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On the adjudication of conflicting claims: an experimental study

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Abstract This paper reports an experimental study on three well-known solutions for problems of adjudicating conflicting claims: the constrained equal awards, the proportional, and the constrained equal losses rules. We first let subjects play three games designed such that the unique equilibrium allocation coincides with the recommendation of one of these three rules. In addition, we let subjects play an additional game that has the property that all (and only) strategy profiles in which players coordinate on the

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same rule constitute a strict Nash equilibrium. While in the first three games subjects' play easily converges to the unique equilibrium rule, in the last game the proportional rule overwhelmingly prevails as a coordination device, especially when we frame the game as an hypothetical bankruptcy situation. We also administered a questionnaire to a different group of students, asking them to act as impartial arbitrators to solve (among others) the same problems played in the lab. Also in this case, respondents were sensitive to the framing of the questions, but the proportional rule was selected by the vast majority of respondents.

1 Introduction

When a firm goes bankrupt, how should its liquidation value be divided among its creditors? If a person dies and the debts left behind are found to exceed the worth of her estate, how should the estate be divided? If a certain amount of money should be collected from a population, how much should each individual contribute? How should medical triage be designed, when the available resources are not sufficient to cover individual needs? These questions are examples of the so-called *problems of adjudicating conflicting claims*. There is an extensive literature (see Herrero and Villar (2001), Moulin (2002) or Thomson (2003) for recent surveys) dealing with the formal analysis of these problems following O'Neill's (1982) seminal contribution. The objective of this literature is to identify well-behaved "rules" to fix, for each problem, the appropriate division among the claimants of the available amount.

There are three rules that emerge from this literature. The *proportional* rule, which chooses awards proportional to claims, is inspired by Aristotle's Maxim ("*Equals should be treated equally, and unequals, unequally in proportion to relevant similarities and differences*"), probably the oldest formal principle of distributive justice. Two other rules, that can be traced back to Maimonides, are the so-called *constrained equal awards* rule and *constrained equal losses* rule. The former distributes the available amount equally, provided no agent ends up with more than she claims; the latter rule imposes equal losses for all the agents with one proviso: no one should obtain a negative amount. Besides their long tradition, these three rules are the most common methods employed for solving practical problems.[1] Furthermore, they are the only ones that satisfy the four basic invariance axioms within the family of rules that treat equal claims equally (e.g., Moulin 2000). On the other hand, no compelling theoretical argument has been found so far to select, among these rules, *a unique optimal solution* to adjudicate conflicting claims. On the contrary, theory (and standard practice) appeal to one or another depending on the economic context at stake.

The aim of this paper is to bring this interesting theoretical debate into an experimental lab. Our main question here can be summarized as follows:

[1] The proportional rule is generally employed to ration shareholders in bankruptcy regulations (e.g., Hart 1999; Kaminski 2006). The constrained equal awards rule makes good sense, for instance, in problems of estate division (e.g., Aumann and Maschler 1985). The constrained equal losses rule is appealing in the case of tax schemes, as it looks for the most egalitarian after-tax income distribution. It is also a natural procedure for cases in which claims are related to needs, as in the case of public support of health care expenses (e.g., Cuadras-Morató et al. 2001).

Is there any particular rule that is salient in subjects' perception of the optimal solution to a problem of adjudicating conflicting claims?

To answer this question, two lines of research are open. One, which is very much in line with the axiomatic approach, is to put subjects in front of hypothetical problems and ask them to solve them from the point of view of an *outside observer*; the other is to fully exploit the experimental methodology and provide subjects with *an active role* to solve the claim problem. This is to say, to design hypothetical situations in which they are actual claimants rather than mere outside observers. The results of such an experiment may provide experimental evidence on how agents play when they are personally involved in real conflicting claim problems.

The experimental methodology we have just mentioned is more in line with the so-called *non-cooperative approach* to conflicting claims problems (e.g., Chun 1989; Dagan et al. 1997). This approach applies to these problems the same methodology known as the *Nash program* for the theory of bargaining, by which specific procedures are constructed as non-cooperative games with the property that the unique equilibrium allocation corresponds to the one dictated by a specific rule (e.g., Nash 1953; Binmore et al. 1992; Roemer 1996). In other words, this approach provides theoretical support to certain rules by constructing specific strategic situations, for which such rules are self-enforcing.

In this paper we collect both survey and experimental evidence, and the results we obtain should be considered as complementary. We first selected 300 students to play in the lab a sequence of games corresponding to three (non-cooperative) procedures proposed by the literature. These procedures share the same game-form and display very similar strategic properties: there is always a player with a weakly dominant strategy (that corresponds to each of the three rules we are considering) by which she can force an outcome of the game in her favor. Thus, if subjects recognize the strategic incentives induced by each game, the choice of a particular procedure may be equivalent to the choice of a particular rule to solve the problem.

We then consider an additional procedure, (a simple "majority game"), which has the property that all (and only those) strategy profiles in which all players coordinate on the same rule constitute a strict Nash equilibrium. This additional game has no selection incentives, but coordination incentives only. Thus, we used this game to investigate more compellingly the rule selection issue.

Since the specific contexts are so important in all practical cases of adjudicating claims, we also checked whether subjects participating in games with such strong strategic properties would be sensitive to *framing effects*. To this purpose, in some sessions we explained to subjects each procedure with a different "story", somehow consistent with the rule supported by the procedure. We then compared the results with the evidence of some (control) sessions in which the same procedures were played under a completely "unframed" scenario, in which only monetary payoffs associated to strategy profiles were provided. We did so to see whether a frame may have induced subjects to behave differently.

The main findings of this experiment can be summarized as follows. While in the first three procedures subjects' play easily converges to the unique equilibrium rule even in the first rounds, in the majority procedure the proportional rule overwhelmingly prevails as a coordination device. As for the framing issue, we find that frames affect subjects' behavior only in the majority procedure. By contrast, for the other procedures, strategic considerations appear to be too compelling to render framing effects relevant.

The alternative approach consisted of administering a questionnaire to a different group of 164 students. These students were asked to choose their preferred rule from the viewpoint of an arbitrator in charge of resolving, among others, the same problem played out previously in the lab by the other group of subjects. Consistently with our experimental findings, the proportional solution prevailed as the modal choice for 90% of the respondents. Nonetheless, they also proved to be sensitive to the particular situation at hand, meaning that framing effects do also occur here.

Despite the extensive experimental literature on related issues such as bargaining (see, for instance, Ochs and Roth (1989), and the literature cited therein), or arbitration (see, for instance, Ashenfelter and Bloom (1984), Ashenfelter et al. (1992), and the literature cited therein), this is, to the best of our knowledge, the first experiment on problems of adjudicating conflicting claims. The closest reference to our work is Gächter and Riedl's (2006) experimental paper. In their independently conducted work, they also combine surveys and standard laboratory experiments. However, differently to ours, in their experiment subjects did not follow any specified protocol, but had to negotiate an agreement in a symmetric free-form bargaining game.[2] As for the comparison with our findings, their questionnaire leads to results quite similar to ours (i.e., the proportional rule prevails), while in the experiment, final agreements were closer to the solution proposed by the constrained equal awards rule.[3]

The remainder of this paper is arranged as follows. In Sect. 2, we set up the model, while in Sect. 3, we present the design of the experiment. In Sect. 4, we report on our experimental results, whereas in Sect. 5, we report on the results of the questionnaire. Our conclusions, comments and further proposals are then presented in Sect. 6. The latter is followed by an Appendix containing the proofs of some theoretical results related to our study and the instructions for the experiment and the questionnaire.

2 The model

Let $N = \{1, 2, \ldots, n\}$ be a set of agents with generic elements i and j. A problem of adjudicating conflicting claims is a pair (c, E), where $E > 0$ represents the amount to

[2] Also, in the questionnaire, subjects were not constrained in their choice by the three rules object of this paper, but they could allocate the available amount between the two hypothetical claimants any way they wanted. In addition, they only deal with 2-player problems.

[3] Another related work is that of Cuadras-Morató et al. (2001). They investigate, by way of questionnaires, the equity properties of different rules in the context of health care problems. In this regard, they find that when asked to choose from among six potential allocations, (including the solution proposed by the proportional and the constrained equal losses rules), using the perspective of an "impartial judge" in the context of health care problems, subjects displayed a slight preference for the constrained equal losses rule. Bosmans and Schokkaert (2007) is another (more recent) related paper whose main concern is to study the within-context consistency and between-context uniformity of individual responses (in different questionnaires) for claims problems. See also the papers of Yaari and Bar-Hillel (1984) and Frolich et al. (1987), in which different bargaining solutions are also investigated by means of questionnaires.

divide, and $c \in \mathbb{R}^n_+$ is a vector of claims whose ith component is c_i, with $\sum_{i \in N} c_i > E$. In words, c_i is the claim of agent i on a certain amount (the *estate*) E. We denote by $\mathbb{B}$ the family of all those problems. We assume, without loss of generality, that agents are ordered by claims, so that $c_1 \geq c_2 \geq \cdots \geq c_n$. In the remainder of the paper, we shall refer to agent 1 (n), that is, the agent with the highest (lowest) claim, as the *highest (lowest) claimant.*

A *rule* is a mapping $r : \mathbb{B} \to \mathbb{R}^n$ that associates a unique allocation $r(c, E)$ with every problem (c, E) such that

(i) $0 \leq r(c, E) \leq c$.
(ii) $\sum_{i \in N} r_i(c, E) = E$.
(iii) For all $i, j \in N$, if $c_i \geq c_j$ then $r_i(c, E) \geq r_j(c, E)$ and $c_i - r_i(c, E) \geq c_j - r_j(c, E)$.

The allocation $r(c, E)$ is interpreted as a desirable way of dividing E among the agents in N. Requirement (i) is that each agent receives an award that is non-negative and bounded above by her claim. Requirement (ii) is that the entire amount must be allocated. Finally, requirement (iii) is that agents with higher claims receive higher awards and face higher losses.[4] We denote the set of all such rules by $\mathcal{R}$.

We then introduce the three rules object of our study. The *constrained equal awards rule* makes awards as equal as possible, subject to no agent receiving more than her claim. The *proportional rule* distributes awards proportionally to claims. The *constrained equal losses rule* makes losses as equal as possible, subject to the condition that no agent ends up with a negative award.

The **constrained equal awards** rule, *cea*, selects for all $(c, E) \in \mathbb{B}$, the vector $(\min\{c_i, \lambda\})_{i \in N}$, where $\lambda > 0$ is chosen so that $\sum_{i \in N} \min\{c_i, \lambda\} = E$.

The **proportional** rule, p, selects for all $(c, E) \in \mathbb{B}$, the vector λc, where λ is chosen so that $\sum_{i \in N} \lambda c_i = E$.

The **constrained equal losses** rule, *cel*, selects for all $(c, E) \in \mathbb{B}$, the vector $(\max\{0, c_i - \lambda\})_{i \in N}$, where $\lambda > 0$ is chosen so that $\sum_{i \in N} \max\{0, c_i - \lambda\} = E$.

Remark Note that for all $(c, E) \in \mathbb{B}$ and all $r \in \mathcal{R}$, $cel_1(c, E) \geq r_1(c, E)$ and $cea_n(c, E) \geq r_n(c, E)$. In other words, *cel* (*cea*) is the rule preferred by the highest (lowest) **claimant among** all of the rules belonging to $\mathcal{R}$.

We now present three noncooperative *procedures* proposed to solve claims problems.

In the *diminishing claims procedure*, if agents do not agree on a particular rule, then their claims are reduced by substituting them with the highest amount assigned to every agent by the chosen rules. Agents' rules are then applied to the resulting problem after claims have been adjusted. If the chosen rules coincide in their allocation to the new problem, the procedure stops. Otherwise, claims are reduced again, and if the process does not converge in a finite number of steps, the limit of the resulting

[4] While conditions (i) and (ii) are standard in the definition of a rule, requirement (iii) is considered in the literature as an independent axiom called *order preservation*, and any rule satisfying condition (iii) is said to belong to the set of *order-preserving* rules. Since all of the rules stipulated for our experiment satisfy condition (iii), we shall abuse standard terminology by referring to order-preserving rules as simply "rules".

claims vectors (if it exists) is chosen as solution to the problem. Otherwise, nobody gets anything. Formally,

The diminishing claims procedure (P_1) (Chun 1989). Let $(c, E) \in \mathbb{B}$ be given. Each player $i \in N$ chooses a rule $r^i \in \mathcal{R}$, with r^{-i} denoting the strategy profile selected by i's opponents. Let $r = \{r^i, r^{-i}\}$ be the profile of the reported rules. The division proposed by the diminishing claims procedure, $dc[r, (c, E)]$ is obtained as follows:

Step 1. Let $c^1 = c$. For all $i \in N$, calculate $r^i(c^1, E)$. If $r^i(c^1, E) = r^j(c^1, E)$, for all $i, j \in N$, then $dc[r, (c, E)] = r^i(c^1, E)$. Otherwise, move on to the next step.

Step 2. For all $i \in N$, let $c_i^2 = \max_{j\in N}\{r_i^j(c^1, E)\}$. For all $j \in N$, calculate $r^j(c^2, E)$. If $r^i(c^2, E) = r^j(c^2, E)$, for all $i, j \in N$, then $dc[r, (c, E)] = r^i(c^2, E)$. Otherwise, move on to the next step.

Step k+1. For all $i \in N$, let $c_i^{k+1} = \max_{j\in N}\{r_i^j(c^k, E)\}$. For all $j \in N$, calculate $r^j(c^{k+1}, E)$. If $r^j(c^{k+1}, E) = r^i(c^{k+1}, E)$, for all $i, j \in N$, then $dc[r, (c, E)] = r^i(c^{k+1}, E)$. Otherwise, move on to the next step.

If the previous process does not end in a finite number of steps, then:

Limit case. Compute $\lim_{t\to\infty} c^t$. If it converges to an allocation x^* such that $\sum_{i\in N} x_i^* \leq E$, then $x^* = dc[r, (c, E)]$. Otherwise, $dc[r, (c, E)] = 0$.

In the *proportional concessions procedure,* if agents do not agree on the proposed rule, then they receive the proportional share of half of the estate. Agents' rules are then applied to divide the remainder after adjusting claims. If the chosen rules coincide in their allocation to the new problem, then the procedure stops. Otherwise, the process starts all over again. If it does not converge within a finite number of steps, the limit of the aggregation of concessions (if it exists) is then chosen as solution to the problem. Otherwise, nobody gets anything. Formally,

The proportional concession procedure (P_2) (Moreno-Ternero 2002). Let $(c, E) \in \mathbb{B}$ be given. Each player $i \in N$ chooses a *rule* $r^i \in \mathcal{R}$, with r^{-i} denoting the strategy profile selected by i's opponents. Let $r = \{r^i, r^{-i}\}$ be the profile of rules reported. The division proposed by the proportional concessions procedure, $pc[r, (c, E)]$, is obtained as follows:

Step 1. Let $c^1 = c$ and $E^1 = E$. For all $i \in N$, calculate $r^i(c^1, E^1)$. If $r^i(c^1, E^1) = r^j(c^1, E^1)$, for all $i, j \in N$, then $pc[r, (c, E)] = r^i(c^1, E^1)$. Otherwise, move on to the next step.

Step 2. For all $i \in N$, let $m_i^1 = p_i(c^1, \frac{E^1}{2})$, $c^2 = c^1 - m^1$, where $m^1 = (m_i^1)_{i\in N}$, and $E^2 = E^1 - \sum m_i^1 = \frac{E}{2}$. For all $i \in N$, calculate $r^i(c^2, E^2)$. If $r^i(c^2, E^2) = r^j(c^2, E^2)$, for all $i, j \in N$, then $pc[r(c, E)] = m^1 + r^i(c^2, E^2)$. Otherwise, move on to the next step.

Step k+1. For all $i \in N$, let $m_i^k = p_i(c^k, \frac{E^k}{2})$, $c^{k+1} = c^k - m^k$, and $E^{k+1} = E^k - \sum m_i^k = \frac{E}{2^k}$. For all $i \in N$, calculate $r^i(c^{k+1}, E^{k+1})$. If $r^i(c^{k+1}, E^{k+1}) = r^j(c^{k+1}, E^{k+1})$, for all $i, j \in N$, then $pc[r, (c, E)] = m^1 + \cdots + m^k + r^i(c^{k+1}, E^{k+1})$. Otherwise, move on to the next step.

If the previous process does not end in a finite number of steps, then:

Limit case. Compute $\lim_{k\to\infty}(m^1 + \cdots + m^k)$. If it converges to an allocation x^* such that $\sum_{i\in N} x_i^* \leq E$, then $x^* = pc[r, (c, E)]$. Otherwise, $pc[r, (c, E)] = 0$.

In the *unanimous concession procedure,* if agents do not agree on the rule proposed, they receive the minimum amount assigned by the chosen rules. Agents' rules are then applied to the residual problem, after adjusting claims and the liquidation value. If the chosen rules agree on the allocation for the new problem, then the procedure stops. Otherwise, the process starts all over again. If it does not end in a finite number of steps, the limit of the aggregation of minimal concessions (if it exists) is then chosen as the solution to the problem. Otherwise, nobody gets anything. Formally,

The unanimous concession procedure (P_3) (Herrero 2003). Let $(c, E) \in \mathbb{B}$ be given. Each player $i \in N$ chooses a *rule* $r^i \in \mathcal{R}$, with r^{-i} denoting the strategy profile selected by i's opponents. Let $r = \{r^i, r^{-i}\}$ be the profile of rules reported. The division proposed by the unanimous concessions procedure, $u[r, (c, E)]$ is obtained as follows:

Step 1. Let $c^1 = c$ and $E^1 = E$. For all $j \in N$, calculate $r^j(c^1, E^1)$. If $r^i(c^1, E^1) = r^j(c^1, E^1)$, for all $i, j \in N$, then $u[r, (c, E)] = r^i(c^1, E^1)$. Otherwise, move on to the next step.

Step 2. For all $i \in N$, let $m_i^1 = \min_{j\in N}\{r_i^j(c^1, E^1)\}$, $E^2 = E^1 - \sum_{i\in N} m_i^1$, and $c^2 = c^1 - m^1$, where $m^1 = (m_i^1)_{i\in N}$. For all $i \in N$, calculate $r^i(c^2, E^2)$. If $r^i(c^2, E^2) = r^j(c^2, E^2)$, for all $i, j \in N$, then $u[r, (c, E)] = m^1 + r^i(c^2, E^2)$. Otherwise, move on to the next step.

Step k+1. For all $i \in N$, let $m_i^k = \min_{j\in N}\{r_i^j(c^k, E^k)\}$, $E^{k+1} = E^k - \sum_{i\in N} m_i^k$, and $c^{k+1} = c^k - m^k$. For all $i \in N$, calculate $r^i(c^{k+1}, E^{k+1})$. If $r^i(c^{k+1}, E^{k+1}) = r^j(c^{k+1}, E^{k+1})$, for all $i, j \in N$, then $u[r, (c, E)] = m^1 + \cdots + m^k + r^i(c^{k+1}, E^{k+1})$. Otherwise, move on to the next step.

If the previous process does not end in a finite number of steps, then

Limit case. Compute $\lim_{k\to\infty}(m^1 + \cdots + m^k)$. If it converges to an allocation x^* such that $\sum_{i\in N} x_i^* \leq E$, then $x^* = u[r, (c, E)]$. Otherwise, $u[r, (c, E)] = 0$.

The strategic properties of these procedures have already been explored in the literature, as the following lemma shows.

Lemma 1 (Chun 1989; Moreno-Ternero 2002; Herrero 2003) *The following statements hold:*

(i) *If, for some $i \in N$, $r^i = cea$, then $dc[r, (c, E)] = cea(c, E)$. Furthermore, in game P_1, cea is a weakly dominant strategy for the lowest claimant and all Nash equilibria are outcome equivalent to cea.*

(ii) *If, for some $i \in N$, $r^i = p$, then $pc[r, (c, E)] = p(c, E)$. Furthermore, in game P_2, if there exists an agent whose preferred allocation is p, then p is a weakly dominant strategy for her. Finally, all Nash equilibria of P_2 are outcome equivalent to p.*

(iii) *If, for some* $i \in N$, $r^i = cel$, *then* $u[r, (c, E)] = cel(c, E)$. *Furthermore, in game* P_3, *cel is a weakly dominant strategy for the highest claimant and all Nash equilibria of* P_3 *are outcome equivalent to cel.*

The basic message of Lemma 1 is that the three procedures selected do not seem to afford the agents any freedom of choice, at least under very mild (first-order) rationality conditions. This is so because there is always some player (the identity of whom depends on the procedure) who can force the outcome in her favor by selecting her weakly dominant strategy. This may render these procedures inadequate if we were genuinely interested in the rule selection problem, that is, in collecting experimental evidence on how subjects reach an agreement in the lab. This is why we also consider an additional procedure which takes the form of a coordination game, which we call the *majority procedure* P_0.

In P_0, a claimant obtains the share of the liquidation value proposed by her chosen rule only if it has been selected by simple majority (that is, all other rules have been chosen by a strictly smaller number of agents). Otherwise, she is fined by $\varepsilon > 0$. More precisely:

Majority procedure (P_0). Let $(c, E) \in \mathbb{B}$ be given. Each player $i \in N$ chooses simultaneously a *rule* $r^i \in \mathcal{R}$, with r^{-i} denoting the strategy profile selected by i's opponents. The payoff function is as follows:

$$\pi_i\left(r^i, r^{-i}\right) = \begin{cases} r_i^i(c, E) & \text{if } r^i \text{ is the rule selected by a } simple \text{ majority;} \\ -\varepsilon & \text{otherwise.} \end{cases}$$

The strategic properties of this procedure are contained in the following lemma, the (trivial) proof of which is omitted here.

Lemma 2 *The set of strict Nash equilibria of* P_0 *is* $\{(r, r, \ldots, r) : r \in \mathcal{R}\}$.

3 Experimental design

In what follows, we describe in detail the main design features of our experimental study.

3.1 Subjects

Our experiment was conducted in 25 computerized sessions.[5] A total of 300 students (12 students per session) were recruited among the undergraduate population at the University of Alicante. Our experimental subjects were mainly Economics students, with no (or very little) prior exposure to game theory.

[5] The experiment was programmed and conducted using the experimental software *z-Tree* (Fischbacher 2007).

3.2 Frames

We ran 15 *framed* and 10 *unframed* sessions. As for the former, the claim problem was framed in three different ways, depending on the procedure being employed. The idea was to provide a framework consistent with the (equilibrium) rule induced by the procedure. All frames had the common feature that the problem was presented by the hypothetical situation of a *bank going bankrupt.*

- **Frame 1: Depositors**. Within this framework, the claimants are all *bank depositors*. In such a case, common-sense (and common practice) gives priority to the smaller claims (i.e., the smaller deposits), as it occurs (in equilibrium) with procedure P_1.
- **Frame 2: Shareholders**. Within this framework, the claimants are all *shareholders* of the bank. This is the typical situation in which, in case of a bankruptcy, each shareholder usually obtains a share of the liquidation value that is proportional to the number of shares of the bank's stock she holds, as occurs (in equilibrium) with procedure P_2.
- **Frame 3: Non-governmental organizations**. In our last framework, claimants are *non-governmental organizations (NGO) sponsored by the bank*. We here assumed that the NGO had signed a contract with the bank before its bankruptcy, according to which it would receive a contribution according with its social relevance (i.e., the higher the social relevance, the higher the contribution). Within such a framework, it would seem appropriate to give priority to higher claimants, as it occurs (in equilibrium) with procedure P_3.
- **Frame 0: No frame (NO)**. We also ran ten unframed sessions. In this case, subjects were only provided with monetary payoff tables and were required to play the four protocols without any story behind.

3.3 Treatments

In the framed sessions, subjects were randomly assigned to groups of three individuals each and played 20 rounds of a *framed* procedure, P_1, P_2 or P_3, followed by 20 rounds of P_0 presented under the same frame. In the unframed sessions, subjects played 20 rounds of each of the four procedures, P_1, P_2, P_3 (in different order, depending on the treatment), followed by P_0, without any framework. Table 1 reports on the precise sequencing of the 25 sessions.

As Table 1 shows, all (un)framed treatments consist of a sequence of (four) two procedures. In all framed and unframed sessions, our procedure P_0 was played *last.* This was to check whether the convergence properties of P_0 were conditioned on the frame (in the framed sessions) or the order of preceding procedures (in the unframed sessions). As it turns out (see footnote 11 below), this was not the case. The framed sessions lasted for approximately 45', whereas the unframed ones lasted about 70'. In all sessions, subjects played anonymously in groups of three players with randomly matched opponents. Subjects were informed that their *player position* (i.e., their individual claims in the problem) would remain constant throughout the session, while the composition of their group would change at every round.

Table 1 Sequential structure of the experimental sessions

Treatments	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8
	P_1	P_2	P_3	P_1	P_3	P_2	P_2	P_3
	P_0	P_0	P_0	P_2	P_2	P_1	P_3	P_1
				P_3	P_1	P_3	P_1	P_2
				P_0	P_0	P_0	P_0	P_0
Number of sessions	5	5	5	2	2	2	2	2
Frame	Framed			Unframed				

Instructions were provided by a self-paced, interactive computer program that introduced and described the experiment. Subjects were also given a written copy of the instructions (identical to those that appeared on the screen), and of the payoff table associated with the procedure being played.[6] At the end of each round, subjects were informed about the outcome of the game and the monetary payoff associated with it.

3.4 The claims problem

All monetary payoffs in the experiment were expressed in Spanish Pesetas (1 euro is approx. 166 Spanish Pesetas).[7] As we mentioned earlier, all four procedures were constructed upon *the same* problem (c^*, E^*), where $c^* = (49, 46, 5)$ (i.e., $\sum c_i = 100$ and $E^* = 20$). The resulting allocations associated with each rule for this specific problem are as follows:

$$\begin{aligned} cea(c^*, E^*) &= (7.5, 7.5, 5), \\ p(c^*, E^*) &= (9.8, 9.2, 1), \\ cel(c^*, E^*) &= (11.5, 8.5, 0). \end{aligned}$$

Since, in all of the sessions, subjects played more than one procedure in sequence, we decided to focus on a single problem to reduce the variability in the environment and facilitate subjects' understanding of the strategic situation in which they were involved. The main motivation for the choice of the particular problem (c^*, E^*) was to provide each claimant with a strictly preferred allocation associated with one of the three rules. We already know, from our Remark, that, for all rules belonging to $\mathcal{R}$, *cel* (*cea*) is the most preferred rule of the highest (lowest) claimant, independently of the

[6] Instructions were presented in Spanish. The complete set of instructions, translated into English, can be found in the Appendix.

[7] It is standard practice for all experiments ran in Alicante to use Spanish Pesetas as experimental currency. The reason for this design choice is twofold. First, it mitigates integer problems, compared with other currencies (USD or Euros, for example). On the other hand, although Spanish Pesetas are no longer in use (substituted by the Euro in the year 2002), Spanish people still use Pesetas to express monetary values in their everyday life. In this respect, by using a "real" (as opposed to an artificial) currency, we avoid the problem of framing the incentive structure of the experiment using a scale (e.g., "Experimental Currency") with no cognitive content.

particular problem in hand. However, this does not guarantee that p will be the most preferred rule for any middle claimant, unless we imposed some conditions that are formally presented in the Appendix.

3.5 Game-forms and payoffs

As we mentioned earlier, all procedures share the same game-form. In each session, each player was assigned to a player position, corresponding to a particular claim in the problem (c^*, E^*), with c_i^* denoting player i's claim. In each round, each player was required to choose simultaneously a rule from among cea, p and cel. Round payoffs were determined by the ruling procedure.

One of our most delicate design choices was just how to construct the (monetary) payoff functions for our experiment. In a standard experimental session, subjects participate in a specific "role-game" protocol after which they receive a certain amount of money as a function of how well they (and the other subjects in the pool) have played the game. In other words, subjects who participate in an economic experiment *win money*. However, in real-life claims situations, *claimants lose money,* in the sense that they get back less than what they have paid (or had the right to be repaid) sometime in the past.

To some extent, the simple fact that subjects must leave the experimental lab with more money than what they had at the time they arrived may be considered incompatible with the possibility of running an experiment on claims problems. To (at least partially) ameliorate this dilemma, we constructed our monetary payoff functions in such a way that, in each round, (out of a predetermined endowment, known in advance), subjects were losing *the difference* between their claim and the award assigned to them, given the ruling procedure and the group's strategy profile.

More precisely, rule allocations in the experiment were constructed as follows:

$$
\begin{aligned}
cea(c^*, E^*) - c^* &= (7.5, 7.5, 5) - (49, 46, 5) = (-41.5, -38.5, 0).\\
p(c^*, E^*) - c^* &= (9.8, 9.2, 1) - (49, 46, 5) = (-39.2, -36.8, -4).\\
cel(c^*, E^*) - c^* &= (11.5, 8.5, 0) - (49, 46, 5) = (-37.5, -37.5, -5).
\end{aligned}
$$

By the same token, the payoff matrix associated to procedure P_1, as shown in Table 2, only contains non-positive amounts.

Table 2 is identical to the one used to explain procedure P_1 to subjects. Player 1 (2) [3] selects the row (column) [matrix]. Each cell contains the monetary payoffs, for the three players, associated to each strategy profile.

The payoffs were obtained as follows: From Lemma 1, if $r^i = cea$ for some $i \in \{1, 2, 3\}$, then the allocation is $cea(c^*, E^*) - c^* = (-41.5, -38.5, 0)$. If $r^i = r^j$ for all $i \neq j$ then the allocation is $r^i(c^*, E^*) - c^*$. The allocations of the remaining six profiles were obtained using the recursive algorithm based on the definition of P_1 that leads to $(10.7, 8.4, 0.9) - c^* = (-38.3, -37.6, -4.1)$.

As we know from Lemma 1, every procedure provides a player (the identity of whom depends on the procedure) with a weakly dominant strategy by which she can force her preferred outcome. In each game, we refer to such a player as the *pivotal*

Table 2 Procedure P_1

	A	B	C
A	−41.5 −38.5 0	−41.5 −38.5 0	−41.5 −38.5 0
B	−41.5 −38.5 0	−41.5 −38.5 0	−41.5 −38.5 0
C	−41.5 −38.5 0	−41.5 −38.5 0	−41.5 −38.5 0

A

	A	B	C
A	−41.5 −38.5 0	−41.5 −38.5 0	−41.5 −38.5 0
B	−41.5 −38.5 0	−39.2 −36.8 −4	−38.3 −37.6 −4.1
C	−41.5 −38.5 0	−38.3 −37.6 −4.1	−38.3 −37.6 −4.1

B

	A	B	C
A	−41.5 −38.5 0	−41.5 −38.5 0	−41 −38 0
B	−41.5 −38.5 0	−38.3 −37.6 −4.1	−38 −37 −4
C	−41.5 −38.5 0	−38.3 −37.6 −4.1	−37 −37 −5

C

Table 3 Procedure P_2

	A	B	C
A	−41.5 −38.5 0	−39.2 −36.8 −4	−39.2 −36.8 −4
B	−39.2 −36.8 −4	−39.2 −36.8 −4	−39.2 −36.8 −4
C	−39.2 −36.8 −4	−39.2 −36.8 −4	−39.2 −36.8 −4

A

	A	B	C
A	−39.2 −36.8 −4	−39.2 −36.8 −4	−39.2 −36.8 −4
B	−39.2 −36.8 −4	−39.2 −36.8 −4	−39.2 −36.8 −4
C	−39.2 −36.8 −4	−39.2 −36.8 −4	−39.2 −36.8 −4

B

	A	B	
A	−39.2 −36.8 −4	−39.2 −36.8 −4	−3 −3 –
B	−39.2 −36.8 −4	−39.2 −36.8 −4	−3 −3 –
C	−39.2 −36.8 −4	−39.2 −36.8 −4	−3 −3 –

C

player in that game. For P_1, the pivotal player is player 3 (the lowest claimant), whose weakly dominant strategy corresponds to rule *cea*.

Analogous considerations hold for P_2 and P_3 whose payoff matrices are drawn in Tables 3 and 4, respectively.

Here we notice that *p* is a weakly dominant strategy in P_2 for the pivotal player 2, whereas *cel* is weakly dominant in P_3 for the pivotal player 1.

As we can see from Tables 2, 3 and 4, all situations where agents' rules do not coincide (and no agent selects the corresponding equilibrium rule) lead to a well-defined limit in the division of the liquidation value. In other words, the event of no convergence (associated with a 0 payoff for all players), contemplated in the definition of all three procedures, never occurs in our games. As it turns out, this is not a special feature of our specific parameterization of the claim problem (c^*, E^*) -or the constraint on the set of rules or the number of players- but rather a general property of all procedures, as the following proposition shows.

Proposition 1 *For all* $(c, E) \in B$ *and for all procedures,* P_1, P_2 *and* P_3*, the limit allocation* x^* *always exists.*

Proof In the Appendix.

The majority procedure, P_0, displays rather different strategic properties, as shown in Table 5.

Since this procedure yields basically a coordination game, no player has a weakly dominant strategy. (Strict) Nash equilibria correspond to those profiles in which all players agree on the same rule.

The payoffs for this game were obtained as follows. If $r^i = r^j$ for all $i \neq j$ then the allocation is $r^i(c^*, E^*) - c^*$. If $r^i = r^j \neq r^k$, then agents i and j get $r^i_i(c^*, E^*) - c^*_i$

Table 4 Procedure P_3

	A	B	C
A	−41.5 −38.5 0	−39.6 −36.6 −3.7	−37.5 −37.5 −5
B	−39.6 −36.6 −3.7	−39.6 −36.6 −3.7	−37.5 −37.5 −5
C	−37.5 −37.5 −5	−37.5 −37.5 −5	−37.5 −37.5 −5

A

	A	B	C
A	−39.6 −36.6 −3.7	−39.6 −36.6 −3.7	−37.5 −37.5 −5
B	−39.6 −36.6 −3.7	−39.2 −36.8 −4	−37.5 −37.5 −5
C	−37.5 −37.5 −5	−37.5 −37.5 −5	−37.5 −37.5 −5

B

	A	B	
A	−37.5 −37.5 −5	−37.5 −37.5 −5	−3 −3 –
B	−37.5 −37.5 −5	−37.5 −37.5 −5	−3 −3 –
C	−37.5 −37.5 −5	−37.5 −37.5 −5	−3 −3 –

C

Table 5 Procedure P_0

	A	B	C
A	−41.5 −38.5 0	−41.5 −47 0	−41.5 −47 0
B	−50 −38.5 0	−39.2 −36.8 −6	−50 −47 −6
C	−50 −38.5 0	−50 −47 −6	−37.5 −37.5 −6

A

	A	B	C
A	−41.5 −38.5 −6	−50 −36.8 −4	−50 −47 −6
B	−39.2 −47 −4	−39.2 −36.8 −4	−39.2 −47 −4
C	−50 −47 −6	−50 −36.8 −4	−37.5 −37.5 −6

B

	A	B	
A	−41.5 −38.5 −6	−50 −47 −6	– −3 –
B	−50 −47 −6	−39.2 −36.8 −6	– −3 –
C	−37.5 −47 −5	−37.5 −47 −5	−3 −3 –

C

and $r_j^j(c^*, E^*) - c_j^*$ respectively, whereas agent k gets $-1 - c_k^*$. Finally, if all agents propose different rules, the allocation is $(-1, -1, -1) - c^*$.

As we already mentioned, the payoffs reported in Tables 2, 3, 4 and 5 were subtracted from subjects' endowments. Before playing a given procedure, all subjects received an initial endowment of 1,000 pesetas in each session, from which all losses were subtracted during the 20 rounds. At the beginning of each following procedure, subjects would receive a new endowment of 1,000 pesetas, and so on. Furthermore, subjects who were selected as players 1 and 2 received 500 pesetas as a show-up fee in the framed sessions, and 1,000 pesetas in the unframed sessions. Subjects who were selected as players 3 did not receive any initial show-up fee, due to the fact that their losses were considerably lower than the others'.[8] As for procedure P_0, the penalty ε was equal to 1 peseta. Average earnings per hour were around 1,800 pesetas (11 euros) for players 1 and 2 and around 3,600 pesetas (22 euros) for player 3.

4 Experimental results

In presenting our experimental evidence, we shall look first at procedures P_1 to P_3 in Sect. 4.1. Here we find that, for each procedure, the corresponding equilibrium rule emerges from the very beginning, independent of the framing conditions. By stark contrast, our majority procedure P_0 (Sect. 4.2) displays a significantly lower rate of equilibrium outcomes and behavior, both in framed and unframed sessions. Moreover,

[8] This asymmetry in the show-up fees, meant to provide also players 1 and 2 with the appropriate financial gain, was communicated privately to each subject, and as such, we shall read the data under the assumption that it played no role in determining their decisions.

Table 6 Outcome distributions of P_1, P_2 and P_3

Procedures	Framed sessions					Unframed sessions				
P_1	400	**0.97**	0	0	0.03	800	**0.96**	0.01	0.01	0.03
P_2	400	0	**0.98**	0.01	0.01	800	0.01	**0.98**	0.01	0
P_3	400	0	0	**0.97**	0.03	800	0.01	0	**0.96**	0.03
Allocations	Obs.	*cea*	*p*	*cel*	Others	Obs.	*cea*	*p*	*cel*	Others

and more strikingly, in P_0, whenever subjects are able to coordinate on an equilibrium, *they do so only under the proportional rule.* This evidence calls for further statistical analysis. Here we find that, for procedure P_0, both frame and learning effects are significant in explaining outcomes and subjects' aggregate behavior, albeit to a different extent across players' positions.

4.1 Procedures P_1 to P_3

Table 6 reports the relative frequency of allocations which correspond to each rule for procedures P_1, P_2 and P_3. The remaining category (labeled as "Others") pools all allocations that do not correspond to any particular rule. We begin by noting that *virtually all* matches (both in the framed and in the unframed sessions) yielded the allocation associated with the corresponding equilibrium rule (boldface in Table 6). We also know, from Lemma 1, that every Nash equilibrium is outcome equivalent to the corresponding equilibrium rule. However, there are also other strategy profiles which are not equilibria but which yield the same allocation (for example, in the case of P_1 if players 1 and 3 select rule p and player 2 selects cea). In this respect, our evidence shows that these strategy profiles occur only marginally. That is to say, if a particular rule dictates the game allocation, it is because the same rule is supported by a Nash equilibrium of the corresponding procedure.[9]

We now look at subjects' aggregate behavior in Table 7, which reports the relative frequencies with which pivotal players (player 3 in P_1, player 2 in P_2 and player 1 in P_3) used each strategy in the corresponding procedure. As Table 7 shows, pivotal players overwhelmingly use their weakly dominant strategies (relative frequencies in boldface), both in framed and unframed sessions. This confirms that compliance with

9 Relative frequencies of Nash equilibria strategy profiles of (un)framed sessions of procedures P_1, P_2 and P_3 are 0.96 (0.94), 0.99 (0.98) and 0.93 (0.9), respectively. We should also notice that, in procedures P_1 and P_3, a Nash equilibrium occurs if either *(a)* the pivotal player selects the equilibrium rule ($p = 1/3$ if she plays randomly) or *(b)* in the case of her not doing so (this, under random playing, would occur with a probability of $1 - p = 2/3$) if the other two players select the equilibrium rule (probability equal to $1/9$). As for P_2, a strategy profile *is not* a Nash equilibrium if 2 and 3 play C (which, under random playing, would occur with a probability of $1/9$) or when players 1 and 2 play A (which, under random playing, would occur again with a probability of $1/9$). The expected probability of a Nash equilibrium under random playing is, therefore, $1/3 + 2/3 * 1/9 \cong 0.4$ in procedures P_1 and P_3 and $1 - 2/9 \cong 0.75$ in procedure P_2. This implies that relative frequencies of equilibrium strategy profiles are much higher than their predicted values under random playing.

Table 7 Aggregate behavior of pivotal players in the sessions of P_1,P_2 and P_3

Pivotal player	Player 3(P_1)			Player 2(P_2)			Player 1(P_3)		
Framed	**0.97**	0.02	0.1	0.1	**0.73**	0.17	0.04	0.07	**0.89**
Unframed	**0.94**	0.03	0.03	0.07	**0.84**	0.09	0.02	0.09	**0.89**
RULES	*cea*	*p*	*cel*	*cea*	*p*	*cel*	*cea*	*p*	*cel*

Table 8 Outcome distributions in P_0

Rounds	Framed sessions					Unframed sessions				
First 10	600	0.01	**0.55**	0.01	0.43	400	0.04	**0.28**	0	0.68
Last 10	600	0	**0.89**	0	0.11	400	0	**0.66**	0.01	0.34
	Obs.	*cea*	*p*	*cel*	Others	Obs.	*cea*	*p*	*cel*	Others

equilibrium is high in normal-form games that are solvable in just one round with the deletion of weakly dominated strategies (e.g., Costa-Gomes et al. 2001).[10]

4.2 The majority procedure P_0

We now focus on P_0, whose outcome distributions are reported in Table 8. Consistently with the layout of Tables 6 and 7, Table 8 partitions our observations of P_0 into two groups: "framed" and "unframed", independently on the actual frame under which they were collected (treatments T1–T3 of Table 1), or, for the unframed sessions, the sequencing of procedures $P_1 - P_3$ (treatments T4–T8).[11] As Table 8 shows, the proportional rule is salient in describing the allocation distributions, for both framed and unframed sessions (boldface). Subjects not only managed to agree on an equilibrium allocation a significant number of times, but also they did so on the proportional rule.[12] Moreover, we also observe a much higher frequency of coordination (and, therefore, a lower frequency of non-equilibrium allocations) in the framed sessions and/or later periods. This is indicating that both learning and frames appear to enhance coordination (on the proportional rule).[13]

[10] As far as non-pivotal players are concerned, weakly dominant strategies are again more frequently selected, although not as frequently as in the case of pivotal players (see Herrero et al. (2003) for details).

[11] This partitioning is justified by the fact that we cannot detect significant differences in (proportional) outcome distributions in P_0—using Mann-Whitney non-parametric tests—within framed ($z = -0.885$, $p = 0.3763$) or unframed ($z = 1.276$, $p = 0.2020$) sessions. Analogous considerations hold when we look at aggregate behavior, disaggregated for player position (Table 11). Results are not reported here, but are available upon request.

[12] Coordination on *cea* or *cel* does not exceed 3% of total observations.

[13] This first impression is confirmed by testing the difference of proportional outcomes between framed and unframed sessions (Mann-Whitney: $z = -10.289$, $p = 0$). Again, analogous considerations hold when we look at aggregate behavior, disaggregated for player position.

Table 9 Testing for frame and learning effects in P_0 at the outcome level

	Coef.	Std. Err.	P>z	[95% Conf. Interval]	
Frame	1.139	0.419	0.007	0.318	1.960
Last10	1.585	0.260	0.000	1.074	2.095
Frame*Last10	0.290	0.391	0.458	−0.476	1.055
Const.	−0.938	0.327	0.004	−1.579	−0.298
dP/dFrame	1.284	0.518	0.013	0.268	2.300
dP/dLast10	1.759	0.203	0.000	1.360	2.157

The evidence of Table 8 calls for further statistical analysis. In particular, we are interested in checking the extent to which frame and learning effects (basically absent in P_1, P_2 and P_3) are significant in explaining subjects' coordination on the proportional rule in P_0, and whether one effects predominates over the other.

In the regressions that follow the dependent variable $y_s(t) \in \{0, 1\}$ is an index which equals 1 if, at any given round t of P_0, (i) at the *group* level, all members of group s are able to coordinate on the equilibrium corresponding to the proportional rule (Table 9) or, (ii) at the *individual* level, subject s selects p as her current strategy (Table 11). For both regressions, we shall assume that the corresponding probabilities distribute according to the classic logit model:

$$\Pr\left[y_s(t) = 1\right] = \frac{e^{f(.)}}{1 + e^{f(.)}},$$

where $f(.)$ is a linear function of treatment conditions.[14] Since, within each session, the same group of 12 subjects is randomly rematched each of the 20 rounds, we also adjust the estimation of the variance-covariance matrices to control for possible correlation among observations drawn from the same session.

Table 9 reports the estimated coefficient of a logit regression in which $f(.)$ includes a constant term (Const. in the table), a dummy variable (Frame), which equals 1 (0) for a framed (unframed) session, another dummy variable (Last10) which equals 1 (0) for observation drawn in the last (first) 10 rounds, together with an interaction term. Since the interaction term introduces non linearity in the measurement of both frame and learning effects, the last two rows of Table 9 report marginal effects evaluated at the sample means of the corresponding regressors. Table 9 confirms the impression we drew from Table 8: frame and learning effects are both highly significant in explaining convergence to the proportional rule outcome. Although the estimated learning marginal effect is higher, the difference (here and elsewhere in this section) is not statistically significant ($p = 0.393$).

Table 10 shows aggregate behavior in P_0, for frame and unframed sessions, disaggregated for rounds and player position. Again, in Table 10 our observations are partitioned in the usual four subsamples.

[14] All regressions were numerically evaluated using Stata 10, by StataCorp.

Table 10 Evolution of subjects' aggregate behavior in P_0

	Player 1			Player 2			Player 3		
Framed: First 10	0.05	**0.8**	0.15	0.09	**0.82**	0.09	0.25	**0.72**	0.03
Framed: Last 10	0	**0.98**	0.02	0.02	**0.97**	0.01	0.06	**0.93**	0.01
Unframed: First 10	0.19	**0.55**	0.26	0.17	**0.71**	0.12	0.35	**0.54**	0.11
Unframed: Last 10	0.04	**0.84**	0.12	0.06	**0.93**	0.01	0.23	**0.76**	0.01
RULES	*cea*	*p*	*cel*	*cea*	*p*	*cel*	*cea*	*p*	*cel*

Table 10 confirms that subjects mainly select the proportional rule (boldface), independently of their player positions, and that frequencies of use of p are higher in the framed sessions and for observations which correspond to the last ten rounds of each session. We also notice that learning effects (i.e., higher propensity to choose the proportional rule in the last rounds of each session) are stronger in the unframed sessions, in that differences in the frequencies of use between first and last ten rounds are higher. From Table 10, we see that player 2 (especially in the framed sessions) starts playing p with higher probability than players 1 and 3, while the increase in probability across time intervals is comparatively lower. Also, frame effects (that is, an increase in the probability of playing p in the framed sessions) are lower for player 2 than for her opponents. Thus, the dynamic pattern we observe (especially in the unframed sessions) mainly consists of players 1 and 3 gradually discarding their first-best rule (*cel* and *cea*, respectively), "joining" player 2 in the choice of their second-best option.

Table 11 reports parameter estimations of a model specification by which $f(.)$ includes dummies for player position (Pli in the table), and interactions of the latter with all regressors included in Table 9.[15]

From Table 11 we derive that player 2 starts off playing p significantly more often than her opponents, both in framed and unframed sessions.[16] As for framing, marginal effects are always positive, although they are significant (at the 5% confidence level) for players 1 and 3 only. In this sense, frames seem to facilitate players 1 and 3 more than the middle-claimant player 2 in the task of coordination toward the proportional rule. By contrast, the increase in probability in the last repetitions (measured by Pli_Last ten for the unframed sessions and Pli_Frame_Last ten for the framed sessions) is the lowest (highest) for player 2 in the (un)framed sessions. That is, framing also enhances players' 1 and 3 shift toward the proportional rule. Overall (look at

[15] Note that, since we introduce dummies for all player positions, the estimation of the constant is omitted here.

[16] As for the unframed sessions, difference in the estimated player constants between Player 2 and her opponents are always positive and significant, with $z = 4.64 (p = 0.000)$ and $z = 4.02 (p = 0.000)$, for Players 1 and 3, respectively. The same considerations hold for the framed sessions, although the difference is statistically significant in case of player 3 only ($z = 0.91$, $p = 0.364$ and $z = 2.71$, $p = 0.007$, respectively). Joint tests (where the null hypothesis is that Player 2 selects p with the same probability of Player 1 *and* Player 3 in the first rounds of framed and unframed sessions are always rejected at the 1% confidence level).

Table 11 Testing for frame and learning effects in P_0 at the individual level

	Coef.	Std. Err.	P>z	[95% Conf. Interval]	
Pl1	0.201	0.292	0.491	−0.371	0.772
Pl2	0.877	0.252	0.000	0.384	1.370
Pl3	0.150	0.160	0.347	−0.163	0.464
Pl1_Frame	1.210	0.367	0.001	0.491	1.929
Pl2_Frame	0.647	0.343	0.060	−0.026	1.320
Pl3_Frame	0.800	0.329	0.015	0.155	1.444
Pl1_Last10	1.439	0.201	0.000	1.044	1.834
Pl2_Last10	1.729	0.176	0.000	1.384	2.074
Pl3_Last10	1.016	0.285	0.000	0.458	1.575
Pl1_Frame_Last10	0.985	0.485	0.042	0.035	1.935
Pl2_Frame_Last10	0.075	0.341	0.826	−0.594	0.744
Pl3_Frame_Last10	0.694	0.514	0.177	−0.313	1.700
Frame					
Player 1	1.702	0.523	0.001	0.676	2.728
Player 2	0.685	0.396	0.084	−0.092	1.461
Player 3	1.147	0.496	0.021	0.175	2.118
Learning					
Player 1	2.030	0.276	0.000	1.488	2.572
Player 2	1.774	0.189	0.000	1.403	2.144
Player 3	1.432	0.281	0.000	0.882	1.982

the marginal effects, bottom of Table 11), learning is always highly significant and increases with player positions (although differences are never significant).

These results complement the evidence of Table 10 we just discussed: player 1 (and especially player 3, whose claim is significantly smaller than the other two) gradually discard their favorite options to join player 2 in selecting the proportional rule, with this movement being stronger in the framed sessions. In other words, convergence to the proportional rule may have been facilitated by some sort of *median voter effect*, since the proportional rule is the only one in which no player receives less than her second-best option. We shall further discuss some alternative explanations for this behavioral pattern in the concluding remarks below.

5 Taking the viewpoint of *outside observers*: survey results

Our previous results concerning procedure P_0 strongly suggest that the proportional rule shows a particular strength as a coordinating device. In the axiomatic literature, rules are typically justified on the grounds of properties reflecting ethical (or operational) criteria that they might satisfy. Nevertheless, people may endorse different criteria and therefore one might ask whether it is the case that, in our problem, a majority of subjects perceives the proportional allocation as being more just or socially appropriate than their alternatives. In doing so, we would be exploring whether the proportional rule may be considered as a social norm for solving problems of adjudicating conflicting claims. If such were the case, the choice of the proportional rule as a coordinating device could be interpreted as evidence of the power of social norms to enhance coordination and cooperation within a society [see, among others, Sugden (1986), Gauthier (1986), Skyrms (1996) and Binmore (1998)]. Now, since we have also observed in our previous results for P_0 that frames help coordination, we should verify first subjects' perception of the adequacy of the proportional rule (as the best way of solving problems of this sort) under different frames, even in the absence of strategic considerations.

To this aim, we adopted the usual approach applied for resource allocation problems, that is, we asked subjects to answer a questionnaire adopting the perspective of an *outside observer*, rather than becoming involved in the problem as a claimant. This sort of survey was inspired by the seminal paper presented by Yaari and Bar-Hillel (1984) and has been applied by Bar-Hillel and Yaari (1993), Cuadras-Morató et al. (2001) and Gächter and Riedl (2006), among others.

More specifically, we distributed 164 questionnaires among undergraduate students at the University of Alicante and at the University of Málaga, none of whom had any prior exposure to problems of adjudicating conflicting claims or any related issue. These students were not the same ones who had been recruited for the experimental sessions in the lab. In the questionnaire, we proposed six different hypothetical situations leading to the same problem (c^*, E^*) used in the experiment. Subjects were asked to select their preferred rule (among *cea*, *p* and *cel*) for each individual problem in hand. The first three situations were those that we presented as Frames 1–3 in Sect. 3.2, while the remaining three situations are described as follows:[17]

- **Frame 4: Estate division.** A person dies and leaves an estate that is insufficient to cover the claims on three legally contracted debts. Then, E^* is interpreted as the estate and the claims vector c^* as the debts contracted with each creditor.
- **Frame 5: Bequests.** A man dies after having promised each one of his three sons a certain amount of money. The value of the bequest he leaves, however, is not sufficient to cover the three promised amounts. His sons are now the claimants on the promises made to them, individually, by their father.
- **Frame 6: Taxation.** The problem now consists of collecting a fixed amount of money (a tax in our case) from a given group of three agents whose gross incomes are known to one another. As such, E^* is interpreted as the amount to be collected and c^* as the vector of individual (gross) incomes.

Table 12 summarizes choice frequencies by our respondents under the six proposed frames.

We first observe from Table 12 that the respondents' choices vary significantly, depending on the frame. Nevertheless, the proportional rule continues to be the solution that receives the highest support in all six cases, not only at the aggregate level (as Table 12 shows) but also at the level of individuals (since *p* represented the modal

[17] See the Appendix for a complete description of the questionnaire.

Table 12 Questionnaire results

Frame	*cea*	*p*	*cel*
F1: Depositors	0.06	0.89	0.05
F2: Shareholders	0.06	0.68	0.26
F3: NGOs	0.12	0.46	0.42
F4: Estate	0.15	0.75	0.10
F5: Bequests	0.38	0.61	0.01
F6: Taxation	0.11	0.56	0.33

Table 13 Testing for frame effects on the survey's rule distributions

	F1	F2	F3	F4	F5
F2	18.1 (0)				
F3	53.6 (0)	14.6 (0.001)			
F4	7.42 (0.02)	13.6 (0.001)	32.5 (0)		
F5	37.7 (0)	54.8 (0)	60.4 (0)	21.3 (0)	
F6	34.5 (0)	5.14 (0.08)	2.75 (0.25)	19.1 (0)	51.7 (0)

choice, across the six questions, for 90% of responders). Furthermore, 16% of them chose the proportional rule in all six cases, where no other rule was ever chosen, in all cases, by any respondent. If we restrict our attention to the (minoritarian) rules *cea* and *cel*, we observe that they are chosen with different rates across frames, with a slight bias towards *cel* (19.2% versus 14.8%, on average). As for the specific frames, *cea* and *cel* are given almost identical support under frame 1 (in which the claimants are depositors). Rule *cea* is preferred against *cel* under frames 4 and 5 (i.e., the heritage situations), while *cel* is preferred in all other cases. Notice that *cel* was selected by 36% of the respondents both under frames 3 and 6 (non-governmental organizations and taxation). As for Frame 3, our evidence is in keeping with the results presented by Cuadras-Morató et al. (2001), in the context of health care problems, where *cel* receives a (slight) majoritarian support. This evidence is consistent with the idea that *cel* is the appropriate solution when claims are related to needs. The support for *cel* under frame 6 (taxation), also responds to the idea of income related to needs: people with low income should contribute relatively less, and thus, taxation schemes should be progressive.[18] The relatively large support of *cea* under frame 5 (34%) may be due to an interpretation of bequests more in line with the Spanish tradition, in which a significant part of the estate is distributed equally among the children.

In Table 13 we perform the statistical analysis to test for the impact of frames on the respondents' rule distributions.

Each cell of Table 13 contains the associated χ^2 test-statistics (p-value within parenthesis), where the null hypothesis is not difference between the rule distributions of the

[18] See Ju and Moreno-Ternero (2008) for the precise link between progressive taxation and inequality reduction in this context.

corresponding frame pairs.[19] As Table 13 shows, all pairwise comparisons reject the null, with one sole exception, Frame 3 versus 6, we have just discussed. This confirms our experimental evidence: frames matter and our subjective sense of justice is sensitive to the context in which the claim problem is posed. Nevertheless, we can safely argue that, also when facing the problem as outside observers, the proportional rule seems salient to characterize the most appropriate solution to the range of proposed claim situations.

6 Conclusions

In this paper, we have studied problems of adjudicating conflicting claims from two distinct, but complementary, perspectives. We believe our work may have implications for solving a variety of problems involving conflicting claims, ranging from common daily-life situations (such as allocating the cost of a public good among a group of neighbors) to more ambitious goals (such as providing a device for lawmakers in charge of designing rules to solve distributional conflicts in the presence of acquired rights). As for our experimental results, we can confidently conclude that, when the rules of a procedure are specifically designed to induce a particular (equilibrium) behavior, subjects are perfectly capable of recognizing the underlying incentive structure and selecting the corresponding equilibrium allocation. This claim is supported by the fact that the majority of our subjects, commenting on how they played procedures $P_1 - P_3$ in the lab, made very similar remarks:

- “In P_3 everything was determined by my own choice.”[20]

As the quote suggests, this is far more evident for pivotal players, who can force the outcome of a game in their own favor by selecting their weakly dominant strategy.

As for the majority procedure P_0, and in stark contrast with the other procedures, coordination on the proportional solution overwhelmingly prevails. Furthermore, in this case, framing and (especially) learning effects significantly enhance coordination. Similar conclusions can be drawn from our survey results. Here again, the proportional rule is the one that receives stronger support, both at the aggregate and at the individual levels. Again, we look at subjects’ comments to find some explanation for such a clear-cut result:

- “At first, I was looking for a way of maximizing my payoff but then I realized that it was quite impossible to do so, as everyone else was acting the same way and we were all losing money. So we finally settled for an intermediate solution that was neither our best nor our worst option”.[21]
- “I chose the option that seemed to be the most equitable one for the three agents involved”.[22]

[19] There is no need of discarding observations here, since we have, for each subject, one decision per frame.

[20] Debriefing section of Session 7 (unframed). Subject # 4 (player 1).

[21] Debriefing section of Session 1 (framed). Subject # 9 (player 3).

[22] Debriefing section of Session 1 (framed). Subject # 10 (player 3).

These two quotes suggest two different, but complementary, explanations for the coordinating power of the proportional rule. First, notice that the proportional rule tends, in general, to favor middle-sized claimants and, therefore, to ease coordination when the rule choice is made by majority voting (as is the case for our procedure P_0).[23] Nonetheless, this *median voter effect* we already referred to may also have been enhanced, as the second quote suggests, by the "social norm property" of the proportional rule we observe from our survey results. In this sense, *subjects' moral judgements may have acted as coordinating device*, exactly where incentives did not provide a clear-cut solution to the coordination problem subjects were facing. Not surprisingly, this effect is stronger in the framed sessions, where moral considerations are easier to apply.[24]

It is quite probable that some other factors may have influenced the coordination pattern. First, if the *median voter effect* we just mentioned were the only one at play, we should not expect strong framing effects, since the same argument holds for both framed and unframed treatments. However, we observe from Tables 9, 10 and 11 that framing effects do occur. Even if players seem sensitive to frames to a different extent, the overall effect, both at the aggregate and the individual level, is always significant.

To conclude, we may alert the reader that we focus on a very specific claim problem, which may have influenced our results in many different ways we cannot properly control for. For example, we focused on a single claim problem (c^*, E) with the (non-generic) property by which the proportional solution corresponds to the first-best for the middle claimant and the second-best for the others. This may have certainly enhanced the median voter effect we just mentioned. On the other hand, other classic justifications, often invoked to explain experimental evidence on coordination games, may fall short (or their application may not be straightforward) in our case. This is, for example, the case of the Pareto dominance criterion, given that all three rules are equally efficient. By the same token, also risk dominance cannot directly be applied to our context, since our games always employ more than two players and two strategies. Moreover, if we apply the maximin criterion as a proxy for risk-dominance, again, we are not able to select among the three equilibria, since out-of-equilibrium punishment does not depend on claims.

[23] By a similar argument, another explanation might be related to the properties that the proportional solution enjoys, in particular, its immunity to strategic manipulations. In this respect, Ju et al. (2007) have shown that the proportional rule is essentially the only rule that is immune to the manipulation via reshuffling, or via merging and splitting agents' claims.

[24] The wording "equitable" we read on many debriefing questionnaire may suggest, as one referee commented, that subjects' *inequality aversion* may have driven the equilibrium selection process in the direction of the proportional rule. To this aim, we analyzed P_0 within the realm of Fehr and Schmidt (1999) classic formalization. Clearly, nothing changes if we look at the Nash equilibria of P_0, independently on how individual preference parameters of envy and guilt are specified. This is because P_0 is a strict coordination game. However, it is no longer true that all equilibria are equally efficient (at least under the assumption of transferable utility). In this respect, we found that, if interdependent utility parameters are constant across players, and efficiency of an equilibrium is measured by simply summing the three players' net payoffs, *cel* is the most preferred rule, followed by *p* and *cea*. On the other hand, if we consider net transfers, instead of payoffs, the preference ranking is reversed.

Appendix A: Proofs

A.1 Proof of Proposition 1

In this section, we address the convergence of procedures P_1, P_2 and P_3 when they are applied to arbitrary rule sets. We show that, for all of the three procedures, whenever the process does not terminate in a finite number of stages, then the limit case is always well defined.

A.1.1 Convergence of P_1

Let $(c, E) \in \mathbb{B}$ be a given problem. Let $r = \{r^j\}_{j \in N}$ be the profile of rules chosen by the agents to solve the problem, where $r^j \in \mathcal{R}$ for all $j \in N$. For the sake of simplicity in the proof we assume that all of the chosen rules are continuous with respect to claims.[25]

Fix $i \in N$ and consider the sequence $\{c_i^k\}_{k \in \mathbb{N}}$, recursively defined as follows:

$$\begin{aligned} c_i^1 &= c_i \\ c_i^{k+1} &= \max_{j \in N} \left\{ r_i^j(c^k, E) \right\}, \quad \text{for all} \quad k \geq 2. \end{aligned}$$

Since $r^j \in \mathcal{R}$ for all $j \in N$, it is straightforward to show that $\{c_i^k\}_{k \in \mathbb{N}}$ is weakly decreasing and bounded from below by 0. Thus, it is convergent. Let $x_i = \lim_{k \to \infty} c_i^k$ and $x = (x_i)_{i \in N}$. Thus, in taking limits in the definition of the sequence, we would have

$$x_i = \max_{j \in N} \left\{ \lim_{k \to \infty} r_i^j(c^k, E) \right\}, \quad \text{for all } i \in N.$$

Since all of the rules chosen by the agents are continuous with respect to claims, then

$$x_i = \max_{j \in N} \left\{ r_i^j(x, E) \right\}, \quad \text{for all } i \in N.$$

Note that, since $c_1 \geq c_2 \geq \cdots \geq c_n$, it is straightforward to show that $c_1^k \geq c_2^k \geq \cdots \geq c_n^k$ for all $k \in \mathbb{N}$, and therefore $x_1 \geq x_2 \geq \cdots \geq x_n$. Let $j_0 \in N$ be such that $x_1 = \max_{j \in N}\{r_1^j(x, E)\} = r_1^{j_0}(x, E)$. Thus, since $r \in \mathcal{R}$,

$$0 = x_1 - r_1^{j_0}(x, E) \geq x_i - r_i^{j_0}(x, E) \geq 0, \quad \text{for all } i \in N.$$

In other words, $x = r^{j_0}(x, E)$, which implies $\sum x_i = E$. □

[25] This mild requirement is satisfied by all standard rules in the literature on bankruptcy. In particular, it is satisfied by the three rules that we consider in our experiment.

A.1.2 Convergence of P_2

Let $(c, E) \in \mathbb{B}$ be a given problem. Let $r = \{r^j\}_{j \in N}$ be the profile of rules chosen by the agents for solving the problem, where $r^j \in \mathcal{R}$ for all $j \in N$.

For all $i \in N$, consider the sequences $\{(c_i^k, E^k, m_i^k)\}_{k \in \mathbb{N}}$, recursively defined as follows:

$$(c_i^1, E^1, m_i^1) = \left(c_i, E, p_i\left(c^1, \frac{E^1}{2}\right)\right)$$
$$(c_i^{k+1}, E^{k+1}, m_i^{k+1}) = \left(c_i^k - m_i^k, \frac{E}{2^k}, p_i\left(c^{k+1}, \frac{E^{k+1}}{2}\right)\right), \quad \text{for all } k \geq 1$$

Now, given $i \in N$ and $K \in \mathbb{N}$ consider $\sum_{k=1}^{K} m_i^k = \sum_{k=1}^{K} p_i(c^k, \frac{E^k}{2})$. It is straightforward to show that

$$\sum_{k=1}^{K} p_i\left(c^k, \frac{E^k}{2}\right) = p_i(c, E) - p_i\left(c^{K+1}, \frac{E}{2^K}\right).$$

Thus, since p is continuous with respect to both arguments,

$$\sum_{k=1}^{\infty} m_i^k = p_i(c, E) - p_i\left(\lim_{K \to \infty} c^{K+1}, \lim_{K \to \infty} \frac{E}{2^K}\right) = p_i(c, E),$$

which proves the convergence. □

A.1.3 Convergence of P_3

Let $(c, E) \in \mathbb{B}$ be a given problem. Let $r = \{r^j\}_{j \in N}$ be the profile of rules chosen by the agents to solve the problem, where $r^j \in \mathcal{R}$ for all $j \in N$.

For all $i \in N$, consider the sequences $\{(c_i^k, E^k, m_i^k)\}_{k \in \mathbb{N}}$, recursively defined as follows:

$$(c_i^1, E^1, m_i^1) = \left(c_i, E, \min_{j \in N}\left\{r_i^j(c^1, E^1)\right\}\right)$$
$$(c_i^{k+1}, E^{k+1}, m_i^{k+1}) = \left(c_i^k - m_i^k, E^k - \sum_{i \in N} m_i^k, \min_{j \in N}\left\{r_i^j\left(c^{k+1}, \frac{E^{k+1}}{2}\right)\right\}\right),$$
$$\text{for all } k \geq 1$$

By definition, $m_1^1 = \min_{j \in N}\{r_1^j(c^1, E^1)\}$. Since $r^j \in \mathcal{R}$ for all $j \in N$, $r_1^j(c^1, E^1) \geq \frac{E}{n}$. Thus, $m_1^1 \geq \frac{E}{n}$ and, therefore, $\sum_{i \in N} m_i^1 \geq \frac{E}{n}$.

Now, it is straightforward to show that $c_1^2 \geq c_i^2$ for all $i \in N$. Then, since $r^j \in \mathcal{R}$ for all $j \in N$, then $r_n^j(c^2, E^2) \geq \frac{E^2}{n}$, which implies $\sum_{i \in N} m_i^2 \geq \frac{E^2}{n} = \frac{E}{n} - \frac{\sum_{i \in N} m_i^1}{n}$.

By iterating this procedure we have the following:

$$\begin{aligned}
E^2 &= E - \sum_{i \in N} m_i^1 \leq \left(1 - \frac{1}{n}\right) \cdot E \\
E^3 &= E - \sum_{i \in N} m_i^2 \leq \left(1 - \frac{1}{n}\right) \cdot E^2 \leq \left(1 - \frac{1}{n}\right)^2 \cdot E \\
&\dots \\
E^{k+1} &= E - \sum_{i \in N} m_i^k \leq \left(1 - \frac{1}{n}\right) \cdot E^k \leq \dots \leq \left(1 - \frac{1}{n}\right)^k \cdot E
\end{aligned}$$

Thus, $\lim_{k \to \infty} E^k = 0$. Now, given $K \in \mathbb{N}$ we have

$$\sum_{i=1}^{n} \sum_{k=1}^{K} m_i^k = \sum_{k=1}^{K} \sum_{i=1}^{n} m_i^k = E - E^{K-1}.$$

Thus, $\sum_{i=1}^{n} \lim_{k \to \infty} \sum_{k=1}^{K} m_i^k = \lim_{k \to \infty} \sum_{i=1}^{n} \sum_{k=1}^{K} m_i^k = E.$ $\square$

A.2 The claims problem

All of the four procedures played in each of the experimental sessions were constructed upon *the same* claims problem, where $c^* = (49, 46, 5)$ (i.e., $\sum c_i = 100$) and $E^* = 20$. The resulting allocations associated with each rule for this specific problem are as follows:

$$\begin{aligned}
cel(c^*, E^*) &= (11.5, 8.5, 0), \\
p(c^*, E^*) &= (9.8, 9.2, 1), \\
cea(c^*, E^*) &= (7.5, 7.5, 5).
\end{aligned}$$

It is straightforward to show that, for every three-agent problem $(c, E) \in \mathbb{B}$ in which $c_1 \geq c_2 \geq c_3$, we have the following:

$$\begin{aligned}
p_2(c, E) &= c_2 \cdot \frac{E}{C}, \\
cel_2(c, E) &= \begin{cases} c_2 - \frac{C-E}{3} & \text{if } c_1 \leq E + 2c_3 - c_2 \\ \frac{c_2 - c_1 + E}{2} & \text{if } E + 2c_3 - c_2 < c_1 < E + c_2 \\ 0 & \text{if } c_1 \geq E + c_2 \end{cases}
\end{aligned}$$

and

$$cea_2(c, E) = \begin{cases} \frac{E}{3} & \text{if } \frac{E}{3} \leq c_3 \\ \frac{E - c_3}{2} & \text{if } E - 2c_2 < c_3 < \frac{E}{3} \\ c_2 & \text{if } c_3 \geq E - 2c_2 \end{cases}$$

As we have already mentioned earlier, the main reason for choosing the particular problem (c^*, E^*) was to provide each claimant with a strictly preferred allocation associated with one of the three rules. This imposes the first restriction on the choice of the problem:

$$p_2(c^*, E^*) > \max\{cel_2(c^*, E^*), \quad cea_2(c^*, E^*)\}.$$

We also wanted to avoid a solution in which the two claimants with lower claims receive nothing. This imposes our second restriction:

$$cel_2(c^*, E^*) > 0.$$

It is straightforward to show that the two restrictions, jointly, imply that either

$(cel_2(c^*, E^*), cea_2(c^*, E^*)) = \left(\frac{c_2^*-c_1^*+E^*}{2}, \frac{E^*-c_3^*}{2}\right)$, or
$(cel_2(c^*, E^*), cea_2(c^*, E^*)) = \left(\frac{c_2^*-c_1^*+E^*}{2}, \frac{E^*}{3}\right)$.

We opted for the first one in order to avoid $cea_j = cea_i$ for all $i \neq j$. All together, it says that (c^*, E^*) must satisfy

$$\begin{aligned} E^* - 2c_2^* &< c_3^* < \frac{E^*}{3} \\ E^* + 2c_3^* - c_2^* &< c_1^* < E^* + c_2^* \\ (C^* - 2c_2^*) \cdot E^* &< c_3^* \cdot c^* \\ c_3^* \cdot E^* &< (C^* - E^*) \cdot (c_1^* - c_2^*) \end{aligned}$$

It is straightforward to show that the problem presented above satisfies all these inequalities.

Appendix B: Instructions

B.1 Instructions for the experiments

We shall now present the instructions given for the experiments, but only for Sessions 1 and 16. The remaining sessions go along the same lines, except for some differences that are explained in footnotes.

B.1.1 Instructions for a framed session (Session 1)

SCREEN 1: WELCOME TO THE EXPERIMENT

We are going to study how people interact in a bankruptcy situation. We are only interested in knowing how the average person reacts, so no record will be kept on how any individual subject behaves. Please do not feel that any particular sort of behavior is expected from you.

On the other hand, keep also in mind that your behavior will affect the sum of money you may win during the course of this experiment.

On the following pages you will find a series of instructions explaining how the experiment works and how to use the computer during the experiment.

HELP: When you are ready to continue, please click on the OK button.

SCREEN 2: HOW YOU CAN MAKE MONEY

- You will be playing two sessions of 20 rounds each. In each round of every session, you and other two participants in this room will be assigned to a GROUP. In each round, each person in the group has to make a decision. Your decisions, and those of the other two people in your group will determine how much money you (and the other) win for that round.
- At the beginning of each round, the computer randomly selects the three members of each group.
- Remember that the members of your group WILL CHANGE AT EVERY ROUND.
- To begin, you will be given 500 pesetas each to participate in the experiment.[26] Furthermore, at the beginning of each session, an initial endowment of 1,000 pesetas will be given to you.
- Please note that the computer assigns a PLAYER'S NUMBER to each participant (1, 2 or 3). This number appears in the upper right-hand corner of your screen and indicates the type of player you are and will be throughout the experiment. There are three types of players, and each group will be composed of one player of each type. Even when your group changes, you will still continue to be the same type of player.
- In the course of each round, you will have to pay out some money. The amount will depend on the decisions you make as well as on the decisions made by the other two members of the group. The amount you need to pay out during each round will be taken from your initial endowment for that round but will be added to your TOTAL PAYOFF for that session. Remember that in this experiment, payoffs are such that, REGARDLESS OF THE CIRCUMSTANCES, YOU ALWAYS WIN MONEY.
- At the end of the experiment you will receive the TOTAL sum of money you obtained for all of the sessions, plus the show-up fee of 500 pesetas.[27]

When you are quite ready to proceed, please click on the OK button.

SCREEN 3: THE FIRST GAME (I)

Background: A bank goes bankrupt and a judge has to decide on how the sum of money obtained from its liquidation would best be divided among its creditors. In this first experiment, you and all of the other participants in the experiment are the bank's creditors who have taken their claims to court in an effort to retrieve as much of it as they can.

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[26] This sentence did not appear in the case of Player 3.

[27] In the case of Player 3: *At the end of the experiment you will receive the TOTAL sum of money you were allotted in each session.*

In other words, for this session only, you, the creditors, are depositors with accounts in the bankrupt company.[28] That is to say, you are people who have savings accounts with the bank. You now have to come to an agreement (with the other two creditors in your group) on the percentage of the liquidation value that should be given to each of you. Obviously, as the bank has gone bankrupt, the sum of your claims, (i.e., the sum of your deposits), is much higher than the liquidation funds available.

During each round, you will try to retrieve as much of your claim as possible, which, in turn, will determine your losses, (i.e., the difference between your claim and the amount you receive at the beginning of each round). The sum of your losses will be subtracted from your initial endowments, and what is left, will be considered to be your TOTAL payoff for that particular session.

Concerning the problem involving you and the other two persons in your group, your claims and the available liquidation value, are shown in the following table:

Player	Claim
1	49
2	46
3	5

The liquidation value is 20.

As you can clearly see, there is not enough liquidation funds available to satisfy all of your claims.

Remember that the Player's Number assigned to you (1, 2 or 3) appears on the computer screen and will be there throughout the experiment.

From the many different options the judge has available to him with regard to how the liquidation value should be shared out, he decides that you, the creditors, must choose from among the following three rules:

1. RULE A: Divide the liquidation value equally among the creditors under the condition that no one gets more than her original claim. In other words, this rule benefits the agent with the lowest claim.
2. RULE B: Divide the liquidation value proportionally, according to the size of the claims.
3. RULE C: Losses should be divided as equal as possible among the three creditors, subject to the condition that all agents receive something non-negative from the liquidation value. In other words, this rule benefits the agent with the highest claim.

For the problem facing you and your group, the allocations awarded by each of the above rules are as follows:

$$A \equiv (7.5, 7.5, 5); \quad B \equiv (9.8, 9.2, 1); \quad C \equiv (11.5, 8.5, 0).$$

For instance, rule B divides the liquidation value in three parts, assigning 9.8 to Player 1, 9.2 to Player 2 and 1 to Player 3.

[28] This is the case of Frame 1. In the case of Frame 2 (3), however, the creditors are now shareholders of the bank (non-governmental organizations that are, at least partially, supported by the bank's profits).

SCREEN 4: THE FIRST GAME (II)

The structure of this game is as follows:

Your decision, and the decisions of the members of your group will determine the division of the liquidation value, as it is shown in the payoff matrices. Note that if you all agree on the same rule, then the division of the liquidation value is exactly the one you propose.

This is how the matrices should be read: There are three tables with nine cells each: Player 1 chooses the row, Player 2 chooses the column and Player 3 chooses the table. Each cell contains three numbers. The first number is the amount of money that Player 1 will lose if that particular cell is chosen. The second number is the amount that Player 2 loses and the third number is how much Player 3 would lose. For further clarity, consider the upper left cell, for example. This cell is chosen if all 3 players choose Rule A, and division of the liquidation funds will therefore be done as Rule A proposes, i.e., (**7.5**, **7.5**, **5**). As such, and taking the above claims into account, Player 1 loses $\mathbf{7.5 - 49 = -41.5}$, which is the first number in that particular cell. Player 2, therefore, loses $\mathbf{7.5 - 46 = -38.5}$, and Player 3 loses $\mathbf{5 - 5 = 0}$.

To summarize,

- You will be playing 20 times with ever-changing group members.
- At the beginning of each round, the computer will select the members of your group at random;
- At the beginning of each round, you and the other two members of your group will have to choose one of the three rules available to you (A, B or C). Your choice (and those of the other members of your group) will determine how much money will be subtracted from your initial endowments, according to the corresponding table in front of you.

To choose an option, simply click on the corresponding letter. Once you have done so, please confirm your choice by clicking on the OK button.

SCREEN 5: THE SECOND GAME.

You will now play 20 rounds of the next game. In this session, just as in the previous one, you, the creditors, are the bank's depositors.[29] That is to say, people who have deposited money in accounts at the bank. As you will notice, on your computer screen, neither the players' claims nor the liquidation value have changed. Just as before, you must arrive at an agreement with the other members of your group on how the liquidation value should be divided among you. Remember that, just as before, 1,000 pesetas will be assigned to you at the beginning of the session.

The instructions for this session are almost identical to the ones for the previous game, but with a few little modifications. In each round, as before, you must choose from among Rules A, B and C. If you all agree on the same rule, the division of the liquidation value will be done exactly as you propose. If only two of you agree on a rule then, those two get the share proposed by that rule and the creditor who does not agree with the division, not only loses her whole claim, but also pays a fixed penalty

[29] This is the case of Frame 1. In the case of Frame 2 (3)the creditors are shareholders (non-governmental organizations which are, at least, partially, supported by the bank) rather than depositors.

of 1 peseta. Finally, if all of you disagree on the proposed sharing, you will all lose your claims and pay the fixed penalty of 1 peseta. The allocations that correspond to each possible situation are shown in the payoff matrices below.

The matrices are to be read exactly as before. If we consider the lower left cell, for instance, this is the cell that will be selected when Players 2 and 3 choose A and Player 1 chooses C. In this particular case, player 1 loses $-1 - 49 = -50$, which is the upper number of that particular cell. Similarly, Player 2 loses $7.5 - 46 = -38.5$, and Player 3 loses $5 - 5 = 0$.

To choose an action, you simply have to click on the corresponding letter. Once you have done so, please confirm your choice by clicking on the OK button.

B.1.2 Instructions for an unframed session (Session 7)

SCREEN 1: WELCOME TO THE EXPERIMENT

This experiment is designed to study how people interact in claims situations. We are only interested in what the average does and not how any individual subject behaves, so no record will be kept of anyone's individual behavior. Please do not feel that any particular behavior is expected from you.

On the other hand, keep also in mind that your behavior will affect the sum of money you may win during the course of this experiment.

On the following pages you will find a series of instructions explaining how the experiment works and how to use the computer during the experiment.

When you are ready to continue, please click on the OK button.

SCREEN 2: HOW YOU CAN MAKE MONEY

- You will be playing four sessions of 20 rounds each. In each round, for all sessions, you and other two persons in this room will be assigned to a GROUP. In each round, each person in the group will have to make a decision. Your decision (and the decision of the other two persons in your group) will determine how much money you (and the other) win for that round.
- At the beginning of each round, the computer will randomly select the members of your group.
- Remember that the members of your group CHANGE AT THE END OF EACH ROUND.
- You will receive 1,000 pesetas for participating in this experiment.[30] Furthermore, at the beginning of each session, an initial endowment of 1,000 pesetas will also be given to you.
- Please note that the computer assigns a PLAYER'S NUMBER to each participant (1, 2 or 3). This number appears in the upper right-hand corner of your screen and indicates the type of player you are and will be throughout the experiment. There are three types of players, and each group will be composed of one player of each type. Even when your group changes, you will still continue to be the same type of player.

[30] This sentence was not included in the case of Player 3.

- In the course of each round, you will have to pay out some money. The amount will depend on the decisions you make as well as on the decisions made by the other two members of the group. The amount you need to pay out during each round will be taken from your initial endowment for that round but will be added to your TOTAL PAYOFF for that session. Remember that in this experiment, payoffs are such that, REGARDLESS OF THE CIRCUMSTANCES, YOU ALWAYS WIN MONEY.
- At the end of the experiment, you will receive the TOTAL sum of money you obtained for all of the sessions, plus the show-up fee of 1,000 pesetas.[31]

When you are ready to continue, please click on the OK button.

SCREEN 3: THE FIRST GAME.

At the beginning of each round, the computer will randomly select the members of your group.

During each round, you and the other two members of your group must choose among three possible decisions: A, B and C.

Your decision, and those of the other two members of your group will determine how much money you lose from your initial endowment in this session, as is shown in the payoff matrices.

This is how the matrices should be read: There are three tables with nine cells each: Player 1 chooses the row, Player 2 the column, and Player 3 chooses the table. Each cell contains three numbers. The first number is the amount of money that Player 1 will lose if that particular cell is chosen. The second number is the amount that Player 2 loses and the third number is how much Player 3 would lose. For further clarity, consider the lower left cell, for example. This cell is chosen when Player 1 chooses C and Players 2 and 3 choose A. In this particular case, Player 1 loses -41.5, which is the first number of that particular cell. Player 2 loses -38.5, and Player 3 loses 0.

To summarize,

- You will be playing 20 times, with ever-changing group members.
- At the beginning of each round, the computer will select the members of your group at random;
- At the beginning of each round, you and the other two members of your group will have to choose one of the three rules available to you (A, B or C). Your choice (and those of the other members of your group) will determine how much money will be subtracted from your initial endowments, according to the corresponding table in front of you.

To choose an action, you simply click on the corresponding letter. Once you have done so, please confirm your choice by clicking on the OK button.

SCREEN 4: THE SECOND GAME.

You will now play 20 additional rounds of the following game. The instructions are identical to those given for the previous game, with a few little modifications. The only difference is in the payoff matrices.

[31] In the case of Player 3: At the end of the experiment you will receive the TOTAL sum of money you were allotted in each session.

For further clarity, consider the lower left cell, for example. This cell is chosen if Players 2 and 3 choose A and Player 1 chooses C. In this case, Player 1 loses −39.2, which is the upper number of that particular cell. Player 2 loses −36.8, and Player 3 loses −4.

HELP: To choose an action, you simply click on the corresponding letter. Once you have done so, please confirm your choice by clicking on the OK button.

SCREEN 5: THE THIRD GAME.

You will now play 20 additional rounds of the following game. The instructions are the same as for the previous game. The only difference is in the payoff matrices.

Consider the lower left cell, for instance. This cell is selected when Players 2 and 3 choose A, and Player 1 chooses C. In this case, Player 1 loses −37.5, which is the upper number of that particular cell. Player 2 loses −37.5, and Player 3 loses −5.

HELP: To choose an action, you simply click on the corresponding letter. Once you have done so, please confirm your choice by clicking on the OK button.

SCREEN 6: THE FOURTH GAME.

You will now play 20 additional rounds of the following game. The instructions are the same as for the previous game. The only difference is in the payoff matrices.

Consider the lower left cell, for instance. This cell is selected when Players 2 and 3 choose A, and Player 1 chooses C. In this case, Player 1 loses −50, which is the upper number of that particular cell. Similarly, Player 2 loses −38.5, and Player 3 loses 0.

HELP: To choose an action, you simply click on the corresponding letter. Once you have done so, please confirm your choice by clicking on the OK button.

B.2 The questionnaire

- The first problem

Background: A bank goes bankrupt and a judge has to decide on how the sum of money obtained from its liquidation would best be divided among its creditors. Obviously, as the bank has gone bankrupt, the sum of creditors' claims, (i.e., the sum of their deposits), is much higher than the liquidation funds available. The claims and the available liquidation value, are shown in the following table:

Creditor	Claim
1	49
2	46
3	5

The liquidation value is 20.

The judge has three different options available to him with regard to how the liquidation value should be shared out. They are the following three rules:

1. RULE A: Divide the liquidation value equally among the three creditors, on the condition that no one gets more than her original claim. In other words, this rule benefits the agent with the lowest claim.

2. RULE B: Divide the liquidation value proportionately, according to the size of the claims.
3. RULE C: Losses should be divided as equal as possible among the three creditors, subject to the condition that all agents receive a 'non-negative' amount from the liquidation funds. In other words, this rule benefits the agent with the highest claim.

For the problem in hand, the allocations awarded by each of the above rules are as follows:

$$A \equiv (7.5, 7.5, 5)\,; \quad B \equiv (9.8, 9.2, 1)\,; \quad C \equiv (11.5, 8.5, 0)\,.$$

For instance, Rule B divides the liquidation value in three parts, assigning 9.8 to Creditor 1, 9.2 to Creditor 2 and 1 to Creditor 3.

What would your choice be if you were the judge?

- The second problem

In the second problem, the claimants are all shareholders of the bank, rather than depositors.

What would your choice be if you were the judge?

- The third problem

In the third problem, claimants are all *non-governmental organizations sponsored by the bank*. Each claimant had signed a contract with the bank, before its bankruptcy, that stated that they would receive a contribution in accordance with their social standing (i.e., the higher their social standing, the higher the contributions they received). Thus, *"Doctors without frontiers"*, for instance, should receive the highest endowment, *"Save the children"* the second highest, and *"Friends of Real Betis Balompié"* the least of all. The judge must now decide on the amounts that they should each obtain.

What sort of distribution would you decide on if you were the judge?

- The fourth problem

A man dies leaving three debts. Let the liquidation value in the table above be the estate that he leaves and let the claims be the debts contracted with each creditor.

What sort of distribution would you decide on if you were the judge?

- The fifth problem

In the fifth problem, a man dies after having promised a certain amount of money to each of his three sons. The value of the bequest, however, is not enough to cover all of his promises. Thus, his sons are now the claimants and their claims are on the promises their father had made to each of them.

What sort of distribution would you decide on if you were the judge?

- The sixth problem

In this case, the situation is different. The problem now consists of collecting a certain sum of money from a group of three agents whose gross incomes are known to one another. The amount to be collected can be interpreted as a tax. More precisely, their individual incomes and the amount to be collected are as follows:

Agent	Income
1	49
2	46
3	5

The amount to be collected is20.

For this problem, we consider three different tax schemes, which are the following:

$$A \equiv (7.5, 7.5, 5)\,; \quad B \equiv (9.8, 9.2, 1)\,; \quad C \equiv (11.5, 8.5, 0)\,.$$

Each one clearly states the amount that each agent must pay for the total amount to be successfully collected. For instance, rule B forces Agent 1 to pay **9**.**8**, Agent 2 to pay **9**.**2** and Agent 3 to pay **1**.

Which scheme would you choose if you were the person in charge of levying the tax?

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