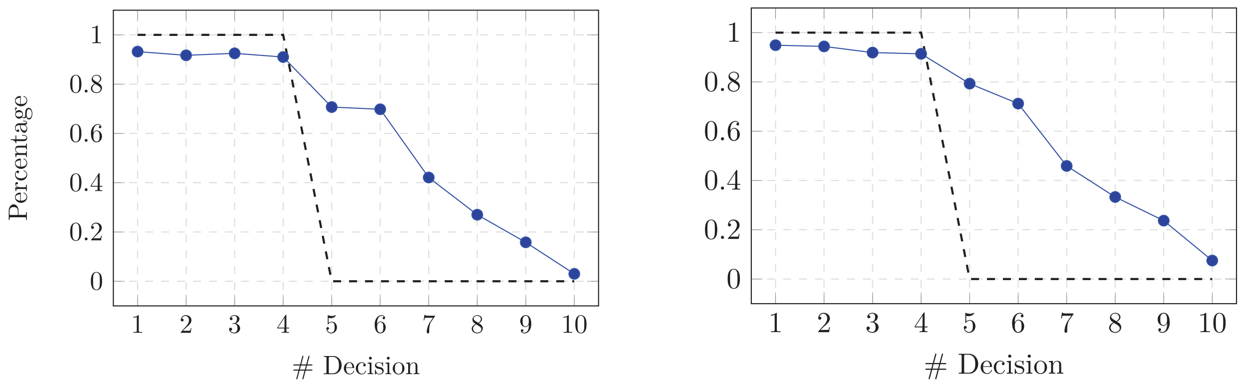
5.2 Econometric Strategy

The econometric strategy is based on the estimation of a pooled probit model of the form $pr(Y = 1 \mid X) = \Phi(X'\beta)$ in which Y is a binary variable that takes value 1 if a run occurs in a bank and 0 otherwise, X is a set of regressors constructed at group level and $\Phi(\cdot)$ is the standard normal *cdf*.[24] Hence, our dependent variable is the probability that a run occurs in a bank.[25]

[24] Since we implement a stranger protocol for bank formation, the banks are not composed by the same participants along all the rounds of each session, hence we cannot exploit a discrete choice panel data analysis.

[25] Recall that a run is the event in which all the depositors of a bank simultaneously decide to withdraw.

Figure 2: Percentage of individual safe choices in each decision



a. Grouping 1 **b.** Grouping 2

Note: The dashed line depicts the theoretical choices of a risk-neutral agent.

In the stranger protocol we implement, it is possible that some subjects are included in the same bank in different rounds of a session and this may create correlation across rounds. We expect this feature to be more pronounced for large banks, since in this case reshuffling occurs between the only two banks formed in the laboratory. To cope with this issue, we cluster standard errors at bank level.[26]

Furthermore, given the repetition of plays and the feedback information provided, there can be correlation between outcomes relative to different banks within a given round. To take it into account, we introduce among the regressors dummy variables that correspond to the ranges of rounds which reflect qualitative differences in the collected data.

Table 3: List of variables

round1_8	Dummy (= 1 if rounds 1 to 8 are considered)
round9_16	Dummy (= 1 if rounds 9 to 16 are considered)
round17_25	Dummy (= 1 if rounds 17 to 25 are considered)
NO	Dummy (= 1 for treatment NO)
FI	Dummy (= 1 for treatment FI)
GI	Dummy (= 1 for treatment GI)
n_5	Dummy (= 1 for 5-depositor bank)
n_7	Dummy (= 1 for 7-depositor bank)
n_10	Dummy (= 1 for 10-depositor bank)
rev_table	Dummy (= 1 for treatment NO_R)
L1with	One-period lagged mean withdrawal rate (in percentage)
HLG	Mean safe (A-)choices in the risk aversion elicitation (Phase 3)
avgScoreF	Mean score in the financial literacy questions (Phase 1)
avgScoreG	Mean score in the general knowledge questions (Phase 1)

Note: All measured variables are at a bank level.

[26]Specifically, in every session the number of clusters coincides with the number of banks formed in each round.

The regressors used in the probit model (Table 3) include three sets of dummy variables: those relative to the relevant ranges of rounds in Phase 2 (round1_8, round9_16 and round17_25); those relative to the information and table treatments (NO, FI, GI and rev_table) and those relative to bank sizes (n_5, n_7, n_10).[27]

Furthermore, there is a set of variables which are constructed aggregating at bank level the individual data collected during the experiment, for consistency with the dependent variable. These are: the average withdrawal rate observed in the previous round (L1with); the average of safe choices in the Holt and Laury (2002) protocol (HLG); the average score in the financial (avgScoreF) and in the general (avgScoreG) questions. All such averages are computed using the data relative to each depositor in a given bank at a given round.

In our interpretation, L1with captures the effect of short-run history on subject's choices;[28] HLG accounts for group attitude towards risk;[29] finally, avgScoreF and avgScoreG summarize the group knowledge in financial and general matters. These average scores constitute an intrinsic characteristic of the group and, depending on the treatments, also part of the information directly revealed to depositors. In the regression analyses we account for these differences.

5.3 Econometric Analysis for Grouping 1

In this section, we present the main results for Grouping 1, which merges the two no-information specifications, NO and NO_R, for every group size.[30]

Table 4 contains two-sample t-tests on the difference in average bank runs for every bank size in the two treatments.[31] It shows that, essentially, there is no framing effect for 5- and 7-depositor banks since the average bank runs are not significantly different in the two treatments, while for 10-depositor banks the difference is significant (in the NO_R treatment there are 20% less bank runs on average). Subjects in large groups appear to be sensitive to the visualization of payoffs. In the econometric analysis we further investigate whether and how this affects the probability of bank run for large groups.

Figure 3 displays the run rate in each session of Grouping 1 distinguished by bank size and table treatment.[32] A common feature is that runs start to appear in some intermediate rounds and persist until final rounds in each session, while they are absent in the initial repetitions. At a closer look, the figure reveals that the run rate increases with bank's size for both treatments: while very few runs occur in small banks, there is a higher frequency in medium and in large banks. Relative to the conclusions of the t-tests, Figure 3 also shows that for large groups, the NO_R treatment reduces the occurrence of bank run mainly in intermediate rounds.

[27] To avoid multicollinearity, in all the regressions we drop one dummy from each of the listed groups.

[28] We checked for longer time spans and found no significant effect of more remote decisions.

[29] In experimental analyses of group interactions, a similar approach in constructing a measure of risk attitude at group level appears in Lamiraud and Vranceanu (2015).

[30] Table 13 in Appendix A reports standard summary statistics for the regressors of Grouping 1.

[31] Values in each cell of Table 4 represent the difference of average bank runs between NO_R and NO. A non-parametric Mann-Whitney U test confirms the t-test results.

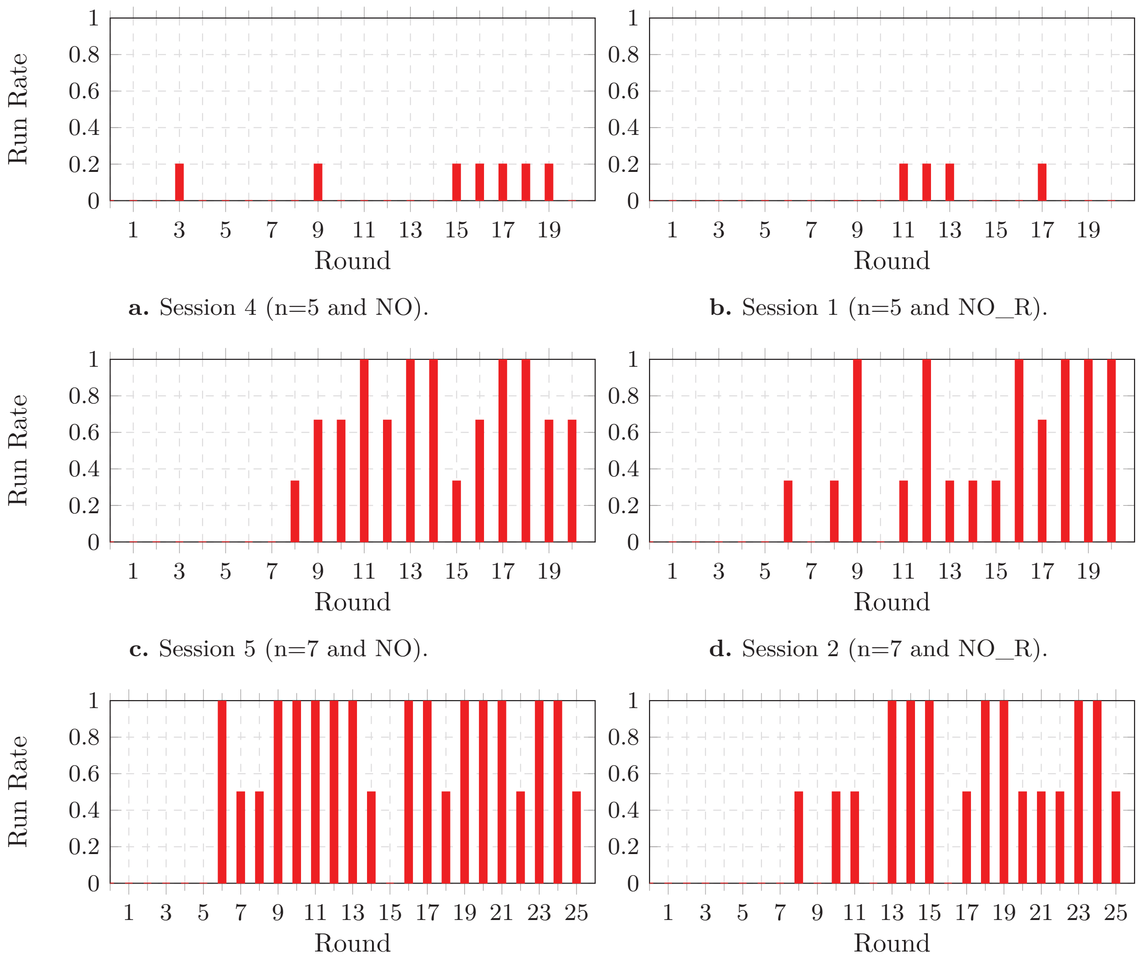
[32] Recall that the number of banks varies with the bank size, due to the fixed capacity of the laboratory. Therefore, a run rate equal to 1 corresponds to five banks in the sessions with 5-depositor banks, to three banks in the sessions with 7-depositor banks and to two banks in the sessions with 10-depositor banks.

Table 4: Two-sample t-tests in Grouping 1

		NO 5	NO 7	NO 10
NO_R	5	-0.03 (0.355)	-	-
	7	-	-0.05 (0.586)	-
	10	-	-	-0.200** (0.045)

Note: P-values are in parentheses.

Figure 3: Run rate in Grouping 1



a. Session 4 (n=5 and NO). **b.** Session 1 (n=5 and NO_R).

c. Session 5 (n=7 and NO). **d.** Session 2 (n=7 and NO_R).

e. Session 6 (n=10 and NO). **f.** Session 3 (n=10 and NO_R).

Note: By rows, data display bank size, $n = 5, 7, 10$. By column, NO and NO_R treatments.

For a proper evaluation of these preliminary observations and to assess the role of the explanatory variables we present the econometric results in Table 5 and Table 6.

Table 5 reports the marginal effects in the probit analysis for all sessions in Grouping 1.[33]

[33]The marginal effects are evaluated at the level of the sample means. We also performed a receiver-operating characteristics (ROC) analysis. For all specifications the area under the ROC curve (AUC) is above 0.78, confirming a

Table 5: Marginal effects for bank runs in Grouping 1

VARIABLES	Grouping 1
round9_16	0.231***
	(0.072)
round17_25	0.287***
	(0.085)
L1with	0.007***
	(0.002)
n_7	0.228***
	(0.077)
n_10	0.229***
	(0.085)
rev_table	-0.057
	(0.042)
avgScoreF	0.003
	(0.038)
avgScoreG	-0.009
	(0.037)
HLG	0.001
	(0.033)
Observations	400

Cluster-robust standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

The econometric analysis confirms that the probability of a bank run significantly increases in intermediate and final rounds relative to the initial ones, what suggests a relevant experience effect. Furthermore, the coefficients of the size dummies are positive and highly significant, supporting that as group size gets larger the probability of bank run increases. Recall that in the withdrawal game the bank run equilibrium is the inefficient one, and such that depositors do not fully recover their initial deposit.

Result 1. When subjects receive no information, larger groups more frequently coordinate on the inefficient equilibrium.

Result 1 is based on a systematic analysis of bank's size on the occurrence of a run, which makes it comparable across groups and reconciles the evidences provided by Garratt and Keister (2009) for small groups and by Arifovic et al. (2013) for large ones.

Table 5 also reveals a highly significant positive effect of one period lagged observed withdrawals. Despite the stranger protocol, short-run history is a relevant determinant of bank run occurrence. The table treatment, instead, is irrelevant for the probability of bank run: since the coefficient of the dummy rev_table is not significant, there is no evidence of a frame effect.

The analysis of the remaining coefficients is of particular interest from our perspective. Group

good performance of the estimates. As a robustness check, for all econometric specifications relative to both groupings, we also estimated a pooled logit, and the results are coherent with those of the probit. All the results of logit regressions and ROC analysis are available from the authors upon request.

characteristics in terms of financial literacy and general knowledge (avgScoreF and avgScoreG) are not statistically significant. Since in Grouping 1 these characteristics are not revealed to participants, in the regression they represent intrinsic features of the group with respect to such issues. According to our findings, a bank composed by more financially literate depositors has the same probability to generate a run of a bank composed by less literate ones.

Result 2. When subjects receive no information, the levels of financial literacy and of general knowledge do not affect the coordination on the inefficient equilibrium.

Table 6: Marginal effects for bank run in Grouping 1 (size split)

VARIABLES	n=5	n=7	n=10
round9_16	0.039	0.697***	0.128
	(0.036)	(0.182)	(0.289)
round17_25	0.029	0.991***	0.223
	(0.046)	(0.245)	(0.217)
L1with	0.00244*	0.00155	0.0215***
	(0.139)	(0.527)	(0.791)
rev_table	0.018	0.050	-0.246
	(0.037)	(0.098)	(0.238)
avgScoreF	-0.011	-0.031	-0.124
	(0.014)	(0.084)	(0.258)
avgScoreG	-0.001	0.091	-0.031
	(0.016)	(0.130)	(0.098)
HLG	0.001	-0.075	0.048
	(0.010)	(0.092)	(0.215)
Observations	190	114	96

Cluster-robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Furthermore, group attitude toward risk is not significant for bank run probability. This seems counter-intuitive since in our design there are two opposite forces that influence participants' decisions. On one side, the individual payoff associated to the choice of withdrawal is less volatile with respect to the choices of the other depositors relative to the no-withdrawal payoff, hence withdrawing is a relatively safer option. On the other side, the decision not to withdraw guarantees a higher individual payoff if selected by sufficiently many depositors, exposing subjects to higher strategic uncertainty. Therefore, one could expect that a more risk averse group would be more likely to coordinate on withdrawing and to generate a run. The data do not confirm this intuition. We further investigate the significance of HLG by performing the same econometric analysis for the three bank sizes within Grouping 1 and we find no difference as Table 6 shows.

Result 3. When subjects receive no information, group attitude towards risk does not affect the probability of bank run irrespective of the bank size.

In Table 6 we report the marginal effects in the probit analysis for the size splits of Grouping 1, which confirm Result 2 and the absence of any frame effect for each size split. Finally, the analysis by bank size also highlights an interesting difference between small and large banks, on one side, and medium ones, on the other side. For 5- and 10-depositor banks the main determinant of the bank run probability is the short run history (L1with), while for 7-depositor banks the repetition of the withdrawal game is the driving force for bank run occurrence.

5.4 Econometric analysis of Grouping 2

To investigate whether and how the likelihood of a bank run is affected by different information treatments, we now consider the sessions included in Grouping 2. We first examine the effect of information disclosure on banks of different sizes, taking the no-information treatment NO as a benchmark.[34] Table 7 contains two-sample t-tests on the mean of realized bank runs for pairs of information treatments, for every group size. It shows that there is a significant difference in realized bank runs on average for all information treatments, with the exception of NO and FI for 7-depositor banks.

Table 7: Two-sample t-tests (for 5, 7, 10-depositor banks) in Grouping 2

	NO	FI	GI
NO	-	-0.24***	-0.18***
		(0.000)	(0.000)
FI		-	0.06**
			(0.035)
GI			-

a. 5-depositor banks

	NO	FI	GI
NO	-	0.03	0.15***
		(0.333)	(0.000)
FI		-	0.12***
			(0.001)
GI			-

b. 7-depositor banks

	No	FI	GI
NO	-	0.34***	0.16***
		(0.000)	(0.000)
FI		-	-0.18***
			(0.000)
GI			-

c. 10-depositor banks

Note: P-values are in parentheses.

Figure 4 and Figure 5 report the fraction of banks experiencing a run comparing FI and GI with NO treatment, respectively. They illustrate for every bank size the impact of revealing information on group financial literacy, respectively general knowledge, relative to the no-information treatment. As in Grouping 1, there is a common pattern of bank runs in all treatments with few or no runs in the first rounds, a marked increase in intermediate rounds that persists up to the final ones.[35]

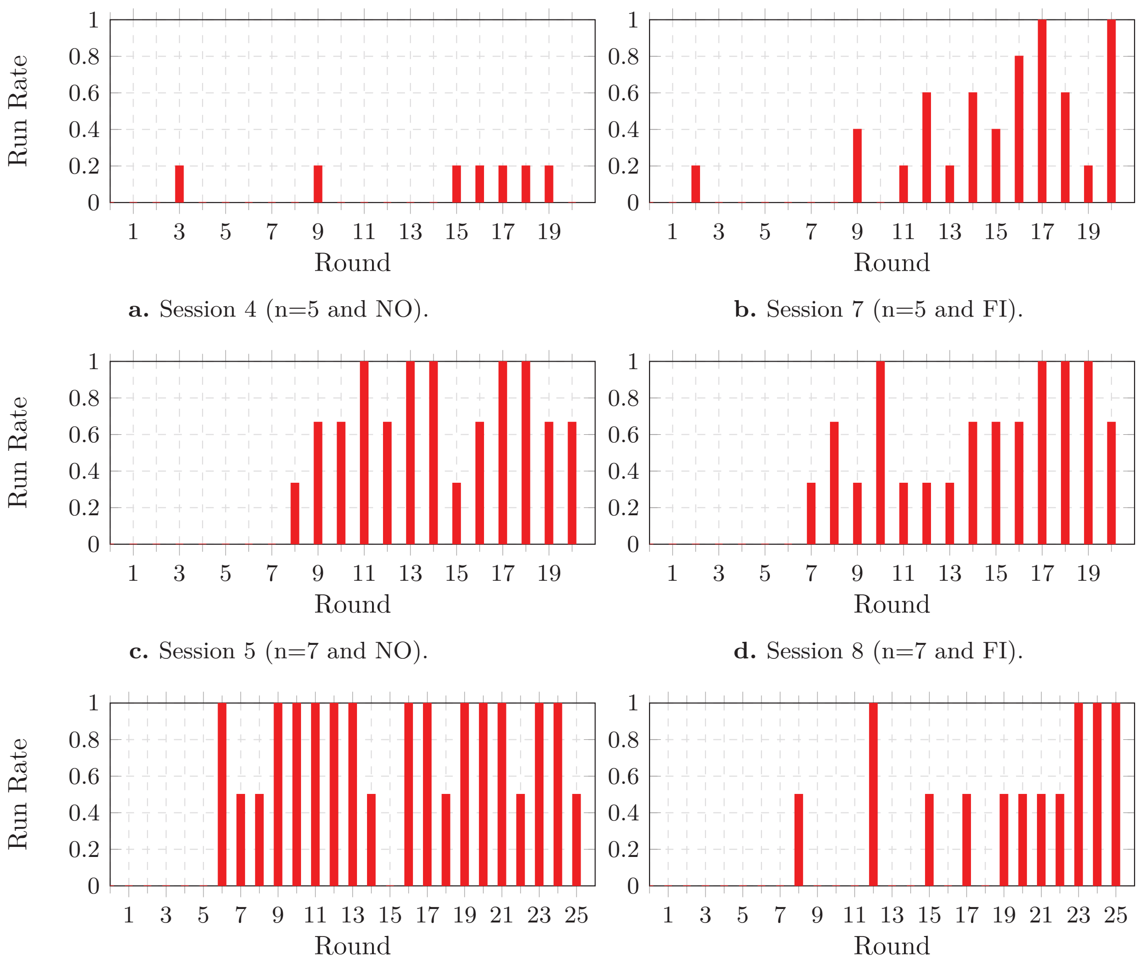
Consider the FI treatment: communicating information on financial literacy has a different impact on subjects' behavior depending on group size, see Figure 4. In particular, depositors of small banks coordinate more easily on the bank run equilibrium, which appears at earlier rounds and with a higher frequency relative to the NO treatment. Conversely, in large groups financial information markedly reduces the occurrence of bank runs throughout the rounds.

For groups of intermediate size, the financial information treatment has no clear effect on coordination and runs occur on average at a similar rate in the two treatments.

[34] We include in Grouping 2 only the no-information sessions in which subjects are given the same payoff matrices of the corresponding information treatments. This allows a straightforward comparison between treatments.

[35] Hence, we include in the econometric analyses for Grouping 2 the same round dummies used for Grouping 1.

Figure 4: Run Rate in Groupings 2 (NO and FI treatments)



a. Session 4 (n=5 and NO). **b.** Session 7 (n=5 and FI).

c. Session 5 (n=7 and NO). **d.** Session 8 (n=7 and FI).

e. Session 6 (n=10 and NO). **f.** Session 9 (n=10 and FI).

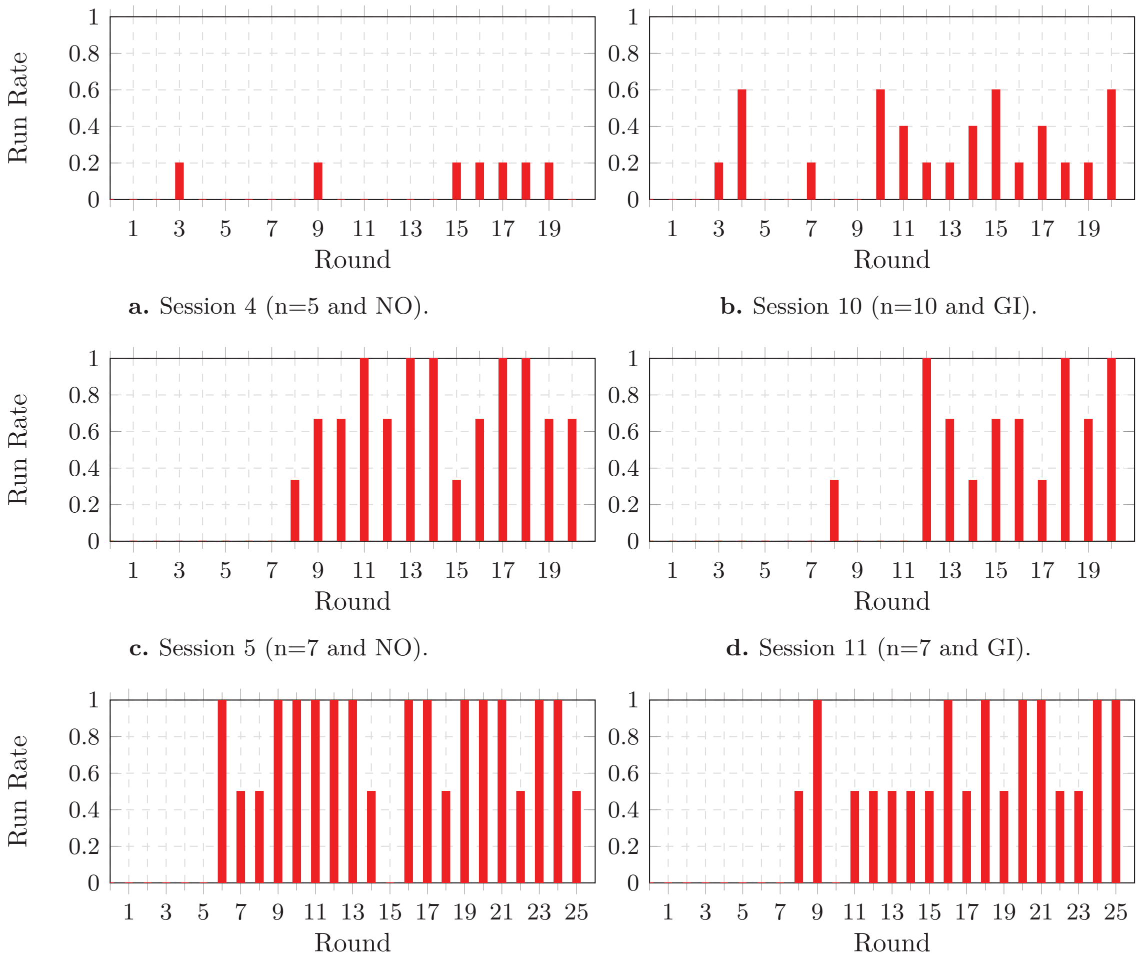
Note: By rows, data display bank size, $n = 5, 7, 10$. By column, NO and FI treatments.

When examining the GI treatment, Figure 5 shows that bank runs increase for small banks, however the pattern looks quite different from the FI one. Runs appear in intermediate rounds and always remain below the threshold of 60%, while they exponentially increase over rounds in FI. For large banks, the GI treatment reduces runs relative to NO, but at a substantially lower rate with respect to FI, in particular in intermediate periods.

To test these observations, we perform a complete econometric analysis of the likelihood of bank runs in Grouping 2 by estimating a pooled probit model with cluster-robust standard errors.[36] We start by examining the impact of information treatments on banks' of the same size, using as explanatory variables round (round9_16, round17_25) and treatments' (FI, GI) dummies, the lagged average withdrawal rate (L1with) and the average measure of group's attitude towards risk (HLG). In these specifications we exclude avgScoreF and avgScoreG to avoid confounding the effects of revealed information with those of intrinsic group characteristics, which may occur since each sub-sample contains all types of information treatments. The results are summarized in Table 8.

[36] Table 14 in Appendix A reports standard summary statistics for the explanatory variables of the regression

Figure 5: Run Rate in Groupings 2 (NO and GI treatments)



a. Session 4 (n=5 and NO).

b. Session 10 (n=10 and GI).

c. Session 5 (n=7 and NO).

d. Session 11 (n=7 and GI).

e. Session 6 (n=10 and NO).

f. Session 12 (n=10 and GI).

Note: By rows, data display bank size, $n = 5, 7, 10$. By column, NO and GI treatments.

Regardless of the bank size, groups with higher average past withdrawal rates exhibit higher probability of runs, i.e. short-run history matters. The probability of bank runs positively reacts to the repetition of the withdrawal game, as captured by the round dummies. This experience effect is stronger and increasing across rounds in small and medium banks relative to large ones. Similarly to what we found for Grouping 1, group's attitude towards risk is not relevant for the occurrence of run regardless of the bank's size.

Let us now focus on the impact of the information treatments in banks of different dimension. The econometric analysis confirms that revealing financial information to subjects in small (large) groups increases (decreases) the likelihood of bank run. On the other hand, treatment GI has a significant and negative effect on the probability of a run only in large groups. However, the relative magnitude of the coefficients reveals that GI has a smaller impact than FI on bank run's reduction. That is, information revelation reduces inefficient coordination in large groups and information of financial knowledge is more effective in lowering the probability of a run. For medium banks, the

analysis for Grouping 2.

Table 8: Marginal effects for bank runs in Grouping 2 (size split)

VARIABLES	n= 5	n= 7	n = 10
round9_16	0.135*	0.308**	0.227
	(0.069)	(0.142)	(0.216)
round17_25	0.200**	0.526***	0.434*
	(0.079)	(0.137)	(0.228)
L1with	0.0048***	0.013***	0.0141***
	(0.162)	(0.403)	(0.539)
FI	0.137**	0.065	-0.323***
	(0.069)	(0.097)	(0.046)
GI	0.102	-0.121	-0.139**
	(0.064)	(0.088)	(0.054)
HLG	0.074*	-0.068	0.232
	(0.040)	(0.073)	(0.171)
Observations	285	171	144

Cluster-robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

FI treatment does not increase the probability of bank run as it happens in small groups, but it is not as effective as in large groups in reducing it. Overall, banks of medium size do not show a significant reaction to any of the information treatments we test.

Result 4. Providing information on financial literacy has an opposite impact on run occurrence in small and in large banks. Specifically, it reduced runs in large banks. Information on general knowledge is only significant in large banks, but less effective than financial information. None of the information treatments has an effect on medium banks.

To examine possibly different behaviours due to the type of information disclosed, we now consider within Grouping 2 two sub-samples consisting of all sessions treated with FI and GI, respectively. The 5-depositor bank is now the benchmark. In this way, we test how subjects react to the actual content of the information they receive, controlling for group size.

Relative to the specification in Table 8, we include in these regressions two size dummies (n_7, n_10) and the group average scores in financial literacy (avgScoreF) and in general knowledge (avgScoreG). These two variables capture the groups' characteristics in terms of financial and general knowledge and, depending on the treatment, they also represent revealed information. For instance, all subjects treated with FI are revealed the group's average score obtained for the financial literacy questions, while they do not know the group score in general knowledge. Hence, in the FI sub-sample avgScoreF is a measure of the impact of the revealed information about the financial literacy at the group level, while avgScoreG is a measure of the group's intrinsic characteristic in terms of general knowledge. Symmetrically, the same applies to the GI sub-sample. Since these sub-samples are homogeneous with respect to the information treatment, the dummies FI and GI do not appear as regressors.

Table 9: Marginal effects for bank runs in Grouping 2 (information split)

VARIABLES	FI sub-sample	GI sub-sample
round9_16	0.252	0.274***
	(0.169)	(0.094)
round17_25	0.513***	0.419***
	(0.178)	(0.134)
L1with	0.009*	0.0049*
	(0.475)	(0.296)
n_7	0.163*	0.067
	(0.084)	(0.059)
n_10	-0.124	0.172**
	(0.087)	(0.072)
avgScoreF	-0.133**	-0.082
	(0.052)	(0.069)
avgScoreG	0.012	0.035
	(0.042)	(0.048)
HLG	0.006	0.228***
	(0.062)	(0.059)
Observations	200	200

Cluster-robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The marginal effects of the pooled probit regressions for these sub-samples are presented in Table 9. In the GI sub-sample, neither the revealed level of the group general knowledge (avgScoreG) nor the embodied level of group financial literacy (avgScoreF) affect the probability of bank run. Whereas in the FI sub-sample only the group financial literacy (avgScoreF), the revealed information, is effective.

Result 5. The group's financial literacy is significant and reduces the probability of bank run only when it is revealed to subjects, whereas the group's general knowledge is never effective.

When information is disclosed subjects perceive general knowledge and financial literacy as qualitatively different. In particular, they react to the actual content of the revealed information only when it refers to group's financial literacy, in which case groups with higher financial literacy exhibit a lower probability of run.

Except for short run history, that positively affects the probability of bank run regardless the treatment, the two sub-samples exhibit different determinants for the probability of bank run. Providing information on financial literacy has a positive impact on the probability of bank run only in medium banks, while small and large groups exhibit a similar behaviour. When looking at the distribution of runs over rounds, the significance of round17_25 highlights that they concentrate in the final repetitions.

In the GI sub-sample all these variables exhibit a different pattern. Both round dummies are significant, hence runs are more dispersed over the intermediate and final rounds. Moreover, the probability of run consistently increases in large groups relative to small ones when general information is revealed, while there is no significant effect of the medium size dummy. The size of the bank seems to matter.

More strikingly, in stark contrast with the FI sub-sample, revealing to subjects information about their group general knowledge makes risk attitude a determinant of the coordination among players.

Result 6. Group's attitude toward risk is significant and increases the probability of bank run only when subjects receive information about general knowledge of their group.

Disclosing to subjects information about their group's general knowledge or financial literacy generates qualitatively different behaviours. In the GI sub-sample, the repetition of play, the large dimension of the group and its risk aversion have a significant and positive effect on the probability of coordinating on the inefficient equilibrium. Disclosing information of group's general knowledge is not determinant for equilibrium coordination. In the FI sub-sample instead, a fundamental role is played by the revealed information on group financial literacy which mitigates the coordination on the equilibrium with bank run. Repetition of play becomes significant only in the final rounds.

In this respect, the results we get suggest that revealing information on financial literacy can potentially mitigate the bank run problem. Financial literacy is hence a relevant variable non only for individual financial decisions but also for strategic interactions in financial contexts. Within these settings though, our experiment emphasizes that the financial competence is not relevant as a characteristic of the group, rather as information made available to the players. This reflects the strategic nature of the interaction, and its contribution to reducing players' strategic uncertainty.

6 Conclusion

We investigate by means of an experiment whether financial literacy affects the behaviour of strategic economic agents, who play a coordination game framed in the bank run setting of Diamond and Dybvig (1983). We elicit subjects' financial literacy and study whether revealing this information impacts on coordination on the inefficient equilibrium. We also investigate whether and how bank size affects coordination on bank run. We find that in the baseline treatment in which subjects receive no information, the likelihood of runs increases with bank size and groups with different literacy behave in the same way, hence subjects understand that their financial literacy does not directly impact their payoff in the game. Whereas, when information on financial literacy is disclosed, the likelihood of runs increases in small banks and decreases in large ones. Hence, such information makes the bank run equilibrium focal if the group size is small, while it reduces strategic uncertainty if the group size is large. Over all banks' dimensions, the probability of coordinating on the inefficient equilibrium is lower when the average financial literacy of the group is higher. These results do not hold when we disclose information about group general knowledge, which makes financial literacy relevant because of its content. From a broader perspective, our findings suggest that, when financial decisions incorporate strategic considerations about market participants, disclosing information about the financial literacy of the agents involved in trades reduces financial instability, in particular when the interaction involves large groups.

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Appendix A. Additional Materials

Table 10: Payoff Matrix for 7-depositor Banks

	Payoff if you withdraw ○	Payoff if you do not withdraw ●
○ ○ ○ ○ ○ ○	98	7
● ○ ○ ○ ○ ○	117	57
● ● ○ ○ ○ ○	122	96
● ● ● ○ ○ ○	122	115
● ● ● ● ○ ○	122	127
● ● ● ● ● ○	122	134
● ● ● ● ● ●	122	150

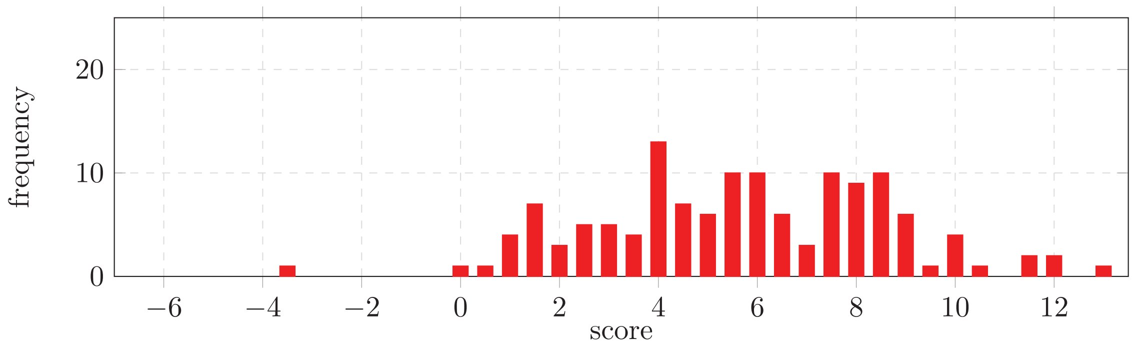
Table 11: Payoff Matrix for 10-depositor Banks

	Payoff if you withdraw ○	Payoff if you do not withdraw ●
○ ○ ○ ○ ○ ○ ○ ○ ○	99	0
● ○ ○ ○ ○ ○ ○ ○ ○	117	7
● ● ○ ○ ○ ○ ○ ○ ○	122	63
● ● ● ○ ○ ○ ○ ○ ○	122	90
● ● ● ● ○ ○ ○ ○ ○	122	107
● ● ● ● ● ○ ○ ○ ○	122	118
● ● ● ● ● ● ○ ○ ○	122	126
● ● ● ● ● ● ● ○ ○	122	132
● ● ● ● ● ● ● ● ○	122	136
● ● ● ● ● ● ● ● ●	122	150

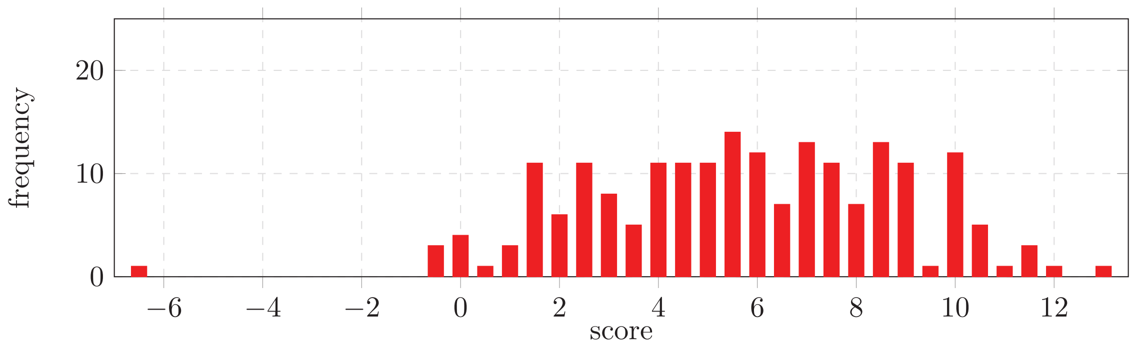
Table 12: Reversed Payoff Matrix for 5-depositor Banks

	Payoff if you withdraw ○	Payoff if you do not withdraw ●
● ● ●●	122	150
● ● ●○	122	132
● ● ○○	122	118
● ○ ○○	122	90
○ ○ ○○	98	7

Figure 6: Individual Total Scores



a. Grouping 1



b. Grouping 2

Table 13: Summary statistics - Grouping 1

Variable	Obs	Mean	Std. Dev.	Min	Max
L1with	400	68.086	24.562	12	100
HLG	420	6.025	0.605	4.4	8.2
avgScoreF	420	2.636	0.651	0.6	4.2
avgScoreG	420	3.029	0.779	1	5.2

Table 14: Summary statistics - Grouping 2

Variable	Obs	Mean	Std. Dev.	Min	Max
L1with	600	76.005	18.825	28	100
HLG	630	6.346	0.645	4.4	8.4
avgScoreF	630	2.879	0.692	0.3	4.8
avgScoreG	630	2.771	0.851	-0.2	5.2

Appendix B. Instructions[37]

Introduction

Welcome! You are participating in an experiment to collect data for a scientific research.

During the experiment you have to make decisions that will contribute to determine a payoff, that will be paid cash at the end of the experiment.

The experiment is totally anonymous: neither the experimenters nor other participants will be able to associate your decisions to your identity.

During the experiment, your interactions with other participants will be intermediated by a computer. Any form of communication between participants is prohibited. If you violate this rule, you will be excluded from the experiment with no payment.

If you have any doubt about the experiment, raise your hand and an experimenter will come to answer to your question, privately.

The experiment consists of a sequence of several phases. For each of phase, you will receive specific instructions.

All the decisions you will take in each phase will contribute to your final payoff. In some phases your payoff depends only on your own decisions, while in others it depends on your decisions and on the decisions of other participants, as it will be explained later on.

Your payoff in each phase and your final payoff are expressed in an experimental currency called *Zed*. Your final payoff in Zed will be converted into a final payment in Euros, at the exchange rate of 20 Zed = 1 Euro.

Phase 1

In this phase you will be asked to answer to 13 questions. Every question has four possibile answers, and your task is to choose the correct answer. For every question there is only one correct answer. You must answer the questions on your own and your payoff depends only on your choices. For each correct answer you will receive 1 point whereas for any wrong answer you will lose 1/2 points.

The questions will appear sequentially on your screen, and for each question you have 90 seconds to answer. If you do not provide any answer within the given time, that question will be considered as unanswered and you will not gain nor lose any point. Please note that once provided, your answer cannot be changed.

At the end of this phase, the computer screen will summarize: your own answers, the correct answers and the points you gained.

Your payoff in Phase 1

Your payoff in this phase depends on your answers to the questionnaire and on a binary lottery that guarantees a prize of 150 Zed or of 50 Zed.

The total points obtained from the questionnaire will determine the probability of winning the prize of 150 Zed. This probability cannot be lower than 0 nor greater than 1, and it increases

[37] This is the english translation of the instructions used in the experiment for the groups of five depositors.

with the points obtained. Recall that the probability of gaining the prize of 50 is one minus the probability of gaining the prize of 150.

If all your answers are wrong, your score from the questionnaire is $(-1/2) \times 13 = -6.5$ and the probability of the prize of 150 is equal to 5%: this is the lowest probability with which you can win the high prize (150 Zed). In this case, the probability of the prize of 50 Zed is equal to 95%.

On the other hand, if all your answers are correct, then your score is $1 \times 13 = 13$ and the probability the prize of 150 Zed is 95%: this is the highest probability with which you can win the high prize. In this case, the probability of the prize of 50 Zed is equal to 5%.

For any other score, you will win the prize of 150 Zeds with a probability between 5% and 95%.

The lottery draw over the two prizes will be performed at the end of the experiment and the prize will be part of your final payoff.

For your convenience, we are providing you with a blank table that you can use to take note of the results of the questionnaire.

Phase 2

Let us now move to Phase 2.

An experimenter will read aloud the instructions of this phase. If you have any question, please raise your hand and an experimenter will come to answer your question, privately.

Recall that communication between participants is prohibited. If you violate this rule, you will be excluded from the experiment with no payment.

Your task in Phase 2

In this phase, you and other 4 participants will be randomly and anonymously selected to constitute an experimental bank.

Every member of the bank owns 100 Zed deposited in the experimental bank. Hence, a bank is composed of 5 depositors, whose identity is unknown to each other.

As a depositor, you have two options: you can either withdraw your 100 Zed and close your deposit account; or you can leave your money deposited in the bank.

How much you receive in either case depends jointly on how much the bank promises to repay and on the decisions of the depositors at your bank, who face your identical task.

The bank promises to repay 150 Zed to every depositor who decides not to withdraw his money and 122 Zed to every depositor who decides to withdraw. However, the bank may not be able to fullfil her promises if too many depositors decide to withdraw. Table 15 lists the payoffs you obtain depending on your choice and on the choices of all other depositors in your bank.

The bullets in the first column represent the possible decisions of the depositors at your bank other than you. In particular, the white bullet represents a depositor who decided to withdraw and close his deposit. The black bullet, on the contrary, represents a depositor who decided not to withdraw.

Table 15: Payoff Table

	Payoff if you withdraw ○	Payoff if you do not withdraw ●
○ ○ ○○	98	7
● ○ ○○	122	90
● ● ○○	122	117
● ● ●○	122	132
● ● ●●	122	150

Example 1. Suppose that all depositors other than you withdraw. As the table shows, if you withdraw your payoff is 98 Zed. If you do not withdraw, your payoff is 132 Zed (see the first row of the table).

Example 2. Suppose that 3 depositors other than you decide not to withdraw. As the table shows, if you withdraw your payoff is 122 Zed. If you do not withdraw, your payoff will be 7 Zed (see the fourth of the table).

Why can't the bank always guarantee the promised repayments? Imagine that once the experimental bank has been constituted, the total deposits of 500 Zed are invested and that it takes time to generate a return.

To repay a depositor who decides to withdraw, the bank has to prematurely liquidate part of the investment. Those who do not withdraw are paid with the resources left after having repaid those who withdraw. Since premature liquidation is costly, if too many depositors decide to withdraw the bank cannot guarantee the promised repayments.

At the time you make your choice, the decision of the other depositors is unknown to you. Since any form of communication is forbidden, you are not allowed to ask to other participants their choice.

Procedure for Phase 2

Phase 2 consists of 20 periods. Each period is independent and completely separate from the others. In every period you will perform the task described in the previous section.

In each period, several experimental banks will be constituted, and each of them is completely separate from the others. Depositors are randomly assigned to an experimental bank. Therefore, you will meet with different depositors in every period. We cannot exclude that you will meet the same depositor more than once. However, the assignment to an experimental bank is completely anonymous, hence it is not possible for you to identify the other depositors.

At the beginning of each period you will have 100 Zed deposited in your experimental bank. As a preparation to your main decision, you will be asked to state your expectations about how many depositors of your bank other than you will withdraw, and about how many will leave their money deposited in the bank. Note that the sum of these two numbers has to be equal to 4 (four).

Then, you will have to decide whether to withdraw or not your deposit. You have 30 seconds to take your decision. If you have not made any decision within the time limit, the computer will randomly select your decision.

At the end of each period your decision, your payoff and the number of withdrawals at your bank will be privately communicated to you.

Computer Instructions

During phase 2, three different screens will appear on your computer: preliminary, decision and report screens.

The preliminary screen gives you information about the experimental bank you have been assigned to.

The decision screen is shown in Figure 7.

Figure 7: Decision Screen

Period 1 out of 20

	Payoff if you withdraw ○	Payoff if you do not withdraw ●
○○○○	98	7
●○○○	122	90
●●○○	122	118
●●●○	122	132
●●●●	122	150

WITHDRAW | DO NOT WITHDRAW

Time left to decide

The decision screen shows the payoff table as described above. It shows the two buttons that you will have to press to take your decision.

Once you press a button, you cannot change your choice.

At the top of the screen, the current period is displayed. At the bottom, there is countdown bar showing the time left to take you decision.

After all depositors in your bank have taken their decisions, a report screen will provide information about: your decision, your payoff and the number of depositors who decided to withdraw in the current period. You have 10 seconds to read those information before the new period starts.

Your payoff in Phase 2

Your payoff for Phase 2 will be determined by random selection of one period out of the 20 ones. The draw will be performed at the end of the experiment and you will be assigned the payoff corresponding to the selected period.

Phase 3

An experimenter will read aloud the instructions of this phase. If you have any question, please raise your hand and an experimenter will come to answer your question, privately.

Recall that communication between participants is prohibited. If you violate this rule, you will be excluded from the experiment with no payment.

In this phase 10 (ten) pairs of binary lotteries will be displayed on your screen. For each lottery, you will find on the screen the value and the probability of each prize. Your task is to choose one lottery within each pair. Your choice will determine your payoff for this phase as described below.

Your payoff in Phase 3

At the end of the experiment, one of the ten lottery pairs will be randomly chosen. Right after, the lottery you chose within the selected pair will be played by your computer. The prize extracted will determine your payoff in Zed for this phase.

Concluding the experiment

This phase is devoted to determine your total payoff, that is the sum of the payoffs you gained in each phase of the experiment.

We start with Phase 1. The computer will summarise on your screen: your answers to the questionnaire, the correct answers, your total score, and your probability to win the prize of 150 Zed. The lottery draw will be visualised on your computer and it will determine your payoff for Phase 1.

As for Phase 2, one period out of the 20 will be randomly chosen. The random draw is common to all participants. At this stage, the computer screen will summarise your payoffs for every period of Phase 2.

As for Phase 3, we will select one of the ten pairs of lotteries through a random procedure. Subsequently, the computer will play the lottery you choose within the selected pair. The prize visualised on your computer will determine your payoff for Phase 3.

The sum of all payoffs will determine your final payoff expressed in Zed. This payoff will then be converted into euro according to the predetermined exchange rate of 20 Zed = 1 Euro, and this amount will constitute your final payment for the experiment.

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