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RESEARCH

Exempting agents from any burden sharing: A lab-experimental study on the distribution of a monetary loss

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Abstract
We present findings of an experimental study of negotiations over the share of a monetary loss. Groups of four agents with differing initial endowments must unanimously agree on the contribution that each member is expected to make so that a financial loss imposed on the group is covered. Two types of proposals are of particular interest: Either the agent with the lowest endowment or the agents with the lowest and second lowest endowment are to be exempted from any monetary contribution. These types of proposals can be related to alternative models of loss sharing that will be briefly discussed before presenting the experimental results. We find that exempting the agent with the lowest endowment only was expressed in 120 proposals, exempting the lowest and the second lowest agents only accounted for 50% of all 428 proposals. We consider two different treatments in case of no agreement among the group members, namely a random mechanism among all the proposals made before the bargaining procedure has ended, and, alternatively, a decision taken by the experimenter after bargaining time has elapsed. We also discuss a third type of proposal that we call "other exemptions" which contains rather nasty loss-division proposals that contradict the very idea of fairness and examine our findings in such contexts particularly under the aspect of gender difference.

Keywords Experimental bargaining · Loss sharing · Exemption from any contribution · Gender differences

JEL Classification C 91 · D 63 · D 71

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1 Introduction

In the economics literature monetary losses have not received the same degree of attention as monetary gains. Losses seem to reflect some kind of deficiency whereas gains or a cooperative surplus are a symbol of success. However, pecuniary losses of high dimension occurred in several South European countries and elsewhere after the collapse of Lehman Brothers in 2008, and during the last years it had become visible that the Corona pandemic generated an even bigger slump in many industrialized countries worldwide. The "Brexit" decision by a majority of voters in the UK in 2016 is another example which led to severe economic losses for the United Kingdom and, to a minor degree, for the European Union. How and by whom should such societal and monetary losses be borne?

If such real-world problems are the "end square" on the game board, in this paper, we provide insights to the "start square" problem via an incentivized experiment: when facing a collective monetary loss (the amount is certain and known to everyone) under a consensus rule, how do people with different endowments or incomes negotiate to share such a loss? We are particularly interested in the behavior of agents at the lower and upper end of the scale in situations in which a burden has to be divided.[1]

During the last three or four decades, economic theory offered a multitude of concepts which prescribe how a benefit or loss should be shared. The proportional solution and the egalitarian rule were axiomatically characterized by Moulin (1987, 2002), the properties underlying the constrained equal-awards and the constrained equal-losses rule were studied by Herrero and Villar (2001) and Moulin (2002), and several other scholars came forward with modifications of these rules as well as with other solution concepts (see, among others, Aumann and Maschler 1985; Pfingsten 1991; Ju et al. 2007; Thomson 2003, 2013, 2015, 2019). Young (1988) provided a characterization of the equal sacrifice rule in taxation, a particular kind of loss, so to speak.

Over the years, many experiments were run in which agents bargained over a monetary surplus. Recently, literature has also seen a larger number of two-person ultimatum games in which situations of gains and losses were compared (Buchan et al. 2005; Zhou and Wu 2011; Berger et al. 2012; Neumann et al. 2017). Various experiments showed an increase in prosocial behavior or generosity in the loss context (Baquero et al. 2013, Cochard et al. 2020, Guo et al. 2013, Thunström 2019, Wu 2014, Yin et al. 2017, Zhang 2022). Several studies investigated multilateral bargaining over losses. In Baranski (2016), five committee members decide how to share the proceeds from a common project. In Christiansen et al. (2018) and in Kim and Lim (2024), equally endowed group members decide via a quota voting rule on a loss that increases over multiple rounds. In a coordination game based on the majority principle, the proportionality principle gained wide support (Herrero et al. 2010). A similar result was reached for third-party arbitrators in bankruptcy situations (Cappelen et al. 2019). Gaertner et al. (2019) could only find mild support for the proportionality rule in their own set-up of a bargaining game. Proportionality trailed behind equal split and constrained equal awards in free-form bargaining with asymmetric claims (Gächter and Riedl 2006).

[1] We would never claim that our rather simple experimental set-up can adequately reflect the economic and socio-economic repercussions and turbulences that hit various parts of Southern Europe and elsewhere almost two decades ago nor the social, political, and economic complexity of the recent pandemic which heavily affected larger sections of society. We think, however, that our findings about grades of exemption indicate interesting attitudes both with respect to the lower end and the upper end of a community and the distributional sensitivity of those affected, namely both politicians and citizens.

The scenario we focus on in this paper differs from the settings in most of these studies. We consider cases in which several agents who have *veto power* possess differing amounts of an initial endowment (real money) which are assigned to them via a random mechanism. They face a situation in which they are required or forced to give some of this endowment away so that they will no longer be able to keep their status quo allocation. We consider under differing economic endowments but the same degree of influence how agents will distribute the collective loss. How will agents grapple with such a problem in an experimentally incentivized environment? Will some agent(s) be exempted altogether from any burden sharing? More concretely, we examine situations with four players gathered in a group who have to negotiate an outcome, i.e., a division of a loss that this group has to bear. Our results show that two types of proposals in particular seem to be well equipped to explain a variety of findings that we obtained. One type proposes exempting the agent with the lowest endowment from any loss contribution, the other type goes even further in so far as it suggests exempting the agents with the two lowest endowments from any contribution. Equal split and proportionality, where no agent is exempted, were considered as possible solutions as well but both rules clearly trailed in our investigations.

The focus on the exemption of the lowest and the second lowest initial position no doubt has a Rawlsian flavor. As already mentioned, the distribution of the initial endowments in our set-up will be a matter of luck. In his own context, Rawls (1973, pp. 73-75) argues that the distribution of wealth and income is determined “by the natural distribution of abilities and talents”. These are the outcomes of a natural lottery, “and this outcome is arbitrary from a moral perspective” (p. 74). Rawls continues to say that “since inequalities of birth and natural endowment are undeserved, these inequalities are to be somehow compensated for” (p. 100). This calls for what Rawls denotes as redress, namely a particular kind of exemption to bring about fairness. Clearly, what Rawls formulates above is a normative claim which will also be visible in the data that we received in our experiments.

In section 2 we describe our experimental set-up (a detailed protocol of our game and the instructions to the participants are included in Supplementary material to this paper). Section 3 presents a brief theoretical analysis of three models of loss sharing that may prove useful to explain a major part of our experimental findings, before we describe and analyze these findings in detail in Section 4. Section 5 offers some concluding remarks and formulates some tasks for future research. Additional tables are relegated to Supplementary material.

2 Experiments over loss sharing

2.1 General setup

We consider a situation of unequal endowments. A total amount of 50 Euros[2] is distributed randomly to four participants in each group where the assignment vector is (5, 10, 15, 20). As soon as the participants entered their code number, they knew the position that had been assigned to them. The players are informed that a total amount of 10 Euros has to be handed back to the experimenter. Agents with an initial endowment of 5, 10, 15 or 20 monetary units will henceforth be abbreviated as P5, P10, P15 or P20 players.

One randomly chosen member within each group will have two minutes to make a first proposal of how to distribute the loss of 10 Euros among the members of this group. Proposals

[2] Pounds instead of Euros were used in our experiments in the United Kingdom.

that lead to individual losses higher than a person's initial endowment are not accepted. After this first proposal, the other members of the group are asked to either accept or reject the proposal. These players have one minute to decide. Should they remain "silent", this will be taken as acceptance of the proposal. If the proposal is accepted by *all* members of the group (we call this "the solution"), the experiment is considered over for these four players.

Should there be no agreement after the first round, i.e., at least one of the three other group members objects, a second person in this group (different from the first) will be randomly selected and make a proposal of how to split up the loss of 10 Euros. As long as no agreement is reached among the group members, a new person is randomly chosen to propose a distribution of the loss. If no agreement is reached after all four players' proposals, it will start over again—a new proposer is chosen among the four with an equal chance.

Whenever at any point in the game, one proposal receives unanimous agreement, the experiment is over and the procedure is as described above. There is a 20-min time limit for each experiment. If after 20 min, no past proposal received unanimous support, the experiment is terminated automatically.

The treatments were two different ways of selecting the final resolution in case no consensus was achieved within 20 min:

(a) "random" treatment: a random mechanism will pick one of the past proposals as the final decision on the share of the loss;
(b) "experimenter" treatment: the experimenter takes a decision on their own in order to resolve the deadlock.

At first sight, the "random" treatment comes close to Rawls's notion of a natural lottery. Randomness determines the initial position of our players which according to Rawls calls for redress. However, the reader will see that when introduced to our main results in Sect. 4, a second thought suggests a strategic aspect in so far as in the case of no agreement after the time limit, a random mechanism determines the final loss allocation. This means that whenever an agent has the chance to propose a loss distribution, they may propose a distribution very favorable to themselves. Such a proposal will most probably find no acceptance among the other agents; however, there is some hope that it will finally be selected via the installed mechanism. In other words, in those instances there is no trace of Rawlsian redress but brute luck or failure.

The "experimenter" treatment, *par contre*, introduces, at least with a certain probability, a fairness aspect. The random assignment of initial endowments is a kind of natural lottery undoubtedly, but the experimenter may follow an idea about what a fair loss distribution should look like and then may act accordingly. That this thought is not pure fantasy will also be seen in Sect. 4.[3]

At this point, we would like to comment on two features of our bargaining game. First, in contrast to related experiments, e.g. by Gächter and Riedl (2006) or by Cappelen et al. (2019), we consider games with four rather than two participants. This allows us to observe distributional aspects somewhat more than it is possible in a two-person constellation. The second feature is the issue of unanimity. If unanimous consent were not required, the method of simple

[3] Apart from the treatment with the experimenter's final decision in case of no agreement, one might have introduced unaffected observers completely outside the game to propose a loss division. Their judgment can be assumed to follow fairness principles without any strategic undertone but admittedly, we did not execute this variant at the time of our experiments due to budgetary constraints. One may argue, however, that the experimenter is in some way replacing the outsider's role.

Table 1 Overview of sessions

Place	Date	Unequal Endowments	Number of groups reached consensus
Halle	April 30, 2015	6 groups (40 proposals)	5 groups
Madrid	Oct. 21, 2015	6 groups (44 proposals)	4 groups
Galway	Nov. 26, 2015	7 groups (54 proposals)	5 groups
Berlin	January 28, 2016	4 groups (46 proposals)	2 groups
Halle	June 23, 2016	7 groups (53 proposals)	5 groups
London	July 5–6, 2017	8 groups (82 proposals)	5 groups
London	Nov. 20–21, 2017	13 groups (63 proposals)	12 groups
London	March 1–2, 2018	7 groups (46 proposals)	5 groups
Total number of groups		58 groups (428 proposals)	43 groups

majority decision or some related rule could lead to an exploitation of the minority, possibly but not necessarily the weakest or the strongest player(s) in terms of initial endowment (Christiansen et al. 2018; Kim and Lim 2024). This is something that we wanted to avoid.

We ran our experimental game on loss sharing between April 2015 and March 2018 at the Technical University of Berlin, the University of Ireland in Galway, the University of Halle-Wittenberg, the London School of Economics, and the University Carlos III in Madrid. Almost all students who participated in these experiments were enrolled in either economics or business administration so that we obtained a fairly homogeneous group of players. Table 1 provides an overview of the sessions that we ran at the various universities. Across all sessions of experiments with 232 subjects, we obtained 428 proposals from 58 groups and 181 individuals.[4]

3 Models of loss sharing and exemption

How would or could a proposal or a final solution to our experimental game look? A priori, "everything" can happen as long as the participants are not primed in one way or another, which was not the case in our series of experiments. A striking observation from our data is that among 428 proposals from our experiments, 214 (50%) chose to exempt individuals with the lowest or the lowest two endowments. In other words, they would like to have their groupmates walk away without any loss.

To tackle this prominent behavioral pattern, we first focus on several theoretical models with axiomatizations from the literature that have prescribed solutions that allow for exemption behavior.[5] The first two models have been widely applied in experimental bargaining, the third model is relatively new. Thomson (2019) discusses various other models, some of which are variants of the ones we consider in this paper.

[4] Not every subject proposed since an agreement may be reached before Round 4. For the cases where agreement had not been reached by Round 4, some subjects had the chance to propose more than once.

[5] Not all models allow for exemption. For example, the proportional rule is such that it distributes one's share of loss based on their share of the overall endowments. In other words, as long as one's endowment is positive, their share of loss is positive. We also focus on the theoretical models with axiomatizations where some ideal properties are satisfied.

3.1 Various models that allow for exemption

In the original setting of the bankruptcy problem with n individuals, each agent has a claim (c_i) and the overall available estate amount to share (E) is smaller than the sum of all the claims ($E \leq \Sigma_{i=1}^{n} c_i$). Then the question is how to allocate and distribute the current resource E to each agent. In our loss frame context, we adopt the notation in Gaertner and Xu (2020) to define a loss-sharing problem: the society consists of n individuals with $N = \{1, \dots, n\}$ and each has an endowment of $\omega_i \geq 0$. The society incurs a collective loss L to be distributed among the members such that $0 \leq L \leq \Sigma_{i \in N} \omega_i$. Denote $\xi = \left(\omega_1, \dots, \omega_n\right) \in \Xi$. The loss division problem therefore is defined as (L, ξ). A sharing rule is a mapping $f : \Xi \to \mathbb{R}_+^n, f(\xi) = \left(f_1(\xi), \dots, f_n(\xi)\right)$, where $f_i(\xi)$ represents the loss individual i with endowment ω_i incurs with constraints on $f_i(\xi) \geq 0, \forall i \in N$, and $\Sigma_{i \in N} f_i(\xi) = L$.

3.1.1 The Constrained Equal Award (CEA) rule

The CEA rule is widely applied in bankruptcy and bequest situations. CEA and its dual solution Constrained Equal Losses (CEL) were proposed by Aumann and Maschler (1985). While CEL divides the loss equally conditional on no one receiving a negative final wealth, CEA leads towards more equal gain, in our case, to a favorable treatment of those with the lowest endowments. The constrained equal awards rule can be defined in the following way with the notation introduced earlier: For all $\left(\xi, \Sigma_{i \in N} \omega_i - L\right)$ and all $i \in N, R_i\left(\xi, \Sigma_{i \in N} \omega_i - L\right)$, agent i's "award", is given by $R_i\left(\xi, \Sigma_{i \in N} \omega_i - L\right) = \min\left\{\omega_i, \lambda\right\}$, where $\lambda \in \mathbb{R}^+$ is a constant non-negative amount chosen so as to satisfy efficiency, which requires $\Sigma_{\mathrm{i} \in \mathrm{N}} R_i = \Sigma_{i \in N} \omega_i - L$. An awards vector for the CEA rule typically looks like $\left(\omega_1, \dots, \omega_i, \lambda, \lambda, \dots, \lambda\right), i < n$. In our experiments, where $\xi = (5, 10, 15, 20)$ and $L = 10$, the CEA rule prescribes a loss vector of $f(\xi) = (0, 0, 2.5, 7.5)$. This means that CEA would exempt the two lowest agents from any loss sharing, with the final allocation being $(5, 10, 12.5, 12.5)$. Exemption is first introduced as a property and used as one of the axioms to characterize CEA in Herrero and Villar (2001).

3.1.2 The Reverse Talmud rule

Another rule, the Reverse Talmud rule, proposed by Chun et al. (2001), also allows for exemption. Adapting to the loss sharing context, it states that when the loss is no more than half of the overall endowment, everyone keeps their half endowment first, and then CEA is applied to the remaining amount to determine the final award which then generates the final loss sharing distribution. When the loss is at least half of the sum of the endowments, then CEL is used to determine the loss with half of the endowments. Within the setting of our experiments, the solution to the Reverse Talmud rule for final wealth is $(5, \frac{55}{6}, \frac{35}{3}, \frac{85}{6})$, which is equivalent to the loss vector being $(0, \frac{5}{6}, \frac{10}{3}, \frac{35}{6})$. In other words, for the Reverse Talmud model, P5 is exempted.

3.1.3 The Gaertner-Xu rule

A third model was put forward in Gaertner and Xu (2020). The authors propose and axiomatically characterize a model that uses the average "burden" to everyone, $\frac{L}{n}$, as reference and then adds to this reference level a weighted proportion of the gap between an individual's endowment and the mean of individuals' endowments to compute individual i's share. The second term can be viewed as a position-dependent corrective to an equal division of the overall loss. The shared amount of loss for individual i is given by $f_i(\xi) = \frac{L}{n} + \alpha\big(\omega_i - \mu(\xi)\big), \forall i \in N$, where $\mu(\xi) = \frac{\omega_1+\dots+\omega_n}{n}$ denotes the mean of the endowments. The parameter α can be interpreted as a behavioural parameter. Given that the endowment vector in our experiments is $\xi = (5, 10, 15, 20), \alpha = \frac{1}{3}$ would lead to loss exemption of the agent with the lowest initial endowment. More precisely, for $\alpha = \frac{1}{3}$, the loss assignment vector would read $(0, \frac{5}{3}, \frac{10}{3}, 5)$; the final allocation would then be $(5, \frac{25}{3}, \frac{35}{3}, 15)$.[6]

3.2 Who should plausibly receive the status of exemption?

Let us zoom out to refocus on the exemption behavior pattern. In the following, we would like to discuss who should plausibly be exempted in our experimental setting. Given the endowments $\xi = (5, 10, 15, 20)$ and the collective loss $L = 10$, we would like to argue in favor of two basic monotonicity properties:

Monotonicity (i): individuals with higher endowments should contribute to the loss at least as much as those with lower endowments. That is, $0 \leq f_5 \leq f_{10} \leq f_{15} \leq f_{20}$.[7]

Monotonicity (ii): after loss sharing, the hierarchy of final wealth should correspond to the original hierarchy of initial endowments. That is, $0 \leq 5 - f_5 \leq 10 - f_{10} \leq 15 - f_{15} \leq 20 - f_{20}$.

Monotonicity properties (i),(ii) reflect some common sense towards fairness, and almost all theoretical solutions in bankruptcy problems follow both properties. We call proposals that satisfy both types of monotonicity "normal", and "abnormal" if otherwise.

First of all, P20 agents who have the highest endowment cannot get exempted. If they got exempted, then all the other players, namely P5, P10 and P15 should be exempted as well based on *Monotonicity (i)*, thus no loss could be shared. Second, P15 cannot get exempted. Otherwise, all the loss would fall on P20, which would result in P20 ending up with 10 Euros as their final wealth while P15 would have 15 units which would violate *Monotonicity (ii)*. So, in our set-up, only P5 or (P5 and P10) are the two plausible cases of exemption complying with the two monotonicity properties.

Therefore, we will single out these two cases below and refer to other cases as "other exemptions" (thus violating at least one of the monotonicity properties stated above) and "no exemption". We call "exempting P5 only" "exempting P10 and P5" "other exemptions" and "no exemption" four types of exemption. Notice that the four types of exemption are mutually exclusive and exhaustive over the whole sample.

4 Results

There are two main motivations reflected in each proposal: The proposer tries to maximize their own income and needs it to be considered as fair such that it gets accepted by every other group member. The self-interested income-maximizing motivation can be seen

[6] Note that this model which is continuous both in relation to loss L and the endowment vector as well as in relation to \alpha, is such that for no value of \alpha , one would achieve a loss exemption of the lowest two agents, namely P5 and P10.

[7] To make the notation simple and straightforward, without causing confusion, we use the endowment amount to represent the individual with that endowment and omit the ξ part in $f_i(\xi)$.

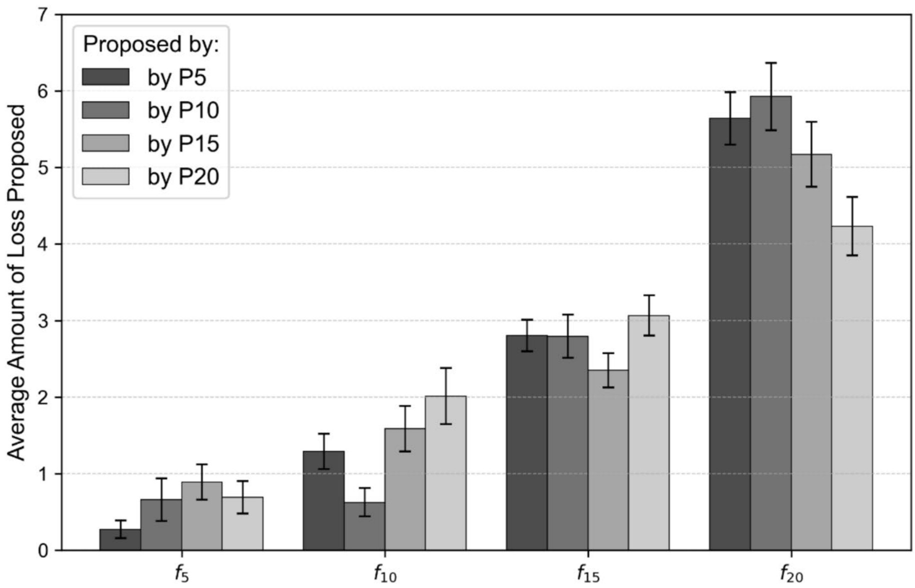

Fig. 1 Average amount of loss f_5,f_{10},f_{15},f_{20} proposed by P5, P10, P15 and P20 (with 95% confidence intervals displayed)

directly from the data: As Fig. 1 shows, the average of $f_i(i = 5, 10, 15, 20)$ is significantly lower when it is proposed by individual i compared to that by other group members. The Kruskal–Wallis tests (because of skewness in the data) show the significant differences in distributions of f_i from different proposers at the $p<0.001$ level for all $i = 5, 10, 15, 20$.[8]

Meanwhile, *Monotonicity properties (i),(ii)* are widely adopted as well. Out of 428 proposals, 335 (78.2%) satisfy both (therefore are considered "normal"), 40 (9.35%) violate *Monotonicity (i)* and 43 (10.05%) violate *Monotonicity (ii)* and only 10 (2.33%) violate both. Overall, after taking averages from all proposals, the proposed loss vector reads $\left(f_5,f_{10},f_{15},f_{20}\right) = (0.625, 1.391, 2.751, 5.232)$, and the average proposed final wealth vector of P5, P10, P15, P20 is (4.375, 8.609, 12.249, 14.768), both of which satisfy the two types of monotonicity.

If the behavior is driven mainly by motivations of maximizing one's own payoff (agent i wants f_i to be low) and being seemingly fair (being "normal"), then without further assumptions in model structures, we can expect that at the aggregate level we arrive at

Prediction 1 (*H*1): *Players with lower endowments get exempted more often than those with higher endowments.*

Explanation: To apply *Monotonicity (i)*, namely $0 \leq f_5 \leq f_{10} \leq f_{15} \leq f_{20}$ to the exemption behavior implies that if a subject's behavior satisfies such monotonicity, i.e., if they exempt an individual with endowment $\omega_i(\omega_i \in \{5, 10, 15, 20\})$, they would exempt all individuals with endowments less than ω_i. Therefore, we would expect to see, from the data,

[8] By means of the post hoc Dunn's tests for pairwise comparisons, among 12 pairs of f_i proposed by agent i versus agent $j(j \neq i)$, significant differences (Bonferroni-adjusted $p<0.05$) are detected in 9 pairs, except for f_5 between the groups of agents P5 and P10, f_{15} between the groups of agents P15 and P10, and f_{20} between the groups of agents P20 and P15.

that individuals with lower endowments get more frequently exempted than agents with higher endowments.

Prediction 2 (*H*2): *P5 are more likely to "exempt P5 only" compared with other types of exemption and other players, respectively.*

Explanation: The prediction is driven by P5 maximizing their income and having the lowest endowment. Exempting both P10 and P5 would be less favored than exempting P5 alone because of P5's self-interests and the higher endowment that agent P10 has.

For other players, exempting P5 only out of fairness concerns might be contradicting their own income maximizing goal.

Prediction 3 (*H*3): *P10 are inclined to "exempt both P10 and P5" compared with other types of exemption and other players, respectively.*

Explanation: If P10 tries to maximize their final wealth, they would like to exempt themselves. However, to make the proposals seemingly fair, with *Monotonicity (i)* $0 \leq f_5 \leq f_{10} \leq f_{15} \leq f_{20}$, they may want to exempt P5 as well. It will make this type to be the most popular type of proposal compared with other types. Meanwhile, P5, P15 and P20 do not have a strong incentive to exempt P10, which may hurt their goal to maximize their own payoff.

Prediction 4 (*H*4): *The higher endowment group (P15 and P20) is more likely to propose "no exemptions" compared with other types of exemption and the lower endowment group (P5 and P10), respectively.*

Explanation: This is due to the goal of self-interest of the higher endowment group. They want to propose seemingly fair proposals, but not necessarily to exempt everyone. If they want to maximize their own payoffs, not exempting anyone can lead to a smaller loss share for themselves.

One last remark before going into details of our results, we wish to make the readers aware of the fact that there could be other motivations, as the proposals within each group cannot be considered as independent of each other. A proposal that is issued later is likely to be influenced by earlier proposals that got rejected. However, the pattern that we received across all groups at all sites is by no means uniform. In several cases where at an early stage the proportionality principle was proposed (and immediately rejected by at least one other group member), proportionality was again proposed at a later stage, either by the same person or by another group member. In other instances, the proportionality principle which does not consider exemptions, was modified in so far as it was proposed that at least one of the group members be exempted. Another finding within our results may be termed "nasty", because such a proposal wanted most of the required loss to be imposed on one or two agents who promptly rejected this and, in their turn, took revenge by proposing to heap the burden on the "aggressor". In other words, this rather diverse picture of largely interdependent proposals mirrors a sequence of tatonnements among the players either in search of a unanimous solution or as an attempt to provoke a final decision "from outside".

Section 4.1 will present our findings regarding the predictions above. Section 4.2 will examine the treatment effect. Section 4.3 will identify the gender effect. All those three subsections will start with the testable null hypotheses and end with the patterns shown in the data. Sections 4.4–4.6 discuss exploratory findings from our data.

Table 2 Four different types of proposals

Type of proposal	Total proposals (percentage)
Exempt lowest only	120 (28.0%)
Exempt two lowest only	94 (22.0%)
Other exemptions	50 (11.7%)
No exemption	164 (38.3%)
- Equal split	10 (2.3%)
- Proportionality	49 (11.4%)
Total number of proposals	428

4.1 General findings regarding the predictions

Table 2 summarizes the four different types discussed regarding exemption behavior in the previous section.

Out of 428 proposals, 264 (61.7%) wanted to exempt at least one player, and 164 (38.3%) exempted none. Among all types of exemptions, the two most popular exemptions are exempting P5 only (120 proposals) and exempting both P5 and P10 only (94 proposals), which together account for 81.1% of the 264 exemption proposals and 50% of all 428 proposals.[9]

Let us check each prediction with our data:

$H1_0$: "All four players get exempted with an equal chance."

Observations: Among 428 proposals, 248 (57.9%) exempted P5, 128 (29.9%) exempted P10, 40 (9.35%) exempted P15, and 20 (4.67%) exempted P20.[10] All the above proportions are different from each other at the 0.01 level of significance by test of proportions. What is more, the tests also reject the one-tailed hypothesis of a lower proportion to exempt lower endowment agents compared with higher endowment agents at the 0.01 significance level.

In other words, *our data show the pattern that low endowment agents are more often exempted than agents with high endowments*.

Table 3 offers detailed information on the answer to "who proposed what" to help us examine Predictions 2-4.

$H2_0$: (a) "P5 are equally likely to propose 'exempt P5 only' compared with any other type of exemptions"; (b) "All players are equally likely to propose the 'exempt P5 only' type."

Observations: (a) Among 110 proposals by P5, 45.5% belong to "exempt P5 only". By singling out each type to make pairwise comparisons, the tests of proportions show the significant difference at the level of 0.05 between the choice of "exempt P5 only" and any other type. (b) Significantly higher proportions ($p<0.001$) are detected when P5 versus P10 (15.8%) or P15 (15.6%) are considered in terms of favoring "exempt P5 only".

[9] For the readers' interest in the other proposals of Table 2, we also single out two common rules under no exemption: 10 (2.3%) refer to equal split (2.5 loss for each player), and 49 proposals (11.4%) match accurately proportionality (loss of 1 for P5, 2 for P10, 3 for P15 and 4 for P20). In our analysis, both proposals are contained in the "no exemptions" category..

[10] Notice that the sum of all individual figures exceeds 428, which is due to double-counting in some cases. For example, a proposal exempted P10 and P5, and it counts as both exempting P5 and exempting P10.

However, the significance between P5 and P20 is only at the level of 0.1. What is more, the proportion of P20 choosing “exempting P5 only” (34.2%) is significantly higher than that of P10 and P15. In other words, P20 clearly support “exempt P5 only” compared with P10 and P15.

To summarize, *(a) compared with other types, P5 significantly like “exempt P5 only” the most; (b) compared with other players, P5 favor “exempt P5 only” significantly more than P10 and P15 at the level below 0.001 and mildly favor “exempt P5 only” more than P20 at the level of 0.1.*

> ***H*3$_0$:** (a) “P10 equally like to propose ‘exempt both P10 and P5’ compared with any other type”; (b) “All players are equally likely to propose ‘exempt both P10 and P5’ type.”

Observations: (a) “Exempting both P10 and P5” takes 45.5% of all 101 proposals by P10. Compared with other types, the proportion tests show the significant higher proportion ($p < 0.001$) of P10 favoring this type than any other type. (b) Similar significant differences ($p < 0.001$) are detected between P10 and P5 (17.3%), P15 (14.7%) and P20 (12.0%).

In our view, P10’s choice of “exempting both P10 and P5” can be seen as a “clever” strategic move rather than as an act of solidarity towards P5 players. The hope may have been that the other agents would perhaps be more willing to support such a move rather than a proposal that would just exempt P10 agents alone. P5 players are at the very bottom of the endowment scale and may therefore deserve some sympathy or fairness from better endowed agents, at least somewhat more than P10 agents.

Such a hope turned out to be a delusion by the exemption behavior of P20 agents. P20 is more likely to propose the exemption of P5 alone than of P5 and P10 together. Redress in the sense of Rawls may have been the guiding principle. Table 4 presents details with respect to the different locations where we staged our experiments. In columns “Player P10” and “Player P20”, the first digit gives the number of proposals to exempt P5 only, the second digit gives the number of proposals to exempt both P5 and P10 agents, the digit in parenthesis gives the total number of proposals made by the respective endowment position (i.e., player P10 and P20 respectively) at each location. As one can see, P10 agents have a clear preference for exempting themselves together with P5 players, while P20 agents are inclined to exempt P5 solely.

As predicted, P10 has a strong preference for “exempting both P10 and P5” compared with other types of exemptions or any other players.

Table 3 Summary based on exemption categories and proposers

Proposers	Exempt P5 only	Exempt P5 and P10	Other exemptions	Total exemptions	No exemption	Total
P5	50	19	9	78	32	110
P10	16	46	15	77	24	101
P15	17	16	14	47	62	109
P20	37	13	12	62	46	108
Total	120	94	50	264	164	428

***H*4$_0$:** "High endowment group (P15 and P20) and low endowment group (P5 and P10) are equally likely to make 'no exemption' proposals."

Both the Kruskal–Wallis test and the χ^2 test show the significant differences of proposals with no exemptions at the 0.01 level. If we form again lower-endowment (P5, P10) and higher-endowment (P15, P20) classes, both T-test and Mann–Whitney-Wilcoxon test show the significant difference of proposals with no exemption at the 0.01 level.

P15 represents the highest percentage of those who favor no exemptions (56.9%). This result is also statistically significant at the 0.05 level compared to any other group of agents (P5: 29.1%; P10: 23.8%; P20: 42.6%). That P15 agents favor no exemption more strongly than P20 players could be a sign of disappointment that may have turned them into "hard liners" against agents below, accompanied by envious feelings in relation to the P20 participants who were, undeservedly in the eyes of the P15 agents, the lucky ones. Admittedly, this explanation is a bit speculative but the 62 instances of "no exemption" on the part of the P15 agents in Table 3 may speak for themselves.

The data from our experiments show that the high-endowment group (P15 and P20) makes "no exemption" proposals more frequently than the low-endowment group (P5 and P10).

4.2 Treatment effect

In this section, we conduct an analysis to detect any treatment effect between "Random" and "Experimenter" treatments.

***H*5$_0$:** "There is no difference between 'Random' and 'Experimenter' treatments."

In Table 5, we further decompose Table 3 and present the results by "random" and "experimenter" treatments.

While most of the results in Table 5 are, qualitatively speaking, in conformity with what we just stated in relation to the overall results of 428 proposals, a separate look at the two

Table 4 Detailed results on exemption by P10 and P20

Location	Player P10 [exempt P5; exempt P10&P5; (total proposals)]	Player P20 [exempt P5; exempt P10&P5; (total proposals)]
Berlin	4; 3 (10)	5; 0 (12)
Galway	1; 7 (13)	0; 2 (12)
Halle '15	3; 3 (9)	1; 0 (9)
Halle '16	0; 10 (12)	9; 1 (14)
Madrid	1; 5 (12)	5; 2 (11)
London July 2017	2; 8 (20)	6; 2 (22)
London Nov. 2017	4; 6 (13)	6; 5 (18)
London March 2018	1; 4 (12)	5; 1 (10)
Total	16; 46 (101)	37; 13 (108)

treatments “random” and “experimenter” reveals a finding that readers may already have expected. There is a large difference between “random” and “experimenter” with regard to “other exemptions”. In the “random” treatment, a player may have speculated that if there has been no agreement before the time limit, a proposal may be “randomly” chosen which could be very favorable for this proposer. So, for P5, P10, and P15, the proposal (0, 0, 0, 10) would be highly appreciated, while for P15 and P20, (5, 5, 0, 0) would be much liked. Also, with such “nasty” proposals another aspect comes into the picture, an act of retaliation, once an atmosphere of friendly negotiations within the group has been left behind. This is immediately seen from the detailed protocol on “other exemptions” given in Tables 12 and 13 in the Supplementary material. In most cases in which “other exemptions” are proposed, these occur at higher frequency or in clusters. In group 2, London July 2017, for example, a (0, 0, 0, 10) proposal alternates with a (5, 0, 5, 0) or a (5, 0, 0, 5) proposal. Table 5 reveals that in “random” there were 45 proposals of “other exemptions” (45/319 = 14.1%), while in “experimenter” there were only 5 such proposals (5/109 = 4.6%).

Table 6 documents marginal effects for loss exemption from two models. The logistic model shows that P15 and P20 are in general reluctant to support exemption compared to P5. The multinomial logistic model further shows that P15 is notably less in favor of exempting P5. From the multinomial logit model, we see that compared with P5, P10 has a preference for exempting P10 and P5 together and does not like to exempt P5 alone, which supports the summary statistics from Table 3. Male students show a preference for “other exemptions” and less favor exempting the lowest two compared with female students. The “experimenter” treatment has a significant (negative) effect on “other exemptions”. Tables 17 and 18 in the Supplementary material reaffirm what has been said above in relation to male players and “other exemptions”.

To summarize our result regarding the difference between “random” and “experimenter” treatments, a significant difference is only detected in the “other exemptions” type of proposals: *In “experimenter” treatments, in cases of no agreement reached where the experimenter would choose their own proposal as the final resolution, subjects proposed fewer instances of “other exemptions” than subjects from the “random” treatments.*

We add three more findings in terms of different behavior between the two treatments:

Table 5 Summary based on exemption categories and proposers by treatments

Proposers	Treatment	Exempt P5 only	Exempt P5 and P10	Other exemptions	No exemption	Total
P5	Random	35 (42.2%)	17 (20.5%)	8 (9.6%)	23 (27.7%)	83
	Experimenter	15 (55.6%)	2 (7.4%)	1 (3.7%)	9 (33.3%)	27
P10	Random	11 (14.5%)	36 (47.4%)	14 (18.4%)	15 (19.7%)	76
	Experimenter	5 (20%)	10 (40%)	1 (4%)	9 (36%)	25
P15	Random	14 (17.5%)	8 (10%)	12 (15%)	46 (57.5%)	80
	Experimenter	3 (10.3%)	8 (27.6%)	2 (6.9%)	16 (55.2%)	29
P20	Random	26 (32.5%)	7 (8.8%)	11 (13.8%)	36 (45%)	80
	Experimenter	11 (39.2%)	6 (21.4%)	1 (3.6%)	10 (35.7%)	28
Total	Random	86 (27.0%)	68 (21.3%)	45 (14.1%)	120 (37.6%)	319
	Experimenter	34 (31.25)	26 (23.9%)	5 (4.6%)	44 (40.4%)	109

The percentages are out of the row totals

Table 6 Marginal effects of regressions on types of proposals

	Multinomial Logistic Model				Logistic Model
Variables	Exempt P5	Exempt P10&P5	Other exemptions	No exemption	Exemption
Endowment 10	−0.2980*** (0.0720)	0.3121*** (0.0875)	0.0162 (0.0469)	−0.0302 (0.0739)	0.0262 (0.0716)
Endowment 15	−0.2705*** (0.0794)	−0.0152 (0.0621)	0.0395 (0.0619)	0.2462*** (0.0887)	−0.2494*** (0.0882)
Endowment 20	−0.1113 (0.0845)	−0.0435 (0.0609)	0.0141 (0.0562)	0.1407* (0.0837)	−0.1436* (0.0827)
Round	0.0031 (0.0042)	0.0006 (0.0038)	0.0060* (0.0031)	−0.0097** (0.0049)	0.0101** (0.0049)
Male	< 0.0001 (0.0569)	−0.1332** (0.0521)	0.2043*** (0.0658)	−0.0711 (0.0665)	0.0408 (0.0642)
Experimenter mechanism	0.0570 (0.0550)	0.0181 (0.0564)	−0.1044** (0.0490)	0.0293 (0.0785)	−0.0114 (0.0783)
Demographic control[1]	Yes				Yes
Observations	428				428
Log-pseudolikelihood	−482.89				−261.55

[1]Demographic control includes age, family income, predicted future income and political orientation

Robust standard errors are in parentheses and clustered at the individual level. $*p<0.1$, $**p<0.05$, $***p<0.01$

Table 7 Self-proposed loss share amount by treatments

Agent *i*	Random	Experimenter	Mann–Whitney-Wilcoxon test significance
P5	0.27 (0.6640)	0.26 (0.4160)	
P10	0.51 (0.8761)	0.96 (1.0085)	**
P15	2.26 (1.2371)	2.595 (1.049)	
P20	3.91 (2.0368)	5.14 (1.6251)	***

Standard deviations are in the parentheses. **: $p<0.05$; ***: $p<0.01$

Table 8 Four different types of proposals and their frequencies

Type of proposal	Female	Male
Exempt lowest only	50 (29.07%)	70 (27.34%)
Exempt two lowest only	50 (29.07%)	44 (17.19%)
Other exemptions	3 (1.74%)	47 (18.36%)
No exemption	69 (40.12%)	95 (37.11%)
Total number of proposals	172	256

The percentages are out of column totals

(1) Since all "other exemptions" are "abnormal" by violating at least one of the monotonicity properties, it is straightforward to check the abnormal rate between the two treatments. Under the random treatment, 97 out of 335 (25.39%) are abnormal, whereas only 12 out of 93 (11.01%) have this property under the experimenter treatment. Both proportional test and χ^2 test verify the significant difference between the treatments ($p < 0.01$).
(2) Supplementary Table 7 shows that under experimenter treatments, P10 and P20 proposed a significantly larger share of the loss to themselves compared with the random treatment.

(3) In terms of reaching an agreement, 26 out of 38 (68.4%) groups under the random treatment reached a consensus with an average of 4.65 rounds of negotiation; under the experimenter treatment, 17 out of 20 groups (85%) reached an agreement with an average of 3.7 rounds of bargaining. Overall, the average number of rounds of bargaining is 8.4 under the random treatment, and 5.5 under the experimenter treatment. More discussion about the accepted proposals will be given in sections to follow.

4.3 The gender effect

Are there any gender differences in relation to loss sharing? Readers will see from our results that there are. To the best of our knowledge, not many experimental investigations exist in which agents incur direct losses of real money subtracted from their initial endowment as the result of a bargaining procedure. True, there are various studies which show that women are more financially risk-averse than men (e.g., Eckel and Grossman 2008). Charness and Gneezy (2012) review a multitude of very similar investment decisions over risky projects (participants can either invest the money they received in a risky option or just keep the money) and find much support for Eckel and Grossman's result. In other investigations, it was shown that women's portfolios are less risky than men's (Jianakoplos and Bernasek 1998). These findings are in conformity with what Grossman and Lugovskyy (2011) call "persistence of gender-based stereotypes" which continue to exist even when individualized information in the form of survey responses are available. Perhaps closer to our own experimental set-up, in which some agents are luckier than others due to a random assignment of endowments, are investigations in the context of dictator games in which female dictators show reciprocity and decrease their taking-rates significantly, in contrast to men, in a real-effort treatment (Heinz et al. 2012). Miller and Ubeda (2012) find that women adopt more often than men conditional fairness principles that require information about the underlying environment. In other words, women are more sensitive to the context (Rodriguez-Lara 2015). Li and Houser (2022) study a multistage bargaining game and find the gender difference in the loss frame, but not in the gain frame: compared with female proposers, male proposers are significantly more selfish over losses.

Are there gender differences from our loss-sharing experiments? The null hypothesis is the following:

***H6*$_0$:** "There are no significant differences regarding the behavior of male and female proposers."

When we look at the distribution of the four types regarding exemption behavior – exempt P5 only, exempt P10 and P5, other exemptions and no exemption, as shown in Table 8, there is a highly significant difference between males and females at the 0.01 level according to the Fisher's exact test.

There is no significant difference detected from χ^2 test between males and females when "other exemptions" are excluded. This shows very clearly that the main "culprit" for the observed gender differences lies in the "other exemptions". Under the random treatment, there were 42 "other exemption" proposals by men and only 3 such proposals by women; under the experimenter treatment, there were 5 "other exemption" proposals by men and not a single proposal of this type by women. Overall, female players less frequently propose "other exemptions" compared with males; male players propose drastically fewer "other exemptions" under the experimenter treatment compared with the random treatment.

Recall that a proposal is called "normal" if it satisfies *Monotonicity (i),(ii)*, and "abnormal" otherwise. Although "other exemptions" shows 50 out of 93 abnormal proposals, there are also abnormal proposals from other types of proposals, for example, the loss assignment vector (f_5,f_{10},f_{15},f_{20}) as $(0, 0.5, 1.5, 8)$ and $(0, 0, 1.5, 8.5)$ by proposer P20 in Halle '16 or $(3, 3, 2, 2)$ by proposer P5 in Halle'15.

Readers will not be surprised to learn that in our experiments, women proposed fewer abnormal proposals than men (significant at the 0.01 level both by test of proportions and the χ^2 test). This is documented in Table 15 in the Supplementary material. Our finding is in stark contrast to results in an experimental "joy-of-destruction" game (Abbink and Herrmann 2011) in which, to our surprise, the authors did not detect significant gender effects. Furthermore, echoing our finding in "other exemptions", the experimenter treatment did not affect females' proposals regarding normal vs. abnormal proposals but significantly reduced males' abnormal proposals (Table 16 in the Supplementary material). The significance of the gender difference in relation to proposing abnormal proposals disappears under the experimenter treatment.

Finally, returning to our earlier argumentation, in general female participants exempted themselves (55 out of 172, 32.0%) from any loss less frequently than males (110 out of 256, 43.0%). This finding is significant at the 0.05 level by both proportion and χ^2 tests. Out of those 165 proposals that involve self-exemption, 54 (34 by male proposers and 20 by female proposers) are just exempting themselves as a proposer and nobody else. In this particular case, we could detect no significant difference between men (34 out of 256, 13.3%) and women (20 out of 172, 11.6%).

From our data, gender differences manifest themselves by the following two aspects: compared with male cohorts, female subjects made (i) fewer "abnormal" proposals under the random treatment (but no gender difference was found under the experimenter treatment), and (ii) fewer self-exemption proposals (but no gender difference was found in self-exemption-only proposals).

4.4 Perseverance

Do agents who have the chance to make more than one proposal during the bargaining procedure show a certain degree of stability or persistence in their behavior and what would this be like?

Before we try to answer this issue more systematically (we call it perseverance), a few particular examples may throw some light on this question. An extreme example of steadiness is Agent P15 of group 2 in Berlin 2016 who proposes the loss vector $(1, 2, 3, 4)$ six times out of six proposals he or she could make. Out of 23 proposals by the whole group, nobody else followed this suggested loss division. Player P15 of group 3 in Halle 2015 proposes (0, 0, 0, 10) three times (out of four possible proposals). Agent P10 of group 2 in London 2017 proposes (5, 0, 5, 0) three times and (5, 0, 0, 5) twice out of six proposals. Agent P5 of group 7 in Galway 2015 pursues some kind of tatonnement. Their proposals which turned out to be unsuccessful were (0, 1, 4, 5), (0, 1.5, 3, 5.5), (0, 2, 3, 5), and (0.5, 2, 3, 4.5).

More generally, we now focus on the proposals coming from 102 subjects who proposed more than once. Table 9 depicts, among other issues, the aspect just exemplified, namely whether an individual agent follows a consistent pattern of proposals on top of the multinomial logistic model in Sect. 4.2. We add two controlled variables: (i) the type of the last proposal in the group; (ii) the type of the last proposal by the same proposer. The former helps us to investigate the carry-on effect at the group level, and the latter does this at the individual level.

Here are our findings: (a) The behavior of exempting P5 is carried on by the same individual. The table shows that, when one proposed exempting P5 or both P10 and P5 in the last proposal, they are more likely to continue exempting P5 for their current proposal (40.57 and 30.71 percentage points correspondingly). (b) No-exemption proposals carry on, both at the group level as well as at the individual level. The results show that when the last proposal in the group exempted no players, the following proposal is 22.59 percentage points more likely to continue exempting no one; for the same individual, when their last proposal didn't exempt anyone, their next proposal is 40.83 percentage points more likely to be of the same type. (c) Exempting both P10 and P5 does not show the carry-on feature. The results are not significant as the table shows, neither at the group level nor at the individual level. This could reflect a certain degree of steadiness or perseverance, but only with respect to exempting the individual with the lowest endowment and the case of no exemptions. Note also that agents who proposed to exempt P5 or both P10 and P5 or were in favor of no exemptions in the last period all manifest a strong aversion to other exemptions in the current period.

Re-examining the gender issue for a moment, there is no gender difference between males and females in relation to sticking to one's previous type of proposal, when the random and experimenter treatments are taken together. However, women stick to their last proposal more frequently in the experimenter treatment compared to the random treatment, which is significant at the 0.01 level. And within the experimenter treatment, female players stick more to the type of their last proposals than their male counterparts, again significant at the 0.01 level (See Tables 17 and 18 in the Supplementary material).

Table 10 shows the predictive probability from the marginal effects of the above multinomial logistic regression, the "carry-on" effect by the same proposer. We consider the same proposer's last proposal, when everything holds the same, and the corresponding probabilities of the type of the proposer's current proposal. The main results we see here are: (i) If one exempted P5 only in their last proposal, the probability they insist to exempt P5 only is 50.21%, and the next most likely type of proposal they make is no-exemption with 27.8%; (ii) One who proposed to exempt P10 and P5 and got rejected is more likely to change over to exempt P5 only with 40.35% compared with insisting to exempt both with 37.6%; (iii) The "abnormal" exemption behavior ("other exemptions" type) carries on as well with 38.9% to predict that one is proposing the "other exemptions" type again when they can next time; (iv) the "no exemption" type has the strongest carry-on effect: if one proposed to exempt no one last time, they are more likely to stick to the same type when they propose again with 64.6%.

In this section, we explore the perseverance of the proposal type at the levels of both group and individual. *From the results, we can see that those who chose to exempt in their last proposal will more likely (> 50 percent) continue exempting someone, and those who*

Table 9 Marginal effects of regressions on the "carry-on" effects

	Multinomial logistic model				Logistic model
	Exempt P5	Exempt P10&P5	Other exemptions	No exemption	Any exemption
Endowment 10	−0.1418 (0.0882)	0.2366*** (0.0755)	−0.0292 (0.0715)	−0.0656 (0.0716)	0.0536 (0.0724)
Endowment 15	−0.1267 (0.0782)	0.0347 (0.0552)	0.0200 (0.0746)	0.0721 (0.0718)	−0.0710 (0.0706)
Endowment 20	0.0020 (0.0809)	0.0223 (0.0514)	0.0027 (0.0771)	−0.0270 (0.0631)	0.0246 (0.0606)
Round	0.0021 (0.0050)	0.0006 (0.0043)	−0.0004 (0.0037)	−0.0023 (0.0046)	0.0027 (0.0045)
Male	0.0028 (0.0590)	−0.2046*** (0.0574)	0.2868*** (0.0834)	−0.0850 (0.0620)	0.0462 (0.0516)
Experimenter mechanism	0.0407 (0.0586)	−0.0993* (0.0540)	−0.0335 (0.0376)	0.0921* (0.0469)	−0.0834* (0.0476)
Proposal in last round being…					
-Exempt P5	−0.0946 (0.0961)	0.0371 (0.0788)	−0.0682 (0.0727)	0.1257* (0.0738)	−0.1315* (0.0738)
-Exempt P10&P5	−0.1298 (0.0881)	0.0621 (0.0705)	0.0184 (0.0741)	0.0493 (0.0689)	−0.0459 (0.0692)
-No exemptions	−0.1205 (0.0824)	−0.0661 (0.0595)	−0.0394 (0.0707)	0.2259*** (0.0720)	−0.2294*** (0.0723)
One's last proposal being…					
-Exempt P5	0.4057*** (0.0826)	−0.1314 (0.0916)	−0.3150*** (0.0797)	0.0407 (0.0870)	−0.0540 (0.0814)
-Exempt P10&P5	0.3071*** (0.1127)	0.0982 (0.1150)	−0.2519*** (0.0928)	−0.1534 (0.0953)	0.1361 (0.0892)
-No exemptions	0.0658 (0.0769)	−0.2018** (0.0934)	−0.2723*** (0.0825)	0.4083*** (0.1267)	−0.4248*** (0.1203)
Demographic control	Yes				Yes
Observations	247				247
Log-pseudolikelihood	−223.93				−109.25

Robust standard errors are in parentheses and clustered at individual level. *$p<0.1$, **$p<0.05$, ***$p<0.01$

Table 10 Overall predictive probabilities of the current proposal type from the last proposal type by the same proposer

The same proposer's last proposal being…	Overall predictive probability of the type of current proposal			
	Exempt P5	Exempt P10&P5	Other exemptions	No exemption
Exempt P5	0.5021 (0.0565)	0.1464 (0.0480)	0.0735 (0.0385)	0.2780 (0.0550)
Exempt P10&P5	0.4035 (0.0872)	0.3760 (0.0668)	0.1366 (0.0654)	0.0839 (0.0408)
Other exemption	0.0964 (0.0597)	0.2778 (0.0816)	0.3885 (0.0684)	0.2373 (0.0879)
No exemption	0.1623 (0.0463)	0.0759 (0.0315)	0.1163 (0.0351)	0.6456 (0.0623)

Standard errors are in parentheses

exempted no one last time will more likely (>50 percent) exempt nobody, a sign of individual consistency.

4.5 Revisiting the theoretical models

In Section 3, we introduced various models of loss sharing which may be candidates to prescribe the exemption behavior. How is the performance for each model? In relation to the constrained equal awards (CEA) rule, 20 proposals from 18 subjects proposed the exact match of $(f_5, f_{10}, f_{15}, f_{20}) = (0, 0, 2.5, 7.5)$. The proposals $(0, 0, 2, 8)$ and $(0, 0, 3, 7)$ appeared 10 and 28 times, made by 8, respectively 26 subjects.[11] For the Reverse Talmud solution $(0, \frac{5}{6}, \frac{10}{3}, \frac{35}{6})$, 14 subjects proposed $(0, 1, 3, 6)$, which is the closest integer solution, 17 times. Concerning the Gaertner-Xu model with $\alpha = \frac{1}{3}$, 32 proposals of $(0, 2, 3, 5)$ which is "close" to $(0, \frac{5}{3}, \frac{10}{3}, 5)$ are made by 30 subjects. If we introduce a Euclidean distance neighborhood of "smaller or equal to 1", in the case of CEA, there are 60 proposals in which both P5 and P10 are exempted. In case of the Reverse Talmud solution, there are 34 proposals which exempt P5 players and fall into the neighborhood (Euclidean distance no greater than 1) of this solution. In case of the Gaertner-Xu model, the corresponding finding is that there are 58 proposals which exempt P5 players only. Notice that such categorization in terms of neighborhood is not mutually exclusive since the Reverse Talmud solution and the Gaertner-Xu solution are close with Euclidean distance of 1.18 and even prescribe the same f_5 and f_{15}.

From our data, within the given distance constraint, the proposals that belong to the CEA solution and those that belong to the Gaertner-Xu model's solution with $\alpha = \frac{1}{3}$ are close contestants in our setting. Both outrun the Reverse Talmud solution.

4.6 The unanimously accepted proposals

Finally, let us focus on what proposals are accepted by all group members. Within the 58 groups (20 from the experimenter treatment and 38 from the random treatment), there were 15 instances (3 from the experimenter treatment and 12 from the random treatment) in which there was no final unanimity (so that a random mechanism or the experimenter determined the assignment of losses). Out of the 43 groups that reached consensus, 18 final agreements exempt P5 only, 13 exempt both P5 and P10, and 12 exempt no agents. There is no "other exemptions" type of proposal accepted as an agreement.

Among the 43 accepted proposals, 39 are "normal" therefore satisfy *Monotonicity (i) (ii)*, and 4 are "abnormal". Two abnormal ones are $(0, 0, 2, 8)$, which is one of the closest integer solutions to the CEA rule; the other two abnormal ones are due to the proposers assigning a larger loss to themselves, namely $(4, 2, 2, 2)$ proposed by P5 and $(2, 4, 2, 2)$ proposed by P10. These may reflect a misunderstanding, which can never be excluded in experiments.

[11] Notice that (0, 0, 2, 8) violates *Monotonicity (ii)* therefore belongs to "other exemption". It is not surprising that (0, 0, 2, 8) being as symmetric as (0, 0, 3, 7) compared with the exact match (0, 0, 2.5, 7.5), the latter seems to be more favored possibly since it satisfies both monotonicity properties.

In Section 4.2, several treatment effects are identified, such as lower rates of the "other exemptions" type or other "abnormal" types of proposals, a higher resolution rate and fewer rounds of negotiations. However, no significant differences are visible from the aspect of the accepted proposals.

By allowing the Euclidean distance to the theoretical solution to be no more than 1 as the "neighborhood", there were (a) 12 instances in which the final allocation of losses was the CEA solution $(0, 0, 2.5, 7.5)$ or "very close" to this, namely $(0, 0, 3, 7)$ or $(0, 0, 2, 8)$ or $(0, 0.25, 2.75, 7)$ (b) 5 instances in which the final loss distribution was near the Reverse Talmud solution $(0, \frac{5}{6}, \frac{10}{3}, \frac{35}{6})$, including $(0,1,3,6), (0, 1.5, 3, 5.5)$ and $(0, 0.75, 3, 6.25)$, (c) 9 instances in which the final agreement was close to $(0, \frac{5}{3}, \frac{10}{3}, 5)$ which, as mentioned above, is the solution in the case of $\alpha = \frac{1}{3}$ in the Gaertner-Xu model (namely $(0, 2, 3, 5), (0, 1.5, 3, 5.5)$ *or* $(0.25, 1.5, 3, 5.25)$), and (d) 5 instances of proportional loss sharing, namely$(1, 2, 3, 4)$.[12]

5 Concluding remarks

How should collective economic losses be shared across society when individuals have the same degree of influence? This was the topic of our paper. Equal split is a very simple but rather unfair answer since it does not take the agents' economic background into consideration. Proportionality is a scheme that has been widely applied in bequest and bankruptcy situations but in our investigations on burden sharing it played only a minor role. In our set-up in which endowments were randomly assigned, the idea that the lowest endowed or even the two lowest endowed agents be spared has some appeal. The former idea which is in conformity with a particular specification of the Gaertner-Xu model in Section 3 expresses a special concern for the worst-off and therefore has some kind of a Rawlsian flavor, the latter concept has a closer relation to the constrained equal-awards rule, which has been successfully applied in cases of bankruptcy and bequest. Both schemes reached prominence in our lab-experimental findings.

That the worst-off in terms of initial endowment will plead for their exemption comes as no surprise. That the second lowest endowed does not favor the exemption of the worst-off alone but strongly prefers their own exemption together with the worst-off can be interpreted as trying to make common cause with the latter in the process of negotiations with the rest of the group. It is interesting to see that the agent with the highest endowment shows some sympathy towards the lowest endowed which may be an expression of inequality aversion or altruism.

An interesting side aspect of our analysis came to the fore when we looked at the gender aspect within the two treatments of "random" and "experimenter". Very nasty proposals that attempt to assign the burden to one or two group members only, were hardly put forward by female participants. In contrast, male players seemed to like such proposals particularly in the random treatment, thereby hoping that in case of no

[12] Notice that we categorize $(0, 1.5, 3, 5.5)$ as being both Reverse Talmud and Gaertner-Xu $\alpha = \frac{1}{3}$ cases since the Euclidean distance to both solutions is smaller than 1, therefore this can be considered as lying in the neighborhood. Also, there are no accepted proposals other than being precisely within the neighborhood of 1 around the Proportional rule, and there are no proposals in the neighborhood of equal split.

agreement after time has elapsed, proposals which are largely to the benefit of the proposer would come about via the installed random mechanism.

Given that exemption behavior plays such an important role in loss division problems, it seems to us that the aspect of exemption from a certain threshold should be given more attention both theoretically and empirically in future research (see Herrero and Villar (2001) and Van den Brink et al. (2013)). In this context, the role of a possible effort on the part of the agents should be worth exploring in greater detail. Also, it is very clear to us that more experimental evidence is needed to substantiate the claims and corresponding findings presented in this paper.

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Declarations

Competing interests The authors declare no competing interests.

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