TI 2021-023/I
Tinbergen Institute Discussion Paper

The initial deposit decision and the occurrence of bank runs

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March 8, 2021

Abstract

In studies of bank runs the initial deposit decision is typically not taken into account. However, it is unlikely that people will entrust money to a bank that they expect to fail in the near future. The aim of this study is to investigate to what extent this mechanism prevents bank runs. It introduces an experiment in which participants first have to choose if they want to receive their endowments as a deposit in a 'risky' bank that pays a high interest or a 'safe' bank that pays a lower interest. After this decision they can withdraw the money from their account or leave it in to receive the interest. The availability of different deposit options leads to a very clear theoretical prediction: all choose to deposit in the risky bank with the high interest rate and consequently leave the deposit in the bank. In the experiment the first prediction is not confirmed: almost half of the participants choose to deposit in a safer alternative. However, in contrast to the control treatment in which participants are not offered a choice, only very few of those that choose the risky bank withdraw their deposits later.

Keywords: Bank runs; Initial deposit decision; Experimental economics; Coordination games
JEL classification: G21; G40; E71; D81

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1 Introduction

Bank runs generally lead to poor outcomes for both the depositors and the shareholders of a bank and are thought to have played a pivotal role in the aggravation of the Great Depression in the 1930s (Bernanke, 1983). In contrast to what is usually assumed for firms, even a financially healthy bank may fail if depositors expect other depositors to withdraw their savings. This fundamental vulnerability is highlighted by Diamond and Dybvig (1983) who model the situation as a coordination game with two equilibria: a Pareto-optimal equilibrium in which only those depositors in immediate need of money withdraw and a bank run equilibrium in which all depositors withdraw. The model has inspired a large theoretical literature on bank runs and is more recently also being used in a growing number of experimental studies, looking at, among other things, the effectiveness of deposit insurance and suspension of convertibility (Madies, 2006; Davis and Reilly, 2016), the role of information, uncertainty, and sunspots (Schotter and Yorulmazer, 2009; Garratt and Keister, 2009; Kiss et al., 2012, 2018a,b; Shakina and Angerer, 2018; Arifovic and Jiang, 2019; Arifovic et al., 2020), the influence of a bank's vulnerability to early withdrawals (Arifovic et al., 2013), and the effects of a (possible) bank run on other banks (Chakravarty et al., 2014; Brown et al., 2017; Duffy et al., 2019; Shakina, 2019).

The experiments to date have provided valuable insights on depositor behavior under many different circumstances. However, there is one aspect that is often mentioned[1], but has not received much detailed attention: depositors have chosen to entrust their savings to a particular bank and this decision is probably not independent from their later decision to withdraw or not. The goal of this paper is to study the initial deposit decision and its effect on subsequent withdrawal decisions by means of a bank choice experiment. In this experiment participants are asked to choose between two banks: one that offers a high interest rate on deposits, but is more vulnerable to bank runs due to relatively illiquid investments ('risky bank'), and a less vulnerable bank with lower interest rates ('safe bank'). After all depositors have chosen a bank, they have the opportunity to withdraw their deposits immediately or leave them in the bank to collect interest.

The participants in the experiment are asked to make two types of decisions: deposit decisions and withdrawal decisions. The withdrawal decisions can be affected by the presence of an initial deposit decision through several channels. First of all, there may be a selection effect. Those for whom the gains do not outweigh the (strategic) uncertainty will not deposit in a risky bank in the first place. This could leave the population of depositors in a risky bank less inclined to participate in a bank run than the general population. Another and perhaps even more important consideration is that the availability of different

[1] This includes Diamond and Dybvig (1983) themselves and later also Van Damme (1994) and Dufwenberg (2015).

deposit options can solve the coordination problem. In case of a bank run, the risky bank pays out less than the safe bank would (under any circumstances). Therefore the bank run equilibrium ceases to exist in the risky bank and the only equilibrium left to coordinate on is the Pareto-optimal equilibrium. In line with these arguments the results of the experiment show a striking difference in the number of withdrawals between the treatments with and without bank choice. Those depositors who choose to deposit in the risky bank, rarely withdraw their deposits in the next period.

The deposit decisions themselves are also of interest. Theoretically, depositing in the risky bank is safe, because all depositors of the risky bank should coordinate on the Pareto-optimal equilibrium. This is also confirmed by the results of the experiment, which show that there are very few withdrawals from risky banks when a safer alternative is also available. However, the participants in the bank choice game do not show a clear preference for the risky bank. Depending on what the characteristics of the two options are, they choose the riskier high-interest bank only between 45% and 71% of the time.

This study builds on and is connected to a wider literature of experimental bank run studies. Only a few of these also feature an environment with multiple banks. Chakravarty et al. (2014) and Brown et al. (2017) study how observing withdrawals in one bank, affects withdrawals in another bank for cases in which bank fundamentals are linked and and cases in which they are not linked. Both find that when the fundamentals are linked, depositors are more likely to withdraw when they observe many withdrawals in the other bank, but only in the experiment of Chakravarty et al. (2014) does this also happen when fundamentals are not linked. Another paper, by Duffy et al. (2019), looks at the effect of the interbank network structure on the likelihood of contagion. They find that when liquidation costs are high, a complete network structure, in which all the banks are linked, is more robust to bank runs spreading from one bank to another than an incomplete network structure. For low liquidation costs no large effect of the network structure is observed. Finally, Shakina (2019) considers a situation with two banks in which depositors of one bank, next to the standard options of withdrawing and leaving the deposit in the bank, also have the option to withdraw and deposit in the other bank. The availability of this option leads to more bank runs in the first bank and fewer bank runs in the second bank, which may receive extra depositors. This study probably comes closest to the one in this paper, but it focusses on the effect of a redeposit option instead of the initial deposit decision. As a consequence the experiment featured a very different design, with an asymmetry of the banks not in economic fundamentals, but in the fact that one bank can only lose depositors, while the other can also gain them.

Since bank run games are essentially coordination games, the experimental literature on coordination games is also relevant. In particular the paper by Cooper et al. (1992), who study a coordination game in which one of the two players has an outside option with a payoff in between the Pareto-dominated and the Pareto-dominant equilibrium payoffs. Unlike the bank choice game, these games have two Nash equilibria: one in which the outside option is chosen and one in which the players successfully coordinate on the Pareto-optimal equilibrium. The first of these can be eliminated using a forward induction refinement. Cooper et al. (1992) find that, after learning, row players choose to play the coordination game 60% of the time, 4 out of 5 times followed by successful coordination on the Pareto-dominant equilibrium. In contrast, without an outside option or with an irrelevant outside option, players do not manage to coordinate on this equilibrium. Note that these results are obtained after learning (only the second half of the played periods are analyzed in the paper). This contrasts with this paper, in which the focus is on initial play (using a series of single-shot games).

In the next section I will briefly outline the bank choice game. Section 3 then deals with the experimental design, followed by the results (Section 4) and the conclusion (Section 5).

2 The bank choice game

The basis for the bank choice game is the model by Diamond and Dybvig (1983). There are 3 periods $t = 0, 1, 2$. In period 0 each player is entitled to an endowment c, which can only be received in a bank account. Here the players can choose between two banks. After choosing they are free to withdraw their money in period 1, but if they wait until period 2 the bank promises to pay an interest rate $R_i > 1$ provided that it has the funds to pay out all depositors. These interest rates are typically different for the two banks. If in any period the available funds are insufficient to cover the banks immediate obligations, the bank is liquidated and the proceeds are divided equally among the depositors who made a withdrawal request.

Each bank B_i uses its depositors' money to finance a project that returns R_i in period 2 for each unit invested in period 0. If necessary the bank may liquidate (a part of) its stake in the project, but in that case it will only get $L_i < R_i$ per liquidated unit. It is natural to assume that projects with lower liquidation values, have higher returns. Therefore larger values of R always combine with smaller values L:

$$R_i > R_j \iff L_i < L_j. \tag{1}$$

The players in this game do not have an explicit need to withdraw money in period 1. In the terminology of Diamond and Dybvig this means that they are all 'patient'. However, they may still be better off withdrawing if other depositors in the bank withdraw. In period 1 they have to take a decision: they can either withdraw their complete deposit or leave everything in the bank (they cannot withdraw a part). If k_i out of N_i depositors of bank B_i withdraw money in period 1, the bank will continue to sell its stake in its project until it either raises enough to pay all its withdrawing depositors an amount c, or its stake is completely liquidated. If the latter happens, the funds raised through liquidation are equally divided among the withdrawing depositors. This means that the payoff to those who withdraw is

$$\pi_{withdraw} = \min\left(\frac{L_i N_i c}{k_i}, c\right). \tag{2}$$

If the bank had to completely liquidate its stake, those who decided to wait until period 2 receive nothing. If the liquidation was only partial, the part of the initial investment that remains is multiplied by R_i and divided over the remaining depositors. They therefore receive

$$\pi_{wait} = \max\left(\frac{\left(N_i - \frac{k_i}{L_i}\right) R_i c}{N_i - k_i}, 0\right). \tag{3}$$

The expressions $\pi_{withdraw}$ and π_{wait} are (non-strictly) decreasing functions of k_i that cross in a single point. A consequence of this is that the bank choice game can not have pure-strategy Nash equilibria in which different depositors in the same bank make different decisions. This can be understood by considering a situation in which some depositors withdraw and some others wait. In this case there are three possibilities: $\pi_{wait} < \pi_{withdraw}$, $\pi_{wait} > \pi_{withdraw}$, or $\pi_{wait} = \pi_{withdraw}$. In the first the depositors who choose to wait are not making a payoff-maximizing choice, while in the second and third this is true for the depositors who withdraw.

When all depositors in a bank either all withdraw or all wait, there are four possible payoffs for players of the bank choice game. Ranked from low to high: the bank run payoff in the risky bank, the bank run payoff in the safe bank, the maximum payoff in the safe bank, and the maximum payoff in the risky bank. When the banks are different, all these payoffs are necessarily different as well. This means that in a pure strategy Nash equilibrium all depositors deposit in a single bank. This cannot be the safe bank, because in that case becoming the single depositor in the risky bank and choosing to wait would yield a higher payoff. A bank run in the risky bank is also not a Nash equilibrium because then depositors could deviate to the safe bank to earn more. Therefore, when the banks are different the bank choice game has only one Nash equilibrium in pure strategies: all players deposit in the most risky bank and leave the deposit in the bank.

The bank choice game extends the Diamond-Dybvig model with an initial deposit decision, but there are also a few other important differences. The most important one is that there are no 'impatient' depositors. This is a crucial element of the risk-sharing problem that banks can help to solve. However, it does not play a role in the coordination problem that is created by the demand deposit solution and therefore it is not included in the bank choice game. The absence of impatience is also the reason that it is not made possible for the players to invest directly in the project. This would allow players to trivially avoid the coordination problem that is the focus of this study. A second difference is that in the bank choice game the potential losses for depositors that choose to wait is generated by the losses from liquidation and not by the interest paid to early withdrawers. This makes the game also suitable for studying situations with high strategic uncertainty in which only a small number of withdrawals leads to losses for depositors who decided to wait. Without liquidation losses this would only be possible with a bank that offers a very high interest rate over the first period and very little over the second and this is unnatural. Finally, in the bank choice game players do not have the possibility to divide their endowments between different options or withdraw a fraction of it in the first period. This simplifies the game by reducing the number of choices of players and therefore also the number of choices by others that players need to consider.

3 Experimental design

3.1 Task

In the experiment participants play the bank choice game. In period 0 they are presented with two banks, Square Bank and Round Bank, and have to choose the one in which they will receive their endowments. Figure 1 shows an example of the screen on which the participants have to make their choices. The banks can differ in their values of R and L or be the same. In total there are five types of banks, which differ primarily in the critical fraction of depositors that can withdraw before withdrawing becomes a dominant choice for the others. For example, in a type 1 bank, the values of R and L are chosen such that if 1 out of 6 depositors withdraws, any other participant would maximize his or her payoff by withdrawing as well. In a type 2 bank 1 depositor may withdraw without this tipping point being reached, but not 2. In general the type number corresponds to the number of depositors that need to withdraw in order to make withdrawing dominant for the others. The values of R and L for each bank type are shown in Table 1, together with the earnings of the participant given his or her choice and the choices of the other depositors. The participants receive this information in the form of a graph. The graphs for each bank type are provided in Appendix A. After all participants have made their choices, the experiment moves to period 1. Here the participants see again the payoff graph of the bank they chose and are asked if they want to withdraw or leave their deposits in ("wait").

In total, the experiment consists of 15 rounds. In each round the participants have to choose from a different combination of bank types, including some combinations in which

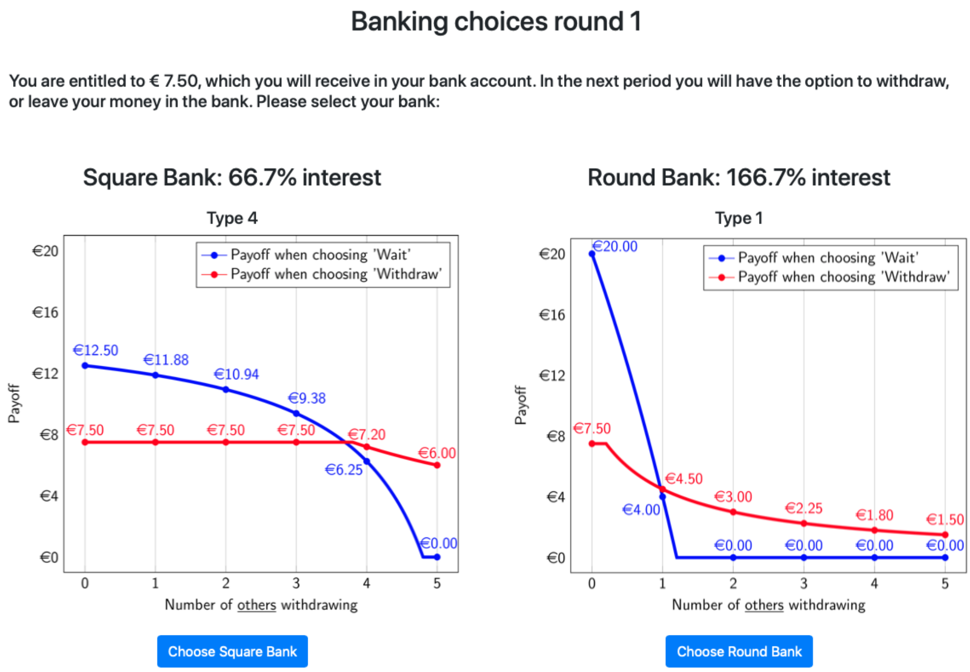

Figure 1: Example of a screen the participants see in period 0, when they have to make a choice between two banks.

Table 1: Payoffs (in euros) for each of the five types of banks, depending on how many of the other depositors withdraw and whether the participant decides to wait or withdraw him or herself in period 1.

# of others withdrawing	Type 1 $R = 2.66$ $L = 0.2$		Type 2 $R = 2.33$ $L = 0.4$		Type 3 $R = 2$ $L = 0.6$		Type 4 $R = 1.66$ $L = 0.8$		Type 5 $R = 1.33$ $L = 0.93$	
	Wait	Run	Wait	Run	Wait	Run	Wait	Run	Wait	Run
0	20.00	7.50	17.5	7.50	15.00	7.50	12.50	7.50	10.00	7.50
1	4.00	4.50	12.25	7.50	13.00	7.50	11.88	7.50	9.86	7.50
2	0.00	3.00	4.38	6.00	10.00	7.50	10.94	7.50	9.64	7.50
3	0.00	2.25	0.00	4.50	5.00	6.75	9.38	7.50	9.29	7.50
4	0.00	1.80	0.00	3.60	0.00	5.40	6.25	7.20	8.57	7.50
5	0.00	1.50	0.00	3.00	0.00	4.50	0.00	6.00	6.43	7.00

the two banks are of the same type[2]. Determination of outcomes and payoffs only takes place at the very end of the experiment. This makes it possible to randomize the order in which the bank combinations appear on an individual level. It also means that the participants are not informed about the outcome or their earnings at the end of a round, which minimizes order effects. The most risky bank of the pair sometimes appears on the right side of the screen and sometimes on the left side. Also this is randomized on the level of individual participants.

At the end of the experiment there are two pools of participants for each combination of bank types: those who deposited in the square bank and those who deposited in the round bank. These pools are then split up in groups of 6 and possibly for each pool one left-over group with fewer than 6 participants. To make the situation in the left-over groups as similar as possible to the situation in the complete groups, the empty spots are filled with computer players that copy the withdrawal decisions of randomly selected participants in other banks of the same type. These are individuals who made the same deposit choice when presented with the same two bank types, but they either are in one of the complete banks in the same session or were participants in a previous session. The only situation in which an incomplete bank is formed is when fewer than 6 people in any of the sessions up to that point made a particular deposit choice. In that case the payoffs still follow from Eqs. 2 and 3, but with N_i smaller than 6. Participants learn how many depositors there were in their bank in each round, how many withdrew and how much they earned, but not if some of their chosen banks were completed with computer players or not.

3.2 Treatments and procedures

To isolate the effect of the initial deposit decision, the experiment consists of two treatments: choice and control. In the choice treatment participants play the full bank choice game, as described in the text above. The control treatment is identical, except that the participants are not given the choice to deposit in either the Square bank or the Round bank. Instead, their endowments are deposited in the banks chosen by choice treatment participants in an earlier session. Each control treatment participant is matched with one choice treatment participant and is presented exactly the same banks as their match chose (in the same order). The control treatment participants are not informed of the existence of the choice treatment and the matching procedure. They simply start in period 1 with their endowments in either a Round bank or a Square bank of a particular type. The screen presents the payoff graph for this particular type and the participants can choose

[2]In principle we would not expect any effect of having an initial deposit decision or not when all options are identical, except when the act of choosing itself can make a difference.

to withdraw or wait.

At the start of the experiment participants receive instructions both on paper and on screen and the experiment only starts when all participants in a session answered a set of control questions correctly. When all rounds of the experiment have finished the participants are asked to complete two risk elicitation tasks, a 2/3-of-average number guessing game, and a questionnaire. The first risk elicitation task is the low payoff multiple price list (MPL) task used by Holt and Laury (2002). The second is the "bomb" risk elicitation task (BRET) by Crosetto and Filippin (2013). The number guessing game is the one by Nagel (1995) and its aim is to access the Depth of Reasoning. The MPL task appeared first, followed by the number guessing game and the BRET. Only after all tasks are completed, the participants are informed about their earnings in each round and in each of the additional tasks. The computer then randomly selects one round of the main experiment for payment and the final screen shows the total earnings.

The experiment took place in April and May 2019 at the CREED laboratory of the University of Amsterdam. It was programmed in oTree (Chen et al., 2016) and incorporated existing apps for the additional tasks (Holzmeister and Pfurtscheller, 2016; Holzmeister, 2017). In total there were 210 participants, 107 in the choice treatment and 103 in the control treatment[3]. All were students, the majority (62%) in an economics or business program. 51% of the participants were female. Sessions lasted approximately 1.25 hours and on average the participants earned €18.37.

4 Results and discussion

4.1 Bank choice and withdrawal decisions

A first question to ask is what participants choose in the different banks in the control treatment. In the control treatment the participants receive their deposits in the bank type chosen by their matches in the choice treatment. They therefore play the classic bank run game, with two Nash equilibria. Based on experiments by Arifovic et al. (2013) one would expect coordination on the run equilibrium in very risky banks and coordination on the Pareto-optimal equilibrium in the safest banks.

Figure 2 shows the fraction of withdrawals in the first period for each type of bank[4]. As expected, withdrawals in banks of type 4 and 5 are quite low at 14% and 8%, respectively. This increases to 27% for type 3 banks, 47% for type 2, and 54% for type 1 banks. All increases are significant ($p < 0.05$) in a Mann-Whitney U test, except for the one between

[3]The last 4 participants in the choice treatment never got matched to control treatment participants and are therefore excluded from the analysis in the next section

[4]In the control treatment participants see most bank types multiple times. In this analysis all withdrawal decisions of all participants are pooled for each bank type.

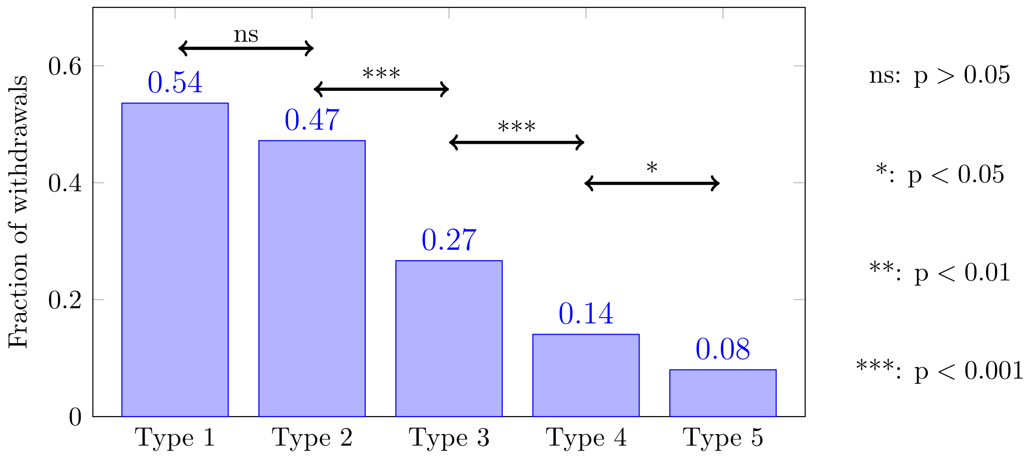

Figure 2: Fraction of withdrawals in period 1 in the control treatment, where participants cannot choose a bank. The stars above the arrows indicate which differences are significant in a Mann-Whitney U test.

type 2 and type 1 banks. Surprisingly, the participants in this experiment never fully coordinate on the run equilibrium, not even in the riskiest banks. This contrasts with the results of Arifovic et al. (2013), who also study the effect of different levels of strategic uncertainty on withdrawing decisions, but use interest to early withdrawers instead of liquidation losses to generate this strategic uncertainty. A possible explanation is that for very risky banks the payoffs in the run equilibrium are reduced to a small fraction of the endowment, due to the banks having to liquidate at a loss. At the same time these banks offer a very high return if everyone coordinates on the good equilibrium. It seems that many participants find it worth taking this gamble.

In contrast to the situation in the control treatment, the bank choice game played by the participants in the choice treatment has only one Nash equilibrium. To coordinate on it, participants should first choose to deposit in the risky bank and consequently leave their deposits in. Fig. 3 shows that the first step is often not taken. When presented the option to choose between two banks of a different type approximately half of the participants choose the more risky bank with the higher interest rate and the other half chooses the safer bank. This is remarkably stable for different pairs of bank types. Only when two very safe banks are involved, types 3 and 5 or types 4 and 5, does the fraction choosing the risky bank rise above 60%. This is somewhat similar to the finding by Cooper et al. (1992) that almost 40% of participants choose a fixed payment over playing a coordination game with one higher-payoff and one lower-payoff equilibrium when given the choice.

The fact that in all cases both banks attract a significant fraction of the depositors opens the door for selection effects to play a role. One could hypothesize that now either

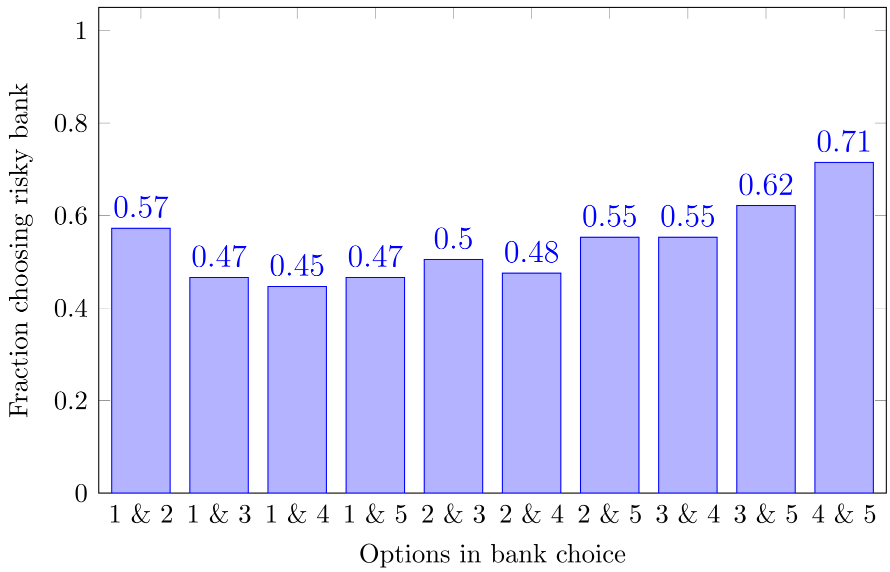

Figure 3: Fraction of participants choosing the riskier bank when offered a choice between two banks of different types.

the resolution of the coordination problem or a population of more risk tolerant depositors or both could drive down withdrawals in the riskier bank. Figure 4 shows the fraction of depositors that withdraw in period 1 from the riskier bank after choosing it (choice treatment) or when not having a choice (control treatment). The treatment effect is very strong. For banks of type 1 and 2 the fraction of participants who withdraw in the first period is reduced by a factor 3 or more in the choice treatment compared to the control treatment. On average fewer than 1 out of 6 depositors withdraw after choosing a riskier bank. For banks 3 and 4 the difference is less pronounced, because they already face fewer withdrawals in the control treatment. However, also there the effect is in most cases significant at the 5% level (sign test, two-sided), except when the choice was between a type 4 and a type 5 bank.

An interesting question is what happens after participants decide to deposit in the safer alternative. If selection effects play a role and the safe bank attracts relatively more risk averse depositors, it is conceivable that here *more* people will withdraw than in the control treatment. Fig. 5 shows that in general this is not the case. For none of the choice pairs the effect is significant at the 5% level (sign test, two-sided) and also when all the data is pooled, there is no significant effect ($p = 0.24$).

Figures 4 and 5 only show results from choices between banks that are not of the same type. The reason is that selection effects and a solution to the coordination problem, the proposed mechanisms through which the initial deposit decision could affect withdrawal decisions, do not work if the two options are identical. The expectation is therefore that there will be no treatment effect for identical options. Surprisingly, the results for identical

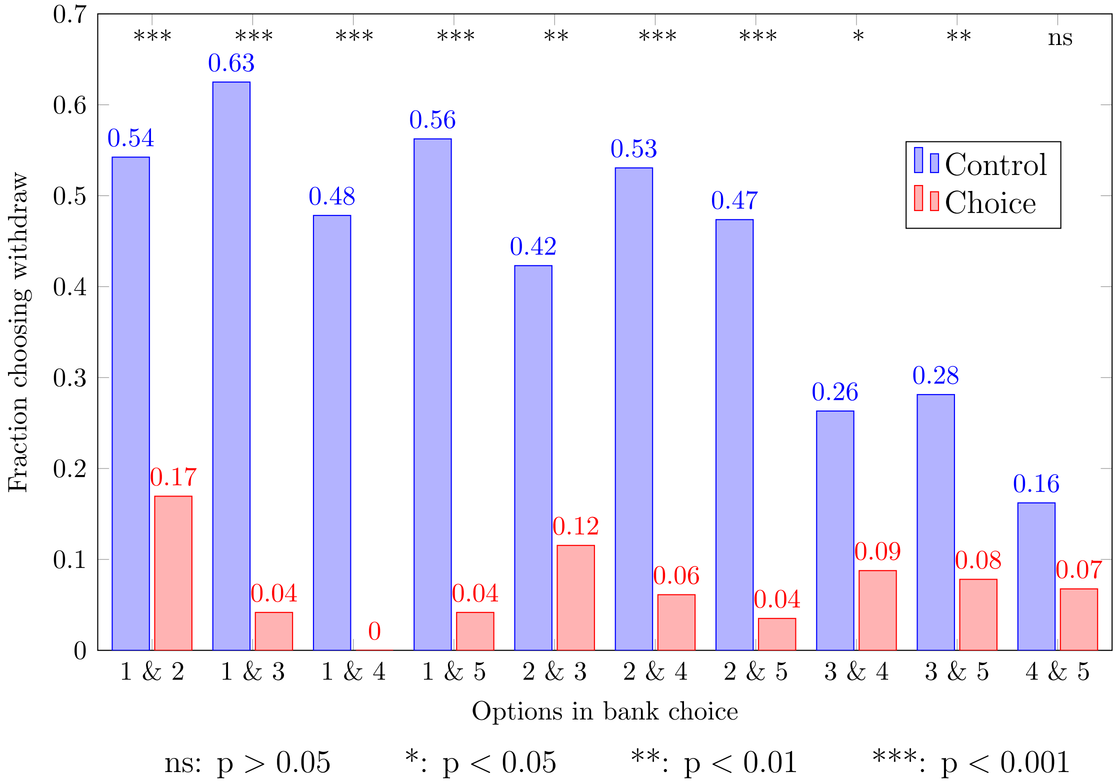

Figure 4: Fraction of participants withdrawing from the riskier bank (of the two shown on the horizontal axis) in the control treatment (blue) and in the choice treatment (red). The stars above the bars indicate which differences are significant in a sign test.

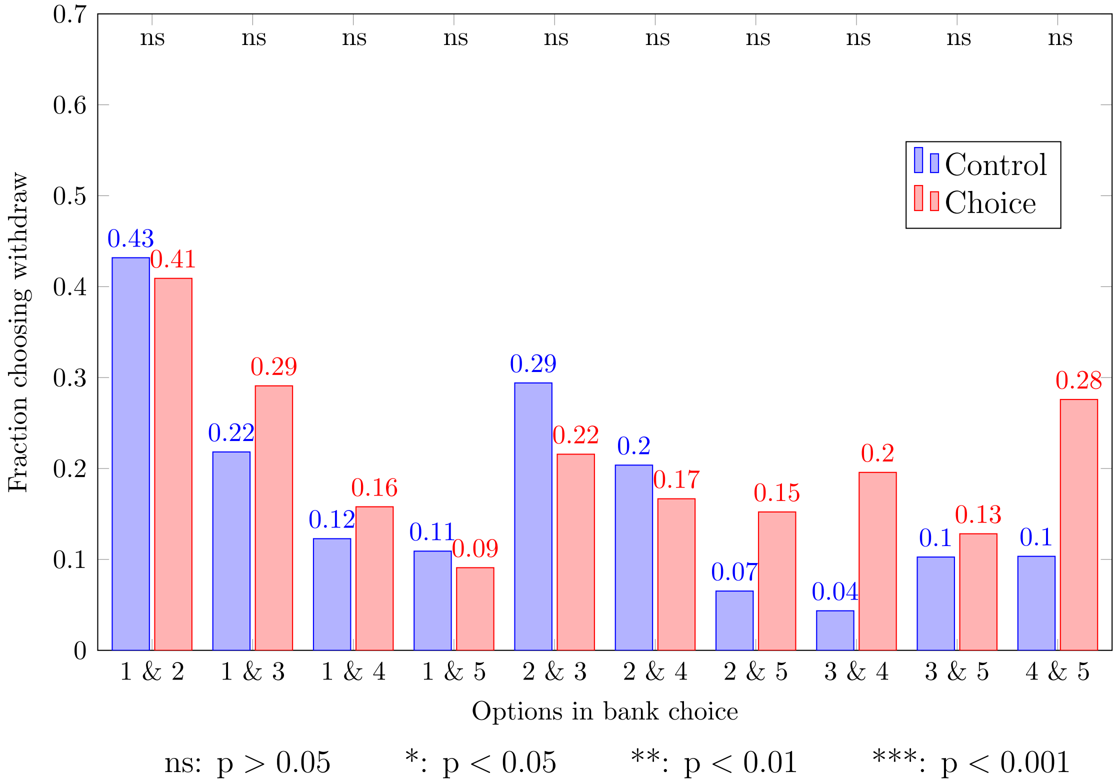

Figure 5: Fraction of participants withdrawing from the safer bank (of the two shown on the horizontal axis) in the control treatment (blue) and in the choice treatment (red). The stars above the bars indicate which differences are significant in a sign test.

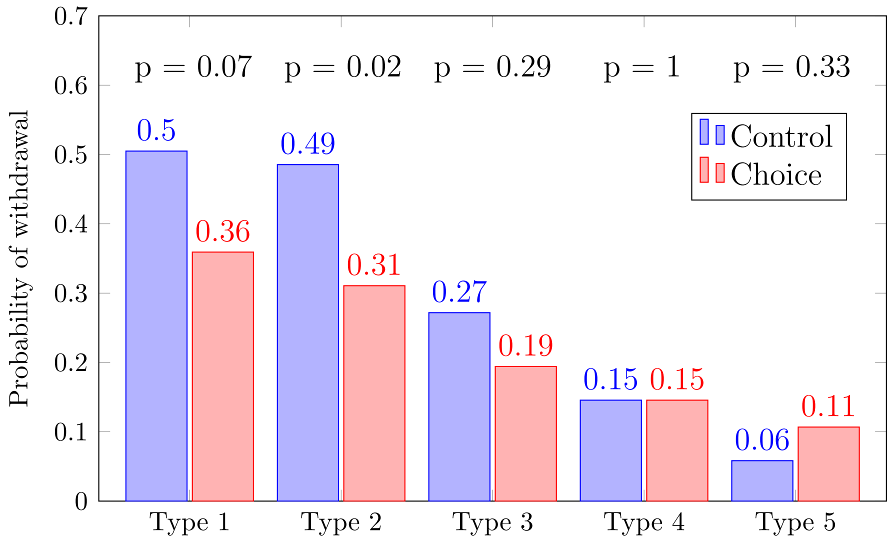

Figure 6: Fraction of participants withdrawing for each bank type when they have a choice between two banks of that same type (choice treatment, blue) and when they have not been given a choice (control treatment, blue). The stars above the bars indicate which differences are significant in a sign test.

options in Figure 6 show an effect for banks of type 1 and 2 that is (close to) significant in a sign test ($p = 0.07$ and $p = 0.02$). Participants who chose these banks are about a third less likely to withdraw compared to participants who could not choose. A possible explanation is that the act of choosing itself can already have an effect.

4.2 Empirical best responses

With the participants in this experiment not coordinating on a particular equilibrium, the question arises which responses are empirically best (in the sense that they maximize the expected payoff). To establish an answer, I will use the choices by the participants in the experiment to estimate the probability that a depositor that is randomly drawn from the population, withdraws ($p_{withdraw}$). In the control treatment the participants encountered most banks multiple times and they did not always make the same decision[5]. Therefore, in this case $p_{withdraw}$ is the average of the probabilities of the individual participants withdrawing from a bank of a certain type (calculated as the number of times that a participant withdrew from a bank of a certain type divided by the number of times the participant acted as a depositor in a bank of that type). Table 2 shows the $p_{withdraw}$ that are estimated in this way in the 2nd column. As expected, the probability of a random individual withdrawing is highest for a bank of type 1 and lowest for a bank of type 5.

[5]One possible reason is that the participant is indifferent between withdrawing and waiting for that particular bank type

Table 2: Estimated withdrawal probabilities for each bank type and expected payoffs for each decision that a participant can take (wait or withdraw) in the bank run game and the bank choice game with two identical banks. An asterisk (*) indicates which decision yields the highest expected payoff.

	Withdrawal probability		Expected payoffs			
Bank type	Single bank	Two identical banks	Single bank wait	Single bank withdraw	Two identical banks wait	Two identical banks withdraw
1	0.55	0.36	0.80	2.67*	3.26	3.69*
2	0.45	0.31	4.83	5.63*	8.21*	6.42
3	0.27	0.21	11.48*	7.38	12.32*	7.44
4	0.14	0.14	11.98*	7.50	11.99*	7.50
5	0.08	0.10	9.94*	7.50	9.92*	7.50

Given a withdrawal probability $p_{withdraw}$, it is possible to calculate expected payoffs for withdrawing and waiting in a bank with five other depositors:

$$\mathbb{E}\left(\pi_{withdraw}\right) = \sum_{k=0}^{5} \binom{5}{k} p_{withdraw}^{k} \left(1 - p_{withdraw}\right)^{5-k} \min\left(\frac{45L_i}{k+1}, 7.5\right), \tag{4}$$

$$\mathbb{E}\left(\pi_{wait}\right) = \sum_{k=0}^{5} \binom{5}{k} p_{withdraw}^{k} \left(1 - p_{withdraw}\right)^{5-k} \max\left(\frac{7.5\left(6 - \frac{k}{L_i}\right) R_i}{6-k}, 0\right). \tag{5}$$

Here R_i and L_i are the return and liquidation values of the chosen bank's investments. The 4th and 5th columns of Table 2 list the expected payoffs for waiting and withdrawing for each bank type. The decisions that yield the highest expected payoffs are indicated with an asterisk. The results show that someone who is interested in maximizing expected earnings in a bank run game should withdraw from banks of types 1 and 2 and wait in banks of types 3, 4, and 5.

In the choice treatment participants encounter a particular combination of bank types only once and in each case the participant pool splits in two populations: one that chooses the safe bank and one that chooses the risky bank. In each population a particular fraction of participants decides to withdraw and this fraction is a good estimate of the withdrawal probability of a random depositor in that bank. Table 3 lists these estimates in the 3rd and 4th columns. The table also provides expected payoffs, calculated with Eqs. 4 and 5, for each of the four combinations of choices that a player can make: wait in risky bank (5th column), withdraw from risky bank (6th column), wait in safe bank (7th column), or withdraw from safe bank (8th column). An asterisk again marks the choice combination

Table 3: Estimated withdrawal probabilities and expected payoffs for each pair of banks in the bank choice game and for each combination of choices that a participant can make (bank choice decision and withdrawal decision). An asterisk (*) indicates which decision combination yields the highest expected payoff.

Bank type		Withdrawal probability		Expected payoffs			
				Risky bank		Safe bank	
Risky bank	Safe bank	Risky bank	Safe bank	wait	withdraw	wait	withdraw
1	2	0.17	0.40	9.51*	5.35	6.15	5.97
1	3	0.04	0.31	16.87*	6.90	10.86	7.33
1	4	0.02	0.17	18.35*	7.19	11.88	7.50
1	5	0.04	0.09	16.93*	6.91	9.93	7.50
2	3	0.11	0.24	14.28*	7.33	11.92	7.41
2	4	0.06	0.17	15.81*	7.45	11.85	7.50
2	5	0.03	0.17	16.58*	7.48	9.86	7.50
3	4	0.08	0.18	14.04*	7.50	11.81	7.50
3	5	0.08	0.12	14.18*	7.50	9.90	7.50
4	5	0.07	0.26	12.28*	7.50	9.75	7.50

that yields the highest payoff. In contrast with the bank run game, withdrawing is never rewarded with the highest expected payoff in a bank choice game with different banks. For all combinations of bank types the expected payoffs are maximized by waiting in the risky bank.

Although this result does not extend completely to bank choice games in which the deposit options are identical, the addition of a deposit decision still causes differences with important consequences. The 3rd column of Table 2 shows the withdrawal probabilities after a randomly selected individual has to choose between two identical banks and the 6th and 7th columns show the expected payoffs for waiting and withdrawing in this case. Comparing to the bank run game, in which a payoff-maximizing player should withdraw in banks of types 1 and 2, this is now only optimal for banks of type 1. Moreover, the difference in expected payoffs for type 1 banks is much smaller than in the equivalent bank run game.

4.3 Additional tasks and questionnaire

To investigate the role of a possible selection effect the participants completed three additional tasks: the multiple price list (MPL) task (Holt and Laury, 2002), the bomb risk elicitation task (BRET) (Crosetto and Filippin, 2013) and a number guessing game in which the person closest to two-thirds of the average wins a price (Nagel, 1995). The expectation was that participants who choose the more risky bank are more risk tolerant, have a higher Depth of Reasoning, or both. However, there were no significant differences in MPL and number guessing scores and very few in the BRET scores (see Appendix C for the results). This could mean that there is either no selection effect or that the populations differ in a dimension not captured by one of the additional tasks[6].

The answers to one of the questions in the final questionnaire provides additional insight on the relation between bank runs and the initial deposit decision. This question is: "Did you ever switch banks in real life, and if so, what was the reason?". 201 participants answered this question and 70% reported to have never switched banks. Although the participant population in this experiment is quite young, 22 years on average, this is one indication that there may be a large number of people who never consciously made an initial deposit decision. An even more striking picture arises when looking at the reasons of the 30% that did switch banks. The most reported reasons are:

1. Services or features (16)
2. Moving to another country (9)
3. Interest rate (8)
4. Benefits for students or new customers (7)
5. Corporate social responsibilty or moral conduct (7)
6. Costs (5)
7. Bank reliability (2)
8. Personal problems or unclear (6)

As can be seen, the drivers for depositing in one bank or another in this experiment, interest rate and bank reliability, play only a limited role in the real life banking decisions of the participants. This means that if a conscious initial deposit decision can help to prevent bank runs, there is still a lot of room to expand its role.

5 Conclusion

Theoretically, whether a bank run occurs or not can depend critically on the initial deposit decision of the depositors. The bank choice experiment in this paper is meant to assess to what extent the presence of an initial deposit decision affects withdrawals. It provides some participants with two options to receive an endowment in, a risky bank with a

[6] Other experimental bank run studies also don't find differences in risk aversion scores between people that choose to withdraw and people that choose to wait (Kiss et al., 2014, 2016, 2018a; Shakina, 2019), but there is some indication that loss aversion plays a role in these type of coordination games (Trautmann and Vlahu, 2013; Kiss et al., 2018a).

high interest rate and a safe bank with a low interest rate. After they have chosen a bank, these participants can either withdraw or leave the money in the bank and receive interest. Other participants cannot choose a bank. They receive their endowments in a certain type of bank and can only decide to withdraw their money or not.

Contrary to the theoretical prediction, about half of the participants who can choose a bank in the experiment chooses the safer option for their deposits. Only when both banks are very safe the fraction of participants choosing the safest option goes down a bit. Participants who choose the risky option rarely withdraw afterwards. Compared to the situation in which participants are not offered a choice, the number of withdrawals dropped by 67% or more for the most risky bank types. At the same time, the number of withdrawals from the safer bank is not significantly different from the number of withdrawals in the case that participants could not choose.

The results show that the initial deposit decision has a strong impact on the withdrawal behavior of depositors in more risky banks. The very low fraction of withdrawals from those banks in the experiment contrasts with the intuition and earlier results that institutions with low liquidity levels are automatically more at risk of facing a bank run. On the other hand, if we generalize the result of this paper too much, we should not observe any panic-based bank runs in the modern setting with an ecosystem of many banks and this, in turn, does not correspond to what we see. The challenge is now to understand what drives bank runs in a world with initial deposit decisions and how this relates to the liquidity level of institutions. The bank choice game can be extended such that it is ideally suited for this purpose.

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Appendix A Payoff plots for each type of bank

Figure 7 shows five graphs, one for each type of bank, of the payoffs of a participant as a function of the number of other depositors that withdraw and the participant's own choice.

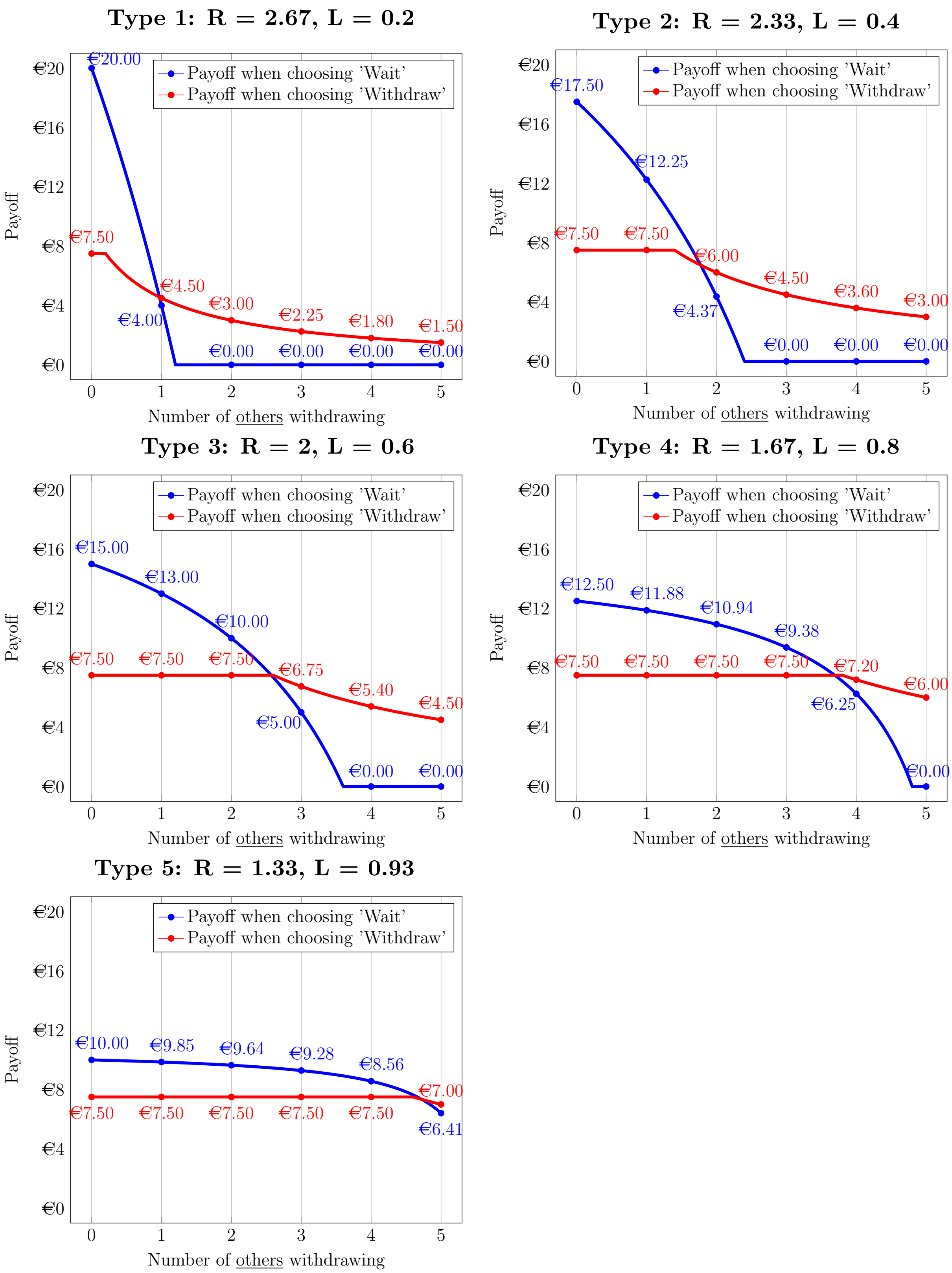


Figure 7: Payoff graphs of the five types of banks in this experiment. These were the graphs used to explain the payoffs to the participants and the relevant graph(s) were shown on every page on which the participants needed to take a decision.

Appendix B Instructions to participants

B.1 Choice treatment

General information

This part of the experiment consists of 15 rounds. In each round you have to make two choices. First you select the bank in which you want to receive your endowment of €7.50. You can choose between two options: Round Bank and Square Bank. These banks may be of a different type or not.

Next you are given the choice to either withdraw this endowment immediately, or wait and collect the interest that the bank offers. Note, however, that the interest rates that the banks in this experiment advertise with, are only correct if none of the depositors withdraws early. If there are early withdrawers, the amount of interest received will be lower. If too many depositors withdraw early, the bank will not be able to fully pay back some of its depositors anymore and will thus go bankrupt. In that case depositors are served in the order in which they requested a withdrawal. This means that first the ones who chose to immediately withdraw get some money. If anything is left, this will be divided by the depositors who chose to wait.

The depositors

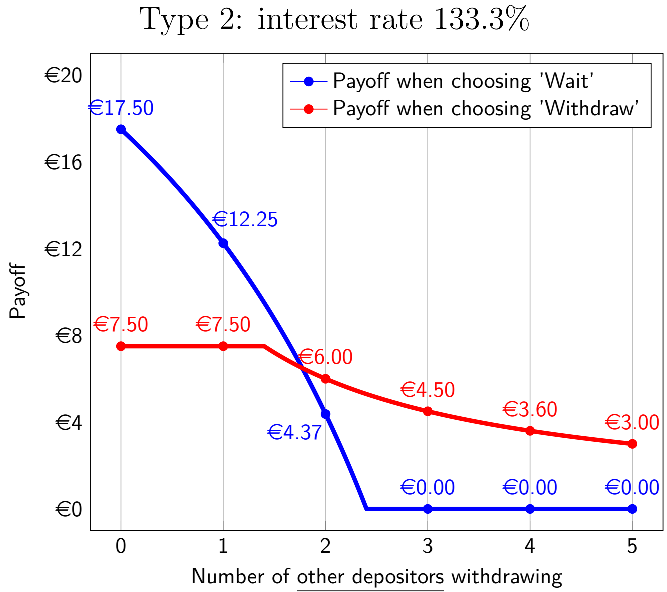
After all participants have made their choices, banks of 6 depositors are formed. Those participants who chose for Round Bank will be in a bank with other participants who chose Round bank and the same is true for the participants who chose Square bank. Because the number of participants who make a particular choice is often not an exact multiple of 6, there can be one Round Bank and one Square bank that initially have fewer than 6 depositors. To provide the participants in those banks with the same experience as the ones in the full banks, the empty spots are filled with computer players who copy the behavior of participants that made the same choice but happen to be in another group of 6. The copied participants can be individuals in the same or in a previous session.

Types of banks

Not all banks are equally vulnerable to bankruptcy. The banks with the highest interest rates are also the ones that are most vulnerable. In this experiment there are 5 types of banks. Type 1 has the highest interest rate (166.7%), but already goes bankrupt if 1 out of 6 depositors withdraws early. For a type 2 bank (interest rate 133.3%) this happens when 2 out of 6 depositors withdraw. In fact, the number of the type corresponds to the number of depositors that need to withdraw such that the remaining depositors will not receive their full deposit back.

Example

The graph on the right provides an example for a bank of type 2. It shows the payoffs of the decision maker (you) for the choices of waiting (blue line) and of withdrawing (red line). Apart from the choice of the decision maker, payoffs also depend on the decisions of the 5 other depositors in the bank. The horizontal axis depicts how many of them choose to withdraw.



Suppose that 1 out of 5 other depositors withdraws and you decide to wait. In this case you and the other 4 depositors who wait get €12.25 and the depositor who withdraws gets €7.50. If in the same situation you choose to withdraw instead, you and the other depositor who withdraws get €7.50. Note that in that case the 4 depositors who do wait get €4.37, because now from their perspective 2 other depositors are withdrawing. We can also consider a situation in which 3 out of 6 other depositors withdraw. In that case depositors who choose to wait get nothing. If you decide to withdraw here you get €4.50.

Results and payoffs

In this experiment participants are not informed about the outcomes until all parts of the experiment are completed. Then also the payoffs become known. At the end, for each participant 1 of the 15 rounds will be randomly selected for payment.

Summary

In each of the 15 rounds you have to choose a bank to receive your endowment in. Banks with lower type numbers provide higher interest rates, but are also more vulnerable to bankruptcy if depositors withdraw early. After you have chosen a bank, you are given the opportunity to withdraw immediately, or leave your money in the bank to collect interest. Depositors who withdraw receive no interest. However, in case of bankruptcy they receive a larger part of their endowments back than those who chose to wait. You will learn the outcomes of all rounds at the end of the experiment.

B.2 Control treatment

General information

This part of the experiment consists of 15 rounds. In each round you will receive an endowment of €7.50 as a deposit in a bank account. You are given the choice to either withdraw this endowment immediately, or wait and collect the interest that the bank offers. Note, however, that the interest rates that the banks in this experiment advertise with, are only correct if none of the depositors withdraws early. If there are early withdrawers, the amount of interest received will be lower. If too many depositors withdraw early, the bank will not be able to fully pay back some of its depositors anymore and will thus go bankrupt. In that case depositors are served in the order in which they requested a withdrawal. This means that first the ones who chose to immediately withdraw get some money. If anything is left, this will be divided by the depositors who chose to wait.

The depositors

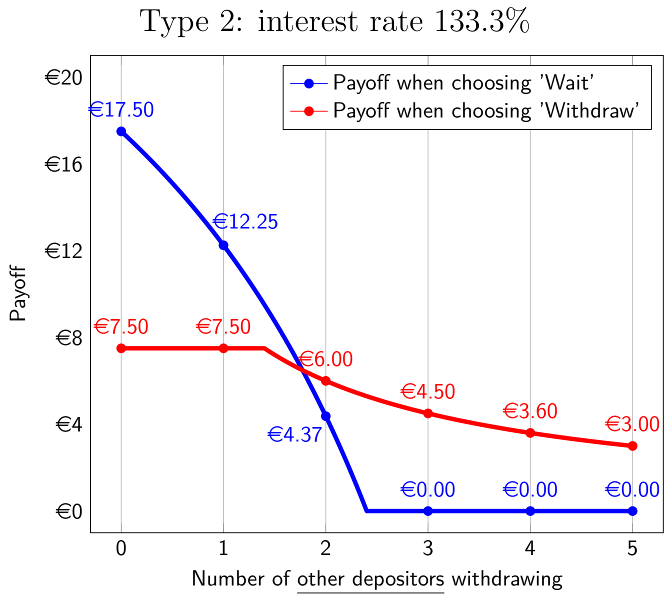
Banks typically have 6 depositors. However, because the number of participants with a deposit in a certain type of bank is often not an exact multiple of 6, there can be banks that initially have fewer than 6 depositors. To provide the participants in those banks with the same experience as the ones in the full banks, the empty spots are filled with computer players who copy the behavior of participants that have a deposit in the same type of bank but happen to be in another group of 6. The copied participants can be individuals in the same or in a previous session.

Types of banks

Not all banks are equally vulnerable to bankruptcy. The banks with the highest interest rates are also the ones that are most vulnerable. In this experiment there are 5 types of banks. Type 1 has the highest interest rate (166.7%), but already goes bankrupt if 1 out of 6 depositors withdraws early. For a type 2 bank (interest rate 133.3%) this happens when 2 out of 6 depositors withdraw. In fact, the number of the type corresponds to the number of depositors that need to withdraw such that the remaining depositors will not receive their full deposit back.

Example

The graph on the right provides an example for a bank of type 2. It shows the payoffs of the decision maker (you) for the choices of leaving the endowment in the bank (blue line) and of withdrawing (red line). Apart from the choice of the decision maker, payoffs also depend on the decisions of the 5 other depositors in the bank. The horizontal axis depicts how many of them choose to withdraw.



Suppose that 1 out of 5 other depositors withdraws and you decide to wait. In this case you and the other 4 depositors who wait get €12.25 and the depositor who withdraws gets €7.50. If in the same situation you choose to withdraw instead, you and the other depositor who withdraws get €7.50. Note that in that case the 4 depositors who do wait get €4.37, because now from their perspective 2 other depositors are withdrawing. We can also consider a situation in which 3 out of 6 other depositors withdraw. In that case depositors who choose to wait get nothing. If you decide to withdraw here you get €4.50.

Results and payoffs

In this experiment participants are not informed about the outcomes until all parts of the experiment are completed. Then also the payoffs become known. At the end, for each participant 1 of the 15 rounds will be randomly selected for payment.

Summary

In each of the 15 rounds you receive a deposit in a bank account and are asked if you want to withdraw this money immediately or leave the money in the bank to collect interest. Banks with lower type numbers provide higher interest rates, but are more vulnerable to bankruptcy if depositors withdraw early. Depositors who withdraw receive no interest. However, in case of bankruptcy they receive a larger part of their endowments back than those who chose to wait. You will learn the outcomes of all rounds at the end of the experiment.

B.3 Multiple price list task

In the following, you'll face 10 decisions listed on your screen. Each decision is a paired choice between "Option A" and "Option B". While the payoffs of the two options are fixed for all decisions, the chances of the high payoff for each option will vary.

After you have made all of your choices, one of the 10 decisions will be randomly chosen for your payment. For the option you chose, A or B, in this decision, it will be randomly determined (according to the corresponding probabilities) whether the low or high outcome will constitute your payoff.

To summarize: You will make 10 choices; for each decision you will have to choose between "Option A" and "Option B". You may choose A for some decision rows and B for other rows. When you are finished, one of the 10 decisions will be randomly picked for your payoff. Then a random number will be drawn to determine your earnings for the option you chose in that decision.

B.4 Number guessing game

You are in a group of x[7] people. Each of you will be asked to choose a number between 0 and 100. The winner will be the participant whose number is closest to 2/3 of the average of all chosen numbers.

The winner will receive €20. In case of a tie, the €20 will be equally divided among winners.

B.5 Bomb task

In the following, you will see a 10x10-matrix containing 100 boxes on your screen.

As soon as you start the task by hitting the 'Start' button, one of the boxes is collected per second. Once collected, the box is marked by a tick symbol. For each box collected you earn 0.1.

Behind one of the boxes hides a bomb that destroys everything that has been collected. The remaining 99 boxes are worth 0.1 each. You do not know where the bomb is located. You only know that the bomb can be in any place with equal probability.

[7] This game was played with the whole session. The number of players therefore differed per session.

Your task is to choose when to stop the collecting process. You do so by hitting 'Stop' at any time. **Note that you cannot restart the process afterwards. Hitting 'Stop' marks your final choice.** If you collect the box where the bomb is located, the bomb will explode and you will earn zero. If you stop before collecting the bomb, you gain the amount accumulated that far.

At the end of the task boxes are toggled by hitting the 'Solve' button. A dollar sign or a fire symbol (for the bomb) will be shown on each of your collected boxes.

Appendix C Results of additional tasks

After playing 15 rounds of the bank choice game, the participants were asked to complete 3 additional tasks before learning their payoffs. These were a multiple price list (MPL) task (Holt and Laury, 2002), the bomb risk elicitation task (BRET) (Crosetto and Filippin, 2013) and a number guessing game in which the person closest to two-thirds of the average wins a price (Nagel, 1995). Figures 8 to 10 show the average scores of participants choosing a riskier bank and the average scores of participants choosing a safer bank next to each other. There are no significant difference in the MPL and number guessing scores (Mann-Whitney U test, two-sided). Also the number of boxes collected in the bomb task is in most cases not significantly different, except when both options are relatively safe banks (types 3, 4, and 5). Here for two out of three combinations participants that choose the safer bank also collect significantly fewer boxes, indicating that they are more risk averse.

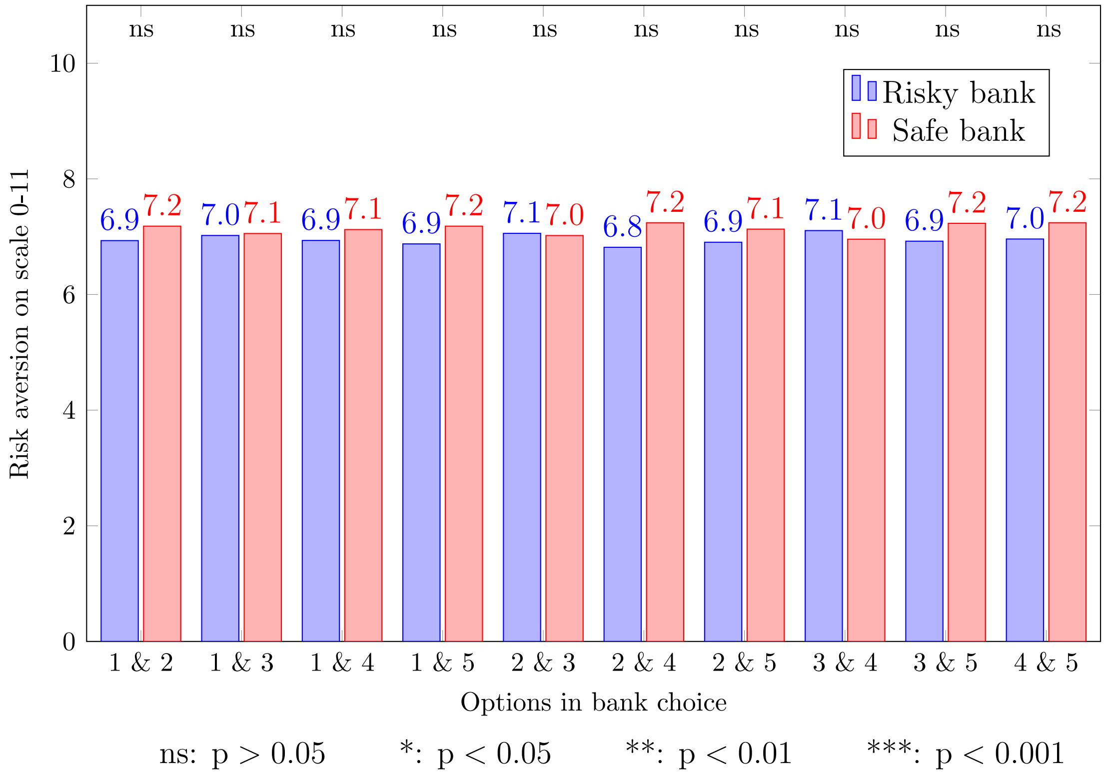


Figure 8: Average multiple price list (MPL) test scores for participants who choose the riskier bank (blue) and the safer bank (red) of the two options. A higher score means that a participant is more risk averse. Mann-Whitney U tests show no significant differences in the average scores of participants who chose different banks.

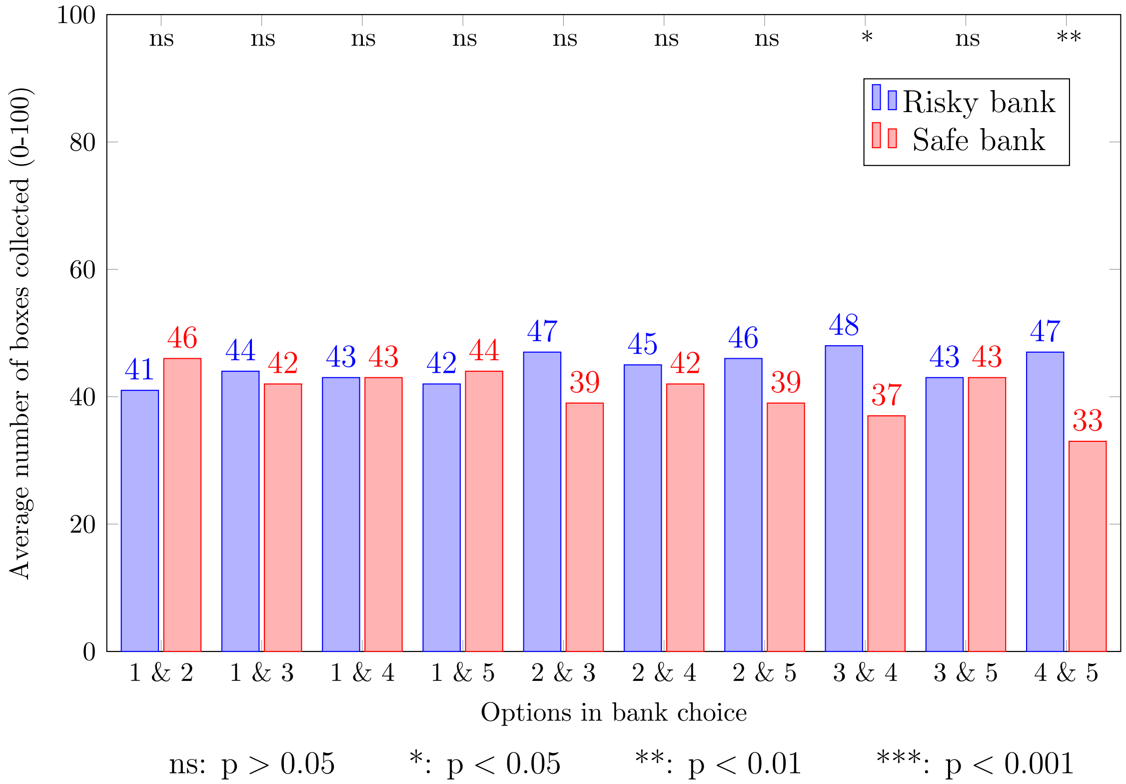


Figure 9: Average bomb risk elicitation task (BRET) scores for participants who choose the riskier bank (blue) and the safer bank (red) of the two options. The score for an individual is the number of boxes collected (out of 100) and the lower the score, the more risk averse the participant is. Mann-Whitney U tests show no significant differences in the average scores of participants who chose different banks for all combinations, except 3&4 and 4&5.

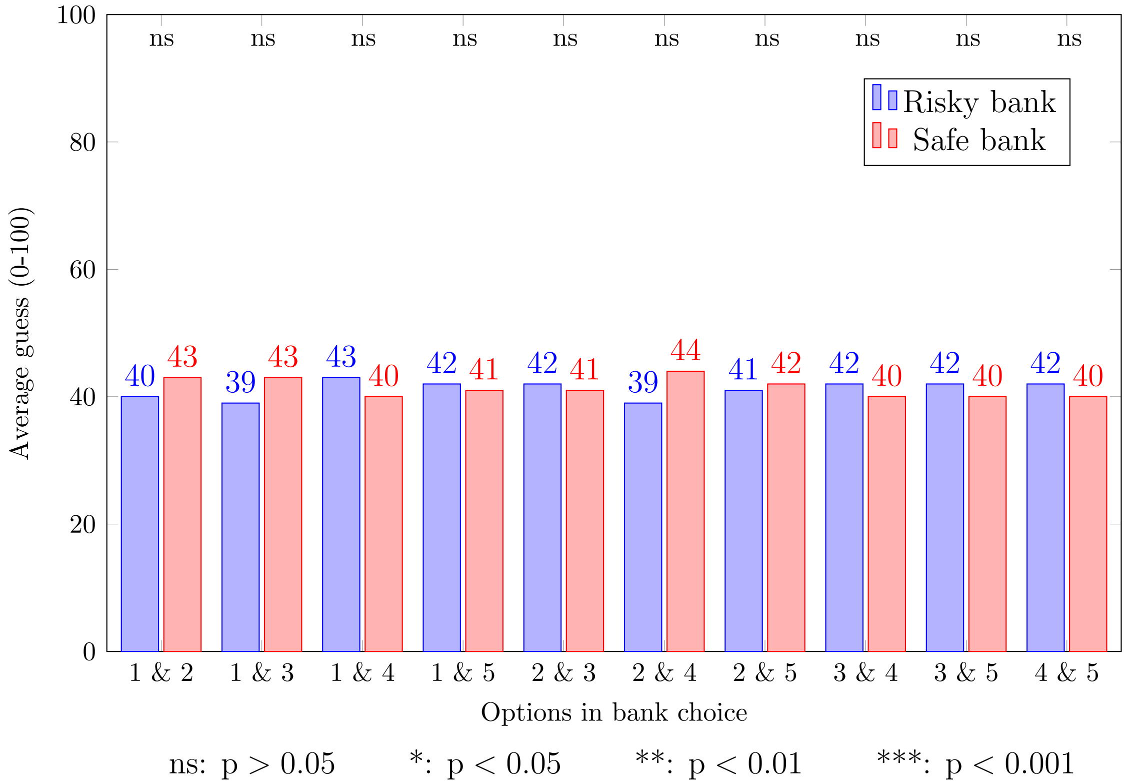


Figure 10: Average number guessed in the number guessing game by participants who choose the riskier bank (blue) and the safer bank (red) of the two options. In the number guessing game the person who guesses the number (between 0 and 100) that is closest to two-thirds of the average wins a price. A lower number is associated with higher Depth of Reasoning. Mann-Whitney U tests show no significant differences in the average scores of participants who chose different banks.