An Experimental Study of the Investment Implications of Bankruptcy Laws∗

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Abstract

We use an experimental design to analyze and compare actual investor behavior under two well-known allocation rules proposed by the theoretical literature on bankruptcy problems: Equal Losses Rule (EL) and Proportional Rule (PRO). More specifically, we experimentally test the following hypotheses, forwarded by the theoretical work of Kıbrıs and Kıbrıs (2013): (i) total investment is higher under EL than under PRO; (ii) under both rules, a decrease in the firm’s probability of bankruptcy (i.e. an increase in its success rate) serves to increase both individual and total investment levels; (iii) under both rules, more risk averse agents choose lower investment levels; (iv) under EL, agents with more risk averse partners invest more, (v) under PRO, an agent’s investment choices are independent of his partner’s risk attitude. Our findings support all hypotheses except (iv). We find that a switch from PRO to EL or an increase in the success rate induces higher investment choices and that more risk averse subjects invest less in general. We do not observe a significant effect of partner’s risk aversion on a subject’s investment choices. Finally, we also find that the bankruptcy rule in play has a significant effect on a subject’s likelihood of choosing an extreme (that is, zero or full) investment level.

Keywords: bankruptcy, noncooperative investment game, proportional, equal losses, total investment, social welfare.

JEL Classification Numbers: C72, C91, D78, G33.

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1 Introduction

Following the seminal work of O’Neill (1982), a vast literature focused on the axiomatic analysis of “bankruptcy problems”. As the name suggests, a canonical example to this problem is the case of a bankrupt firm whose monetary worth is to be allocated among its creditors. Each creditor holds a claim on the firm and the firm’s liquidation value is less than the total of the creditors’ claims. The axiomatic literature provided a large variety of “bankruptcy rules” as solutions to this problem. In this study, we will focus on two of these principles: (i) proportionality (PRO), and (ii) equal losses (EL). As their names suggest, these principles suggest that the agents’ shares should be chosen, respectively, (i) proportional to their investments, and (ii) so as to equate their losses from initial investment.

Bankruptcy has also been a central topic in corporate finance where researchers analyze a large number of issues related to it (e.g. see Hotchkiss et al (2008)). This literature shows that, in practice almost every country uses the following rule to allocate the liquidation value of a bankrupt firm. First, creditors are sorted into different priority groups (such as secured creditors or unsecured creditors). These groups are served sequentially. That is, a creditor is not awarded a share until creditors in higher priority groups are fully reimbursed. Second, in each priority group, the shares of the creditors are determined in proportion to their claims.

This forwards an important question. Even though equal losses seems to be as a central idea as proportionality from an axiomatic perspective, why has proportionality been preferred to equal losses in actual bankruptcy practices? Kıbrıs and Kıbrıs (2013) provides a theoretical answer to this question, based on the observation that alternative bankruptcy rules affect investment behavior in different ways. Analyzing equilibria of a noncooperative game which simulates a bankruptcy situation, Kıbrıs and Kıbrıs (2013) compares the bankruptcy rules in terms of their effect on investment decisions and investor welfare. Its findings, detailed in Section 3, point to an interesting trade-off between EL and PRO: EL induces higher total investment levels than PRO, yet induces lower social welfare levels for the investors. Thus, a policy maker interested in increasing the investment levels in the economy is advise to revise bankruptcy laws to replace proportionality with the equal losses.

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1This is not surprising considering that in US between 1999 and 2009, more than 551000 firms filed for Chapter 7 bankruptcy and more than 22.16 billion USD were allocated in these cases (see http://www.justice.gov/ust/index.htm).

2Procedures on the liquidation of the firm and its allocation among creditors exist in bankruptcy laws of every country. For examples, see Chapter 7 of the U.S. Bankruptcy Code or the Receivership code in U.K. In some countries such as Sweden or Finland, these procedures provide the only option for the resolution of bankruptcy. Bankruptcy laws of some other countries, such as U.S., also offer procedures (such as Chapter 11) for reorganization of the bankrupt firm.

3This is a very old and common practice, referred to as a pari passu distribution; the term meaning “proportionally, at an equal pace, without preference” (see Black’s Law Dictionary, 2004).

4Although they compared three bankruptcy rules, Proportionality, Equal Awards, and Equal Losses in their paper, here we will focus on only two of them, Proportionality and Equal Losses.
principle (at the cost of reduced investor welfare). Before giving such a strong policy advise to the policy maker, however, one should observe how actual people behave under these rules and whether their behavior conforms with the game theoretical predictions of Kıbrıs and Kıbrıs (2013). This is an important exercise since it is well-known that game theoretical predictions can significantly deviate from actual behavior (e.g. see Rabin 1998; Mullainathan and Thaler, 2000).

This paper uses an experimental design to analyze and compare actual investor behavior under the bankruptcy rules PRO and EL. More specifically, we experimentally test the following hypotheses, forwarded by Kıbrıs and Kıbrıs (2013): (i) total investment is higher under EL than under PRO; (ii) under both rules, a decrease in the firm’s probability of bankruptcy (i.e. an increase in its success rate) serves to increase both individual and total investment levels; (iii) under both rules, more risk averse agents choose lower investment levels; (iv) under EL, agents with more risk averse partners invest more, (v) under PRO, an agent’s investment choices are independent of his partner’s risk attitude.

To test these predictions, we construct a simple experiment with two stages. In the first stage, we use a common technique (due to Holt and Laury, 2002) to elicit subjects’ risk aversion. In the second stage, the bankruptcy rules PRO and EL serve as treatments and for each rule, 2 investors simultaneously choose how much money to invest in a firm. The total of these investments determine the value of the firm. The firm is a lottery which either brings a positive return (with a probability $p$, called hereafter the success rate) or goes bankrupt (with the remaining probability $1 - p$). In the former case, the firm distributes dividends with an interest $r$. In the latter case, that is bankruptcy, its liquidation value (firm’s value after bankruptcy) is allocated among the investors according to the pre-specified bankruptcy rule.

Three main insights emerge from the experiments. First, EL induces higher total investment levels than PRO. Furthermore, the difference is more prominent when the success rate is lower (that is, the probability of bankruptcy is higher). Second, investment levels increase by the success rate, as expected. Third, agents’ investment levels decrease by their own risk aversion under EL and PRO, as expected. However, we do not find significant evidence that it changes in response to information about partners’ risk aversion. Although this is consistent with the theoretical predictions of Kıbrıs and Kıbrıs (2013) for PRO, it is not so for EL.

Our experiments also check whether the bankruptcy rule in play has anything to do with a subject’s likelihood of choosing an extreme (that is, zero or full) investment level. Our results reveal that the likelihood of a subject investing all (none) of his endowment is significantly higher (lower) under EL than under PRO. Also, subjects are more (less) likely to invest all (none) of their endowments under a high success rate and a low level of risk aversion. Interestingly, these extreme choices become more likely as subjects gain more experience with a given rule. Furthermore, although we do not find any significant effect of gender on investment levels, we do
find it on extreme investment choices. In particular, male subjects have a higher likelihood of making extreme investment choices than female subjects. This result is consistent with earlier findings in the literature (e.g. see Bajtelsmit and VanDerhei, 1997; Bajtelsmit, Bernasek, and Jianakoplos, 1996; Hinz, McCarthy, and Turner, 1997; Yuh and Hanna, 1997).

The paper is organized as follows. In Section 2, we present the related literature. In Section 3, we provide the theoretical background and state the hypotheses. In Section 4, we explain experimental design and the procedures. In Section 5, we present the results of our experiment. We conclude in Section 6. All supplementary material, including the instructions for the experiment, are presented in an Appendix.

2 Related Literature

Bankruptcy is a very important economic issue and as such, it has attracted scholarly attention in a wide variety of fields, the most relevant of which will be discussed next.


The corporate finance literature also contains a large number of papers that study bankruptcy (e.g. see Bebchuck (1988), Aghion, Hart, and Moore (1992), Atiyas (1995), Hart (1999), Stiglitz (2001)). However, most of these papers study reorganization procedures such as Chapter 11 in the US. There are some papers that discuss liquidation procedures (and some, such as Baird (1986) argue that they are superior to reorganization procedures). For example, Bris, Welch, and Zhu (2006) use a comprehensive data set from the US to compare liquidation and reorganization procedures in terms of costs and efficiency. Stromberg (2000) uses Swedish data to evaluate liquidation procedures. Also, Hotchkiss et al (2008) summarize bankruptcy laws in different countries and as part of it, describe liquidation procedures (as these constitute the only resolution to bankruptcy in some countries). Finally, there are studies that discuss the implications of priority classes on investor behavior. How-

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5Chun (1988) also provides an axiomatic support for the proportional division of a surplus.
ever, all of these studies take the existing proportional allocation rule (i.e. PRO) as a given, nonchanging constant and do not discuss its merits in relation to alternative rules.


This paper is closely related to Kıbrıs and Kıbrıs (2013) and to a lesser extent, Karagözoglu (2014). Both are game theoretic papers that utilize noncooperative investment games to analyze investment implications of a class of bankruptcy rules. Our experimental design closely follows the game theoretic model analyzed in Kıbrıs and Kıbrıs (2013), whose findings are discussed in detail in Section 3.

We finally discuss the experimental literature on bankruptcy which, surprisingly, is rather thin. There are only a few papers. Gächter and Riedl (2005) studies an environment where subjects bargain over a resource that falls short of the sum of their claims (as typical in bankruptcy) and inquires which of the three main principles (proportionality, equal awards, equal losses) is a better predictor of behavior. They find that while the subjects demand shares consistent with the equal awards principle, their sharing suggestions for others are consistent with the proportional principle. Gächter and Riedl (2006) studies how the differences between the subjects’ claims affect offers, duration, concessions, and (dis)agreements in negotiations. Herrero, Moreno-Ternero and Ponti (2010) ask subjects to play three games with different frames. In the games, three group members have claims over the shrank value of a project. Each subject declares which of the three bankruptcy rules (Constrained Equal Awards, Proportional and Constrained Equal Loss) he prefers. The authors choose the claims in the bankruptcy problem such that the allocation according to each rule favors exactly one of the claimants. The authors first analyze which rule is chosen under these conditions. Then they analyze which rule is chosen if the implemented rule is determined according to the majority rule. They find that while subjects’ play converges to the unique equilibrium rule (that is, each player chooses the rule that favors him or her), in the majority procedure the proportional rule prevails as a coordination device.

Earlier experimental studies, mentioned above all focus on the allocation stage
of bankruptcy and try to see how good a predictor of demand behavior the PRO, EA and EL are. Different from the above papers, we do not take these principles as predictor of behavior. But rather, we take each as a fixed parameter of the environment where a group of investors interact and we try to see how the choice of bankruptcy rule affects the agents’ investment choices. Our experiment is thus a very simple and stylized version of a real investment environment.

3 Theoretical Framework and Hypotheses

In this section, we summarize the model and findings of Kıbrıs and Kıbrıs (2013). We then summarize the hypotheses produced by these findings.

There are $n$ investors, endowed with Constant Absolute Risk Aversion (CARA) utilities on money, $u_i(x) = -e^{-a_i x}$, and ordered according to their degrees of risk aversion as $a_1 \leq \ldots \leq a_n$. Each investor $i$ invests $s_i \in \mathbb{R}_+$ units of wealth on a risky company. The company has value $\sum N s_i$ after investments. With success probability $p \in (0, 1)$, this value brings a return $r \in (0, 1]$ and becomes $(1 + r) \sum N s_i$. In this case, each investor $i$ receives a dividend of $(1 + r) s_i$. With the remaining probability $(1 - p)$, the company goes bankrupt and its value becomes $\beta \sum N s_i$ where $\beta \in (0, 1)$ is the fraction that survives bankruptcy. This amount is allocated among the investors according to a prespecified bankruptcy rule.

Kıbrıs and Kıbrıs (2013) analyzes a multitude of bankruptcy rules but, among them, the following two will be central to our experimental analysis. The Proportional Rule (PRO) is defined as follows: for each investor $i$, $PRO_i(s) = \beta s_i$, that is, in case of bankruptcy each investor receives a share proportional to his investment. The Equal Losses rule (EL) is, on the other hand, defined as $EL_i(s) = s_i - \frac{1 - \beta}{n} \sum N s_j$; that is, in case of bankruptcy all investors lose the same amount ($\frac{1 - \beta}{n} \sum N s_j$) out of their initial investments.

Kıbrıs and Kıbrıs (2013) shows that under PRO, the investment game has a unique dominant strategy equilibrium and no other Nash equilibria. If $pr > (1 - p)(1 - \beta)$, all agents choose a positive investment level at the dominant strategy equilibrium. Also $s_i^*$ is increasing in the probability of success $p$ and the fraction of the firm that survives bankruptcy $\beta$ and it is decreasing in the agent’s degree of risk aversion $a_i$.

On the other hand, the Nash equilibrium under EL turns out to be of the form $s_1^* \geq \ldots \geq s_n^*$ where agents up to some $k \in N$ choose positive investment and the rest chooses zero investment. However, if the inequality

$$\frac{1}{a_n} \sum N \frac{1}{a_j} \geq \frac{(r + 1)(1 - \alpha)(1 - \beta)}{n (1 - \beta + r)(1 - \alpha + \alpha \beta)}.$$  

(which requires that the agents are not too different from each other in terms of their
risk attitudes) is satisfied, either all agents pick a positive investment, or they all invest zero. More specifically, if \( pr > \frac{1-\beta}{n} (1 - p) (1 + (n - 1) \alpha) \), all agents choose a positive investment level at the Nash equilibrium. Also \( s_i^* \) is increasing in the probability of success \( p \) and the fraction of the firm that survives bankruptcy \( \beta \) and it is decreasing in the agent’s degree of risk aversion \( a_i \).

The main finding of Kıbrıs and Kıbrıs (2013) is that, in terms of total investment, \( EL > PRO \) for all parameters of the game. It is interesting to note that, even when all agents are identical in terms of risk aversion, the ordering of the rules in terms of total investment is as above. This means that PRO and EL not only differ in terms of how they treat big versus small investors, but they also differ in terms of the investment incentives that they provide in a symmetric game where all agents are identical in terms of risk aversion.

The implications of the above findings on individual and total investment decisions can be summarized in the following hypotheses that we test in this experimental study:

**Hypothesis 1:** Total investment \( \sum s_i \) is higher under EL than under PRO.

**Hypothesis 2:** Under both PRO and EL, an increase in the success rate \( p \) increases an individual’s investment choice \( s_i \).

**Hypothesis 3:** Under both PRO and EL, an increase in an investor’s own risk aversion level \( a_i \) corresponds to a decrease in his investment level \( s_i \).

**Hypothesis 4:** For EL, an increase in the partner’s risk aversion level \( a_j \) increases the investment level of an investor \( i, s_i \).

**Hypothesis 5:** For PRO, an increase in the partner’s risk aversion level \( a_j \) has no effect on the investment level of an investor \( i, s_i \).

### 4 Experimental Design and Procedures

The experiment was designed to address the five hypotheses listed in Section 3. It had two stages.

In the first stage of the experiment, we elicited the risk attitude of each subject by using the Holt and Laury (2002) method: subjects were offered ten pairs of lotteries (situations) and asked to pick one from each (as summarized in Figure 3 of the Appendix). In Situation 1, the less-risky lottery (Option A) has a higher expected payoff than the more-risky one (Option B). Hence, only very strong risk

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6This condition simply guarantees that the returns in case of success outweigh the losses incurred in case of bankruptcy.
lovers pick Option B in this situation. Moving further down the table in Figure 3, the expected payoff difference between the lotteries in Option A and in Option B decreases and eventually turns negative in Situation 5. In Situation 10, all subjects must choose between a sure payoff of 400 token (Option A) and a sure payoff of 770 token (Option B). Since Option B offers a higher payoff in this last situation, by then all subjects should have switched from Option A to Option B. In this experiment, a consistent subject should switch from Option A to Option B just once. However, earlier experiments using Holt and Laury’s (2002) method showed that some subjects may go back and forth between Option A and Option B. To prevent such behavior in our experiment, we asked subjects the situation number at which they wanted to switch from Option A to Option B. With these payoffs, it is optimal for a risk-neutral subject to switch from Option A to Option B in Situation 5. Similarly, it is optimal for a risk-averse (risk-loving) subject to switch from Option A to Option B after (before) Situation 5. The payment for this stage was determined according to a randomly chosen row among these ten situations and the subject’s lottery choice in that particular row.

The second stage of the experiment replicated the Kıbrıs and Kıbrıs (2013) model summarized in Section 3. In this stage, we implemented a $2 \times 2 \times 2$ design. Namely, we varied the bankruptcy rule (EL or PRO), success rate ($p = 0.3$ or $p = 0.6$), and risk information about teammate (teammate’s risk group is given or not). We used a between-subject design for success rate and risk information treatments and a within-subject design for the bankruptcy rule treatment. The within-subject design for the bankruptcy rules allowed us to isolate the effect of the bankruptcy rule on investment. In particular, this way we were able to control the risk-aversion distribution of the subject group (by keeping the group intact) while changing only the bankruptcy rule. The parameters and the conditions for each of the eight treatments are summarized in Table 1. In all treatments we kept the fraction that survives bankruptcy ($\beta = 0.4$) and the return rate in the case of success ($r = 1$) constant.  

There were 14 sessions in total. We had 7 sessions with the high success rate (in 3 of which, the teammate’s risk information was given, in 4 of them not) and 7 sessions with the low success rate (in 4 of which, the teammate’s risk information was given, in 2 of which, it was not given.

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### Table 1: Treatments

<table>
<thead>
<tr>
<th>Bankruptcy rule</th>
<th>EL</th>
<th>EL</th>
<th>EL</th>
<th>EL</th>
<th>PRO</th>
<th>PRO</th>
<th>PRO</th>
<th>PRO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Success rate ($p$)</td>
<td>0.6</td>
<td>0.3</td>
<td>0.6</td>
<td>0.3</td>
<td>0.6</td>
<td>0.3</td>
<td>0.6</td>
<td>0.3</td>
</tr>
<tr>
<td>Teammate’s risk information</td>
<td>Given</td>
<td>Given</td>
<td>Not</td>
<td>Not</td>
<td>Given</td>
<td>Given</td>
<td>Not</td>
<td>Not</td>
</tr>
</tbody>
</table>

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7Each subject participate this stage only once. Throughout the experiment, payoffs were described in terms of “tokens”. A hundred tokens corresponded to one Turkish Lira.

8We chose the parameters so that the subjects had ample incentive not to deviate from their equilibrium actions under the CARA utility functions used in Kibris and Kibris (2013) as well as an alternative CRRA utility representation as a robustness check.
in 3 of them not). Each session was organized with a within-subject block design: each subject went through 9 rounds of the EL bankruptcy rule, followed by 9 rounds of PRO, and then again 9 rounds of EL, and 9 rounds of PRO again (EL-PRO-EL-PRO). For each between-subject design treatment (risk aversion information and success rate) we also conducted PRO-EL-PRO-EL sessions to check for possible order effects.

To each of the computerized experimental sessions we typically admitted 12 subjects. At the beginning of each session, participants were divided into matching groups of 4, in order to avoid dependencies between all observations of one session. In a given round, the subjects interacted in pairs and during the 9 rounds of a given block, each subject was matched with every other member of this matching group exactly three times. The order of these matchings were also randomly determined. This procedure was not explicitly stated in the instructions but the subjects were told that while it is possible to be matched with the same person in two consecutive rounds, the person they are matched with will likely be different at each round.

In the experiment, each subject went through the following stages. First, they made their choices for the first stage. Their payoffs from the first stage were only revealed at the end of the experiment. At the beginning of the second stage, the subjects were informed that they would play 4 blocks of 9 identical rounds, that is, in total they would play 36 rounds. They were also told that before each block starts, they would be given information about the game they would play in that block. Block 1 in the Appendix presents the instructions we used for bankruptcy rule EL when $p = 0.6$ and the teammate’s risk information was not given. The instructions in other treatments were similar. For the second stage, subjects were paid only for four periods (among 36) where each is drawn from a block, to avoid potential wealth effect.

For each period of the second stage, subjects were told that both they and their team member were given 400 tokens. Then, each subject had to decide how many of these tokens they would like to contribute into the team project (keeping the remaining tokens in their private account). In each team, the sum of the two teammates’ investments determined the value of their project. A randomization device chose between either doubling this value or reducing it to 40% of its original value. Depending on the treatment, the probability that the project value doubled was either 0.6 or 0.3 (thus, it decreased to 40% of the original value either with probability 0.4 or 0.7). If the project value doubled, both team members earned twice as much as their investment. If the project value decreased to 40% of the original value, the subjects’ payoffs were calculated by using the bankruptcy rule announced at the beginning of that block (EL or PRO). More specifically, if the bankruptcy rule was PRO (as in 18 rounds of each session) and the project value decreased, each subject earned 40% of his investment in that round. Alternatively, if the bankruptcy rule was EL (as in the remaining 18 rounds of each session) and
the project value decreased, each subject earned his investment minus half of the loss (i.e. 30% of the value of the project).

After each subject made his investment to the team project and the randomization was made, the subjects were informed about (i) their teammates’ investments to the project (being also reminded of their own), (ii) whether the project value increased or decreased (i.e. the result of the randomization), and (iii) both own and teammates’ payoffs in that round. Then, each subject was randomly and anonymously matched with another subject and the next round started.

At the end of the session, the subjects’ payoffs were calculated from the first and the second stages. For the second stage, one round for each block (4 rounds in total) was randomly chosen and the total tokens won for that 4 rounds were given to the subject as the second stage payoff. The subjects also received a participation fee.

The sessions in which the subject was given the teammate’s risk information were similar to the ones explained above. The only difference was that at the end of the first stage, the subjects were asked which color they liked more, green or blue. Then, in each round of the second stage, they were given the following information about their teammates: (i) which color their teammate liked more, and (ii) whether their teammate switched from Option A to Option B at one of situations 1, ..., 5 (risk loving or risk neutral) or at 6, ..., 10 (risk averse). In the theoretical model it is assumed that each agent is informed about the other’s risk attitude, and this treatment tried to replicate that feature of the model. Nevertheless, in order to avoid an experimenter effect (where the subjects might feel like they should respond to such information), the risk-attitude information was given together with unnecessary information (i.e. favorite color).

In the instructions, a neutral language (employing the terms “project, team members, increase and decrease in project value, sharing scheme, and contribution to the team”) was used. First, the project corresponds to the firm, the members of a team correspond to the investors in the firm, an increase in the project value corresponds to the success of the firm, a decrease in the project value corresponds to the bankruptcy of the firm, a sharing scheme when the project value decreases corresponds to the bankruptcy rule, and contribution to the team project corresponds to investment in the firm.

Subjects were recruited by using posters hanged around the Middle East Technical University campus. The participants were undergraduate students. The experiment was computerized using z-tree (Fischbacher, 2007). Finally, 168 subjects participated in the experiment and a subject earned 27.2 TL on average, including a 5 TL participation fee.
Table 2: Mean and Standard Deviations

<table>
<thead>
<tr>
<th>Success Rate</th>
<th>Rule</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EL</td>
<td>PRO</td>
<td>Pooled over Rule</td>
</tr>
<tr>
<td>Low ( (p = 0.3) )</td>
<td>221.1(135.4)</td>
<td>194.1(137.6)</td>
<td>207.6(137.2)</td>
</tr>
<tr>
<td>High ( (p = 0.6) )</td>
<td>293.4(110.9)</td>
<td>280.5(116.8)</td>
<td>286.9(114.0)</td>
</tr>
<tr>
<td>Pooled over Success Rate</td>
<td>257.2(128.9)</td>
<td>237.3(134.7)</td>
<td></td>
</tr>
</tbody>
</table>

Notes: Average investment with respect to the bankruptcy rule and success rate. Standard errors are in parentheses.

5 Data

In this section, we provide a summary of our experimental data, including its descriptive statistics. In Table 2, we summarize the mean individual investment levels under the EL and PRO rules, as well as for when the investment data under the two rules is pooled; and for the high, low, and pooled success rates. The table suggests that, on average, EL yields substantially higher individual investment levels than PRO when the success rate is low, that this difference is somewhat mitigated (though not reversed) when the success rate is high, and is still there when the data is pooled over the success rate.\(^9\) Mann-Whitney tests suggest that, when the success rate is low there is a significant difference between the average investment levels under EL and PRO \( (p = 0.054, n = 21) \). The difference remains substantial when the success rate is high, nonetheless, it loses statistical significance \( (p = 0.455, n = 21) \). Motivated by this observation, we specifically analyze in the next section whether the association between bankruptcy rule and investment choice is conditional on the success rate.

As can be seen in Table 2, a higher success rate yields higher investment levels both under EL and PRO: investment levels increase by a factor of 1.44 under PRO and by a factor of 1.33 under EL. Mann-Whitney tests indicate that these differences are statistically significant. In other words, they support the hypothesis that observations under the high success rate come from a stochastically greater distribution than those under the low success rate, both under EL \( (p < 0.01, n = 42) \) and PRO \( (p < 0.01, n = 42) \).

In Figure 1, we present the time trend for the average investments to the group project under each one of the bankruptcy rules and success rates. Remember that, for a given session, subjects play with a fixed success rate \( (p = 0.3 \text{ or } p = 0.6) \) and go through 4 blocks of 9 rounds, with every block implementing a particular

\(^9\)At the time of the experiment, 1 $ corresponded to 2.25 TL.\(^{10}\)Note that the first part of this finding is seemingly stronger than our first theoretical hypothesis which stated an increase in only the total investment levels in response to a change in the bankruptcy rule. This is because the table presents an average over all subjects.
bankruptcy rule and the bankruptcy rule changing from one block to the next (in the order of either EL-PRO-EL-PRO or PRO-EL-PRO-EL). The figure shows that EL consistently produces higher investment than PRO and this difference is especially prominent under the low success rate. We also see that, in all cases but one (namely, PRO with a low success rate), the subjects increase their investments as they gain experience.

In Figure 2, we present the histograms for investment levels under the high and low success rates, respectively. These figures imply that a move from PRO
to EL slightly increases the fraction of subjects who invest all their endowment. Additionally, a move from PRO to EL slightly decreases the fraction of subjects who choose zero investment. We address this issue in more detail in our regression analysis, presented next.

6 Analysis

In this section, we analyze our experimental data. More specifically, we provide detailed regression analyses of individual investment decisions. We control for many relevant factors that can potentially affect a subject’s investment choices, such as the subject’s risk attitude, gender, information, or experience about previous rounds, as well as the order of treatments in the experiment. We then use the regression results to test the validity of our five hypotheses stated at the end of Section 3. In this section, we also discuss the determinants of a subject’s likelihood of making extreme investment choices.

We model individual investment as a linear function of the bankruptcy rule, the success rate, as well as a subject’s personal characteristics such as gender, level of risk aversion, awareness of partner’s risk attitude, and number of prior rounds in which he or she played with the same bankruptcy rule. Note that subjects were only allowed to invest nonnegative amounts and they were also constrained by the total amount of funds (400 tokens) available to them at each round. Consequently, to model the investment choices of our subjects, we employed a random effects Tobit regression analysis in which we accounted for unobserved subject level factors with random effects. The results are presented in Table 3. In what follows, we use these results to test our first three hypotheses.

Our first hypothesis is that switching from PRO to EL increases total investment. The estimated coefficient for the bankruptcy rule indicator shows that switching from PRO to EL is on the average associated with a 28.2 unit increase in individual investments. With higher individual investments, total investment is then expected to be 56.4 units higher under EL compared to PRO, yielding clear support for our first hypothesis. Given that the average individual investment under PRO was 237 units out of 400, the switch from PRO to EL then corresponds on the average to a 12% jump in individual (and total) investments holding other factors constant.

Note that the Mann-Whitney tests we report in the previous section signal that the difference in investment levels under EL and PRO might be dependent upon the success rate. To follow up on that signal, we rerun our model with the inclusion of an interaction variable between the bankruptcy rule and the success rate. The results are reported in the second column of Table 3. As can be seen, the difference between investment levels under EL and PRO remains significant regardless of the success rate. Nonetheless, it is almost twice as high when the success rate is low compared to when it is high. Note that this finding is not surprising from a
Table 3: Results on Investment Choice

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th># of obs.: 6048</th>
<th># of subjects: 168</th>
<th>Obs. per subject: 36</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bankruptcy rule indicator (EL=1, PRO=0)</td>
<td>28.20***</td>
<td>37.37***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(7.13)</td>
<td>(6.79)</td>
<td></td>
</tr>
<tr>
<td>Success rate indicator (High=1, Low=0)</td>
<td>119.07***</td>
<td>128.42***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(6.92)</td>
<td>(7.27)</td>
<td></td>
</tr>
<tr>
<td>Interaction between bankruptcy rule and success rate</td>
<td></td>
<td></td>
<td>-18.92***</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(-2.39)</td>
</tr>
<tr>
<td>Availability of information on partner’s risk attitude indicator</td>
<td>15.33</td>
<td>15.38</td>
<td></td>
</tr>
<tr>
<td>(Available=1, Not available=0)</td>
<td>(0.90)</td>
<td>(0.90)</td>
<td></td>
</tr>
<tr>
<td>Stage at which the subject switches from option A to option B in the first stage (from 0 to 10)</td>
<td>-13.13***</td>
<td>-13.15***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(-2.95)</td>
<td>(-2.96)</td>
<td></td>
</tr>
<tr>
<td>Experience with the bankruptcy rule (number of rounds played under the same rule)</td>
<td>2.67***</td>
<td>2.67***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(7.03)</td>
<td>(7.04)</td>
<td></td>
</tr>
<tr>
<td>Bankruptcy rule in the first round indicator (EL=1, PRO=0)</td>
<td>15.85</td>
<td>15.94</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.92)</td>
<td>(0.93)</td>
<td></td>
</tr>
<tr>
<td>Gender indicator (male=1, female=0)</td>
<td>5.98</td>
<td>5.92</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.35)</td>
<td>(0.34)</td>
<td></td>
</tr>
</tbody>
</table>

z-values in parentheses.
***: statistically significant at 1% level.
theoretical perspective. An increase in the success rate decreases the likelihood of bankruptcy and thus, renders the bankruptcy rule less relevant for the subjects in determining investment levels.

**Hypothesis 2** states that an increase in the probability of success in turn increases individual investment. This hypothesis is also supported very strongly by the regression results. The estimated coefficient indicates that higher success probability is associated with substantial increases in investment levels. In fact, given the average investment levels reported in Table 2, a switch from low to high success probability is associated with more than a 50% increase in investment levels.

**Hypothesis 3** states that an increase in the investor’s own risk aversion corresponds to a decrease in his investment level. Our regressions also lend support to this hypothesis. A subject’s risk-aversion level turns out to be significantly and negatively associated with his investment levels. In particular, one unit increase in the switching point during the Holt-Laury procedure is associated with a 13 unit decrease in individual investment (3.25% of the endowment).

To test hypotheses 4 and 5 we modified our original model to include partner’s risk group and analyzed its association with investment choice under the two bankruptcy rules separately. (Note that because the interaction between partner’s risk group and bankruptcy rule turns out to be 96% correlated with the bankruptcy rule, we are not able to conduct a pooled analysis.) Partner’s risk group is a binary variable. It takes on the value 1 if the individual’s partner is risk-lover or risk-neutral, or in other words, if the individual’s partner switched from option A to B before situation 6 in Step 1 of the experiment. Similarly, it takes on the value 2 if the individual is risk-averse, or in other words, if the individual’s partner switched from option A to B after situation 5. If hypotheses 4 and 5 are supported by the data we should observe partner’s risk group to have a significant positive association with investment levels under EL, and we should observe this significant association disappear under PRO. Table 4 presents the results. As can be seen, we fail to find a statistically significant association between partner’s risk attitude and choice of investment levels regardless of the bankruptcy rule in place. In other words, our empirical evidence fails to provide support for Hypothesis 4. Nonetheless, we can not reject Hypothesis 5.

Finally, we checked whether the bankruptcy rule in play has anything to do with a subject’s likelihood of choosing extreme investment levels (that is, full or zero investment). To this end, we coded our dependent variable as a bivariate one which takes the value 1 if a subject chooses full (zero) investment in a given round and 0 otherwise. Then we ran random effects probit regression analyses with the same set of controls as in our Tobit model to investigate the association between the bankruptcy rule and the probability of choosing extreme investment levels.

The results on the likelihood of extreme investment choices are presented in Table 5. The first column reveals that the likelihood of a subject investing all of his
Table 4: Results on hypotheses 4 and 5

<table>
<thead>
<tr>
<th>Results of the Random Effects Tobit Regressions</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Random effects at the subject level</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Dependent Variable</strong>: Contribution to the investment game</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Independent Variables</strong></td>
<td>under EL</td>
<td>under PRO</td>
</tr>
<tr>
<td>Success rate indicator (High=1, Low=0)</td>
<td>101.60*** (3.21)</td>
<td>102.53*** (4.41)</td>
</tr>
<tr>
<td>Stage at which the subject switches from option A to option B in the first stage (from 0 to 10)</td>
<td>-5.16 (-0.56)</td>
<td>-4.94 (-0.75)</td>
</tr>
<tr>
<td>Risk group of the partner (0= Risk lover, 1= Risk averse)</td>
<td>6.21 (0.59)</td>
<td>-9.51 (-0.84)</td>
</tr>
<tr>
<td>Experience with the bankruptcy rule (number of rounds played under the same rule)</td>
<td>4.60*** (6.17)</td>
<td>1.36 (1.70)</td>
</tr>
<tr>
<td>Gender indicator (male=1, female=0)</td>
<td>20.72 (0.65)</td>
<td>-38.53 (-1.63)</td>
</tr>
</tbody>
</table>

z-values in parentheses.
***: statistically significant at 1% level.
endowment is significantly higher under EL compared to the same likelihood under PRO. In line with the results we obtained for our original model, subjects are more likely to invest all their endowments when success rate is higher, and less likely to do so as they become more risk averse.

The second column of Table 5 reports the results on the likelihood of zero investment. As can be seen there, our findings are similar to the previous case. The estimated coefficients show that the likelihood of a subject investing nothing is significantly lower under EL compared to under PRO. Similarly, subjects are much less likely to choose zero investment under the higher success rate scenario. Unlike the case of investing all endowment, risk aversion has no significant effect on the likelihood of making zero investment, which seems to be determined mainly by the bankruptcy rule and the return rate.

Interestingly, subjects become more likely to make these extreme choices (full or zero investment) as they gain more experience with a given rule. We also find a significant gender effect, suggesting that male subjects have a higher likelihood of making extreme investment choices than female subjects. This result is consistent with other findings in the literature (e.g. see Bajtelsmit and VanDerhei, 1997; Bajtelsmit, Bernasek, and Jianakoplos, 1996; Hinz, McCarthy, and Turner, 1997; Yuh and Hanna, 1997).

7 Conclusion

We report results from experiments that compare subjects' investment behavior under two alternative bankruptcy rules, EL and PRO. Additional to changes in the bankruptcy rule, our treatments allow the invested firm's success rate to be either high or low and information about the partner's risk attitude to be either supplied or not.

Our findings support four of the five hypotheses forwarded by theoretical studies. More specifically, we find that EL induces higher total investment levels than PRO. Holding other factors constant, the switch from PRO to EL corresponds on the average to a 12% jump in individual (and total) investments. We also find that a higher success rate induces higher investment levels, both under EL and PRO. Finally, we observe that subjects with higher risk aversion levels tend to choose lower investment choices decrease by their own risk aversion.

Our analysis does not support Hypothesis 4, which stated that an agent's investment choices under EL responds to information about his partner's risk attitude. We believe there are two potential reasons for this. First, to guarantee a significant difference between predicted investment levels under EL and PRO, we chose to provide a coarser than actual information to subjects about their partner's risk aversion levels. More specifically, the subjects were either told that their partner was risk averse (corresponding to a switch from A to B in situations 6,...,10) or
Table 5: Results on Extreme Investment Choices

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>Full Contribution Indicator (Full contribution: 1, Otherwise: 0)</th>
<th>Zero Contribution Indicator (Zero contribution: 1, Otherwise: 0)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bankruptcy rule indicator (EL=1, PRO=0)</td>
<td>0.157*** (3.73)</td>
<td>-0.276*** (-4.09)</td>
</tr>
<tr>
<td>Success rate indicator (High=1, Low=0)</td>
<td>0.795*** (4.53)</td>
<td>-1.215*** (-5.49)</td>
</tr>
<tr>
<td>Availability of information on partner’s risk attitude indicator (Available=1, Not available=0)</td>
<td>0.263 (1.51)</td>
<td>0.392* (1.86)</td>
</tr>
<tr>
<td>Stage at which the subject switches from option A to option B in the first stage (from 0 to 10)</td>
<td>-0.156*** (-3.49)</td>
<td>-0.059 (-1.13)</td>
</tr>
<tr>
<td>Experience with the bankruptcy rule (number of rounds played under the same rule)</td>
<td>0.054*** (12.92)</td>
<td>0.054*** (8.08)</td>
</tr>
<tr>
<td>Bankruptcy rule in the first round indicator (EL=1, PRO=0)</td>
<td>0.088 (0.51)</td>
<td>0.255 (1.19)</td>
</tr>
<tr>
<td>Gender indicator (male=1, female=0)</td>
<td>0.354** (2.01)</td>
<td>0.633*** (3.02)</td>
</tr>
</tbody>
</table>

z-values in parentheses.  
***: statistically significant at 1% level.  
**: statistically significant at 5% level.
not risk averse (corresponding to the remaining cases). This significantly decreased the variance since most subjects belonged to the risk-averse group. So, as the subjects were matched with a new partner in every period, the information about the partner rarely changed. In particular, the subjects could not differentiate the behavior of risk averse subjects from the behavior of risk loving subjects as they played the game repeatedly. The second reason is also related to our experimental design. Costa-Gomes and Weizsäcker (2008) find that a subject pays more attention to the opponents’ incentives when she is asked to state her beliefs about it. Since, we do not ask about the subjects’ beliefs in the experiment, it might have been that they were not very sensitive to this information.\footnote{Büyükboyacı (2014) showed that even though subjects responded to their opponents’ risk-aversion information while choosing their actions, they did show no strategic sophistication on guessing how others may have chosen their actions with the same information.}

Our experiments also check whether the bankruptcy rule in play has anything to do with a subject’s likelihood of choosing an extreme (that is, zero or full) investment level. Our results reveal that the likelihood of a subject investing all (none) of his endowment is significantly higher (lower) under EL than under PRO. Also, the subjects are more (less) likely to invest all (none) of their endowments under a high success rate and a low level of risk aversion. Interestingly, the subjects are more likely to make these extreme choices as they gain more experience with a given rule.

We also find a significant gender effect, suggesting that male subjects have a higher likelihood of making extreme investment choices than female subjects.

In this study, we treat the bankruptcy rule as an exogenous variable. It would be very interesting to see whether endogenous determination of the bankruptcy rule would affect the subjects’ investment choices. Another interesting question is the role of bankruptcy (sharing) rule in team contests. Both questions are left for future research.

References


8 Appendix: Instructions Used in the Experiment

Welcome and thank you for participating in our experiment!

We will read the instructions together. Please do not touch the keyboard for now and listen to these instructions carefully.

This is an experiment about economic decision making. All participants will earn some money during the experiment. The money you earn might be different from the other participants' earnings. This amount is dependent on your decisions as well as the decisions of other participants. Please do not talk to each other during the experiment. We will have to terminate the experiment if you violate this rule. We will now describe the experimental procedures. It is very important that you understand all the parts. Please raise your hand if you have a question.

There will be two parts in our experiment. You will be instructed about each part before it starts. Your aim in both parts is to earn as much money as possible. At the end of the experiment, you will learn about your total earnings from each part. Your earnings will be in tokens. 100 tokens corresponds to 1 TL. Your total earnings will be rounded to the nearest 25 kurus. In addition to your earnings in the experiment, you will be paid a 5 TL participation fee.

**PART 1**

You will see a table like this in stage 1. In this part, you will face 10 different rows.

<table>
<thead>
<tr>
<th>Option A</th>
<th>Use the slider to choose between options A and B</th>
<th>Option B</th>
</tr>
</thead>
<tbody>
<tr>
<td>400 tokens with probability 10%, 325 tokens with probability 90%</td>
<td>A Slider</td>
<td>B Slider</td>
</tr>
<tr>
<td>400 tokens with probability 20%, 325 tokens with probability 80%</td>
<td>A Slider</td>
<td>B Slider</td>
</tr>
<tr>
<td>400 tokens with probability 30%, 325 tokens with probability 70%</td>
<td>A Slider</td>
<td>B Slider</td>
</tr>
<tr>
<td>400 tokens with probability 40%, 325 tokens with probability 60%</td>
<td>A Slider</td>
<td>B Slider</td>
</tr>
<tr>
<td>400 tokens with probability 50%, 325 tokens with probability 50%</td>
<td>A Slider</td>
<td>B Slider</td>
</tr>
<tr>
<td>400 tokens with probability 60%, 325 tokens with probability 40%</td>
<td>A Slider</td>
<td>B Slider</td>
</tr>
<tr>
<td>400 tokens with probability 70%, 325 tokens with probability 30%</td>
<td>A Slider</td>
<td>B Slider</td>
</tr>
<tr>
<td>400 tokens with probability 80%, 325 tokens with probability 20%</td>
<td>A Slider</td>
<td>B Slider</td>
</tr>
<tr>
<td>400 tokens with probability 90%, 325 tokens with probability 10%</td>
<td>A Slider</td>
<td>B Slider</td>
</tr>
<tr>
<td>400 tokens with probability 100%, 325 tokens with probability 0%</td>
<td>A Slider</td>
<td>B Slider</td>
</tr>
</tbody>
</table>

Figure 3: Holt-Laury instrument in Part 1

Each row provides two options, Option A and Option B. You will slide the bar in the middle to show which option you chose for that situation. These options

---

1 TL is 100 kurus
are basically lotteries that indicate your chances of winning a certain payoff. For each row, you will be asked to choose one among option A and option B. Choosing Option B at some row automatically means that you choose Option B in all the rows below it.

For instance, consider Row 1. In Row 1 Option A offers 400 tokens with probability 1/10 and 320 tokens with probability 9/10. In Row 1 Option B offers 770 tokens with probability 1/10 and 20 tokens with probability 9/10.

Your earnings from this part will be determined as follows: First the system will pick a number between 1 and 10. This number will tell us the row that will be used in determining your earnings from this part.

Suppose that this number turns out to be 7 and that you have chosen option A for row 7. The system will choose another number between 1 and 10. If this number is 7 or smaller (with probability 7/10), you will earn 400 tokens. If this number is 8 or larger (with probability 3/10), you will earn 320 tokens.

**PART 2**

This stage will consist of 36 periods: 4 blocks of 9 identical decision periods in each block. Before the start of each block you will be given information that is relevant for the following 9 periods. Once the block is over, you will receive information that will be relevant for the next 9 periods and so on. (The instructions below are for the bankruptcy rule EL when \( p = 0.6 \) and the teammate’s risk information was not given. Instructions used in other treatments were similar.)

**Block 1:** (please see Figure 4)

At the beginning of each period, you will be matched with another subject randomly and you will form a team with him/her. Your teammate will change in every period. The identity of your teammate will not be revealed to you at any time.

At the beginning of each period, you will be given 400 tokens as your endowment. Then, you will decide how many of these tokens to contribute to the team project (between 0 and 400) and how many of them to keep in your private account. You will enter your contribution to the team project into the box on the screen.

Similarly, your teammate will be given 400 tokens as his/her endowment. Then, he/she will be asked to choose how many of these tokens to contribute to the team project and how many of them to keep in his/her private account. Both your contribution and your teammates contribution can be any number between 0 and 400.

The value of the project will be determined as the sum of your and your teammate’s contributions. Once the value of the project is determined this way, we will randomly choose a number between 1 and 10. If it is 6 or lower (occurring with probability 6/10): The value of the project doubles. If it is higher than 6, the value
of the project shrinks to 40% of its original value. If the value of the project doubles, period earnings for each group member will be 2 times her contribution to the project plus the tokens she keeps in her private account. If the value of the project shrinks to 40% of its original value, period earnings for each group member will be the tokens she keeps in her private account plus her contribution to the project minus half of the total loss (0.3 times total contributions).

After you and your teammate state your contribution levels, you will observe the following on the screen: (i) Both your and your teammate’s contribution levels, (ii) Whether the value of team project increased or decreased, and (iii) Your earnings for that period.

This will be the end of the current period. You will then move on to the next period where you will be randomly matched with someone to play the game again.

**Example 1:**

- Suppose you contribute 220 of your 400 tokens and you keep 180 tokens in your private account.

- Your teammate contributes 280 of his 400 tokens to the team project and keeps 120 tokens in his private account.

- The value of the project is 220 + 280 = 500.

- Then a random number from 1 to 10 is selected and it comes out as 8 (higher than 6).
• The value of project becomes $500 \times 0.4 = 200$. The loss in the value of the project is $500 - 200 = 300$

• Your period payoff is: $180 + 220 - 300/2 = 250$.

• Your teammates’ period payoff is: $120 + 280 - 300/2 = 250$.

*Example 2:*

• Suppose you contributed 200 of your 400 tokens and you keep 200 tokens in your private account.

• Your teammate contributed 240 of his 400 tokens to the team project and keeps 160 tokens in his private account.

• The value of the project is $200 + 240 = 440$.

• Then a random number from 1 to 10 is selected and it comes out as 3 (lower than 6).

• The value of project becomes $440 \times 2 = 880$.

• Your period payoff is: $200 + 200 \times 2 = 600$.

• Your teammates’ period payoff is: $160 + 240 \times 2 = 640$. 