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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 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 with 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.

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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.

Three are the rules that emerge from this literature. The *proportional* rule, which chooses awards proportional to claims, is inspired in 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* and *constrained equal losses*. 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 (or other alternatives) 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

[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).

an experimental lab. Our main question here can be summarized as follows:

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 just mentioned is more in line with the so-called *non-cooperative approach* to conflicting claim 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 examine both lines of research and the results we obtain should be considered as complementary. We first selected 144 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, and 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 selecting a different group of 164 students, administering them a questionnaire in which they 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 Gatcher and Riedl's (2004) 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.[2] As for the comparison with our findings, their questionnaire leads

[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

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 Section 2, we set up the model, while in Section 3, we present the design of the experiment. In Section 4, we report on our experimental results, whereas in Section 5, we report on the results of the questionnaire. Our conclusions, comments and further proposals are then presented in Section 6, 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 divide, and $c \in \mathbb{R}^n_+$ is a vector of claims whose i^{th} 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 $c_1 \geq c_2 \geq ... \geq c_n$.[4]

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

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. 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.

[4]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.*

(*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.[5] 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 1 *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 from among all of the rules belonging to* $\mathcal{R}$*.*

We now present three noncooperative *procedures* proposed to solve claim 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 claims vectors (if it exists) is chosen as solution to the problem. Otherwise, nobody gets anything. Formally,

[5] 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".

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 the next step.

Step 2. For all $i \in N$, let $c_i^2 = \max_{j \in N} \left\{ r_i^j(c^1, E) \right\}$. 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 the next step.

Step k+1. For all $i \in N$, let $c_i^{k+1} = \max_{j \in N} \left\{ r_i^j(c^k, E) \right\}$. 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 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 concessions 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 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 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 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 concessions 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 concessions 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 $r = \left\{r^i, r^{-i}\right\}$ 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 the next step.

Step 2. For all $i \in N$, let $m_i^1 = \min_{j \in N}\left\{r_i^j(c^1, E^1)\right\}$, $E^2 = E^1 - \sum_{i \in N} m_i^1$, 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 the next step.

Step k+1. For all $i \in N$, let $m_i^k = \min_{j \in N}\left\{r_i^j(c^k, E^k)\right\}$, $E^{k+1} = E^k - \sum_{i \in N} m_i^k$, 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 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 a single 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:

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

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* $\{(r, r, ..., r) : r \in \mathcal{R}\}$.

3 Experimental design

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

3.1 Subjects

Our study was conducted in 12 experimental sessions in July 2001, May 2003 and May 2005. A total of 144 students (12 students per session, each session containing 4 groups of 3 subjects playing) were recruited among the undergraduate population at the University of Alicante, mainly Economics students with no (or very little) prior exposure to game theory.

3.2 Frames

In the first six sessions the 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** (P_1). 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** (P_2). 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** (P_3). Our last framework is focused on *non-governmental organizations sponsored by the bank*. In such a case, we assumed that each claimant had signed a contract with the bank, before its bankruptcy, according to which she will receive a contribution that is in accordance 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**. We also run six unframed sessions. In this case, subjects were only provided with the payoff tables and were required to play the four games without any story behind.

3.3 Treatments

The 12 sessions were run in a computer lab.[6] In the first 6 sessions, subjects were randomly assigned to groups of 3 individuals each and played twenty rounds of a *framed* procedure, P_1, P_2 or P_3, followed by twenty rounds of P_0 presented under the same frame. In the last 6 sessions, subjects played twenty rounds of each of the four procedures, P_1, P_2, P_3 and P_0, without any framework. Table 1 reports on the precise sequence of procedures played in the 12 sessions.

treat 1		treat 2		treat 3		treat 4		treat 5		treat 6	
ses1	ses2	ses3	ses4	ses5	ses6	ses7	ses8	ses9	ses10	ses11	ses12
P1	P1	P2	P2	P3	P3	P1	P1	P3	P3	P2	P2
P0	P0	P0	P0	P0	P0	P2	P2	P2	P2	P1	P1
						P3	P3	P1	P1	P3	P3
						P0	P0	P0	P0	P0	P0
framed						unframed					

(1)

Table 1: Sequential structure of the experimental sessions

As Table 1 shows, all (un)framed treatments consist of a sequence of (four) two procedures. 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

[6] The experiment was programmed and conducted with the software z-Tree (Fischbacher, 1999).

in the problem) would remain constant throughout the session, while the composition of their group would change at every round.

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.[7] 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 claim problem

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 $E^* = 20$.[8] The resulting allocations associated with each rule for this specific problem are as follows:

$$cea(c^*, E^*) = (7.5, 7.5, 5),$$
$$p(c^*, E^*) = (9.8, 9.2, 1),$$
$$cel(c^*, E^*) = (11.5, 8.5, 0).$$

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 Remark 1, that, for all rules belonging to $\mathcal{R}$, *cel* (*cea*) is the most preferred rule of the highest (lowest) claimant, independently of the particular problem at 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

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

[8] All monetary payoffs are expressed in Spanish pesetas (1 euro=166 pesetas approximately).

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*. In a real-life claims situation, however, the 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 claim 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.

$$(2)$$

Table 2: Procedure P_1

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* 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.

(3)

Table 3: Procedure P_2

(4)

Table 4: Procedure P_3

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 2-4, 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 parametrization 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 $(c, E) \in \mathbb{B}$ and for all *procedures,* P_1, P_2 *and* P_3 *with arbitrary strategy set* $\mathcal{R}^* \subseteq \mathcal{R}$, *the limit allocation* x^* *always exists.*

Proof. In the Appendix.

The last procedure object of this study, the majority procedure P_0, displays rather different strategic properties, as shown in Table 5.

(5)

Table 5: Procedure P_0

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 $r^i_i(c^*, E^*) - c^*_i$ 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 will be $(-1, -1, -1) - c^*$.

As we already mentioned, the payoffs reported in Tables 2-5 were subtracted from subjects' endowments. Before playing a given procedure, all subjects received an initial endowment of 1000 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 1000 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 1000 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'.[9] As for procedure P_0, the penalty ε was equal to 1 peseta. Average earnings per hour were around 1800 pesetas (11 euros) for players 1 and 2 and around 3600 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. Here we find that, for each procedure, the corresponding equilibrium rule emerges from the very beginning, independently on the framing conditions. By stark contrast, our majority procedure P_0 displays a significantly lower rate of equilibrium outcomes and behavior, both in framed and unframed sessions. Moreover, and more strikingly, *convergence to equilibrium only takes place under the proportional rule.* This evidence calls for further statistical analysis which we carry out in Section 4.3. Here we find that, for procedure P_0, both frame and learning effects are significant in explaining outcomes and subjects' aggregate behavior, although their relative impact is heterogenous across players.

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 (labelled as

[9] 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.

"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.[10]

Procedures	Framed Sessions					Unframed Sessions				
P_1	160	**.98**	0	0	.02	480	**1**	.01	01	.03
P_2	160	0	**1**	0	0	480	01	**1**	.01	0
P_3	160	0	0	**.98**	.02	480	0	0	**.99**	.01
Allocations	Obs.	*cea*	*p*	*cel*	Others	Obs.	*cea*	*p*	*cel*	Others

(6)

Table 6: Allocation distributions of P_1, P_2 and P_3.

We now look at subjects' aggregate behavior in Table 7. Table 7 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 used their weakly dominant strategies (relative frequencies in boldface), both in framed and unframed sessions. This confirms that compliance with 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).[11]

[10] Relative frequencies of Nash equilibria strategy profiles of (un)framed sessions of procedures P_1, P_2 and P_3 are .98 (.94), .99 (.98) and .93 (.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, $1/3 + 2/3 * 1/9 \cong .4$. in procedures P_1 and P_3 and $1 - 2/9 \cong .75$ in procedure P_2. This implies that relative frequencies of equilibrium strategy profiles are much higher than their predicted values under random playing.

[11] As far as non-pivotal players are concerned, weakly dominant strategies are again

Pivotal player	Player 3 (P_1)			Player 2 (P_2)			Player 1 (P_3)		
Framed	**.97**	.02	.01	.07	**.76**	.17	.02	.06	**.92**
Unframed	**.93**	.03	.04	.06	**.86**	.08	.02	.08	**.90**
RULES	*cea*	*p*	*cel*	*cea*	*p*	*cel*	*cea*	*p*	*cel*

(7)

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

4.2 The majority procedure P_0

We now focus on P_0, whose allocation distributions are reported in Table 8. As we already anticipated, here the proportional rule is salient in describing the allocation distributions, for both framed and unframed sessions. As Table 8 shows, subjects not only managed to agree on an equilibrium allocation, but they did so by way of the proportional rule (i.e., for each procedure, coordination on *cea* or *cel* never exceeds 3% of total observations). Moreover, we also observe a much higher frequency of coordinations (and therefore a lower frequency of non-equilibrium allocations) in the framed sessions and later periods. This is therefore indicating that both learning and frames appear to enhance coordination (on the proportional rule).

Rounds	Framed Sessions					Unframed Sessions				
First 10	240	0	**.61**	01	.38	240	.07	**.24**	0	.69
Last 10	240	0	**.9**	0	.1	240	.03	**.55**	.01	.42
	Obs.	*cea*	*p*	*cel*	Others	Obs.	*cea*	*p*	*cel*	Others

(8)

Table 8: Allocation distributions of P_0.

Moving to aggregate behavior, Figure 1 shows relative frequencies of choices in P_0, for frame and unframed sessions, disaggregated for rounds and player position. Consistently with the layout of Table 8, in Figure 1 we partition all observations of P_0 in four subsamples:

1. (F, F) : framed sessions, first 10 rounds;

2. (F, L) : framed sessions, last 10 rounds;

more frequently selected, although not as frequently as in the case of pivotal players (see Herrero et al. (2003) for details).

3. (U, F) : unframed sessions, first 10 rounds;

4. (U, L) : unframed sessions, last 10 rounds.

Figure 1 : Evolution of subjects' aggregate behavior in P_0.

Again, we can notice from Figure 1 that subjects mainly selected the proportional rule, independently of their player positions, in all sessions, and that frequencies are higher in the framed sessions and for observations which correspond to the last 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 sessions) are stronger in the unframed sessions. From Figure 1 we also notice that player 2 "learns less" than what her opponents do. This may be due to the fact that, while the proportional allocation corresponds to the second-best choice for players 1 and 3, it is the first best for player 2. The learning pattern, therefore, mainly consists of players 1 and 3 gradually discarding their first-best rule (*cel* and *cea* for players 1 and 3 respectively), "joining" player 2 in the choice of their second-best option. In this respect, our evidence is consistent with the main literature on coordination games (see, for example, Cooper and John (1988), Cooper and Ross (1985), Van Huyick *et al.* (1990a) or Van Huyick *et al.*. (1990b)). Moreover, also players 1 and 3 differ in their learning pattern. While compliance with her favorite choice is higher for player 3 (especially in unframed sessions, where player 3 selects her favorite rule, *cea*, always more than 30% of the times), also learning effects are stronger (i.e. the increase in the probability of playing strategy for player 3 is higher than that of the other two players). The presence of strategic uncertainty, created by the multiplicity of equilibria, yields a high variability in behavior in the first repetitions. This variability vanishes relatively quickly, once subjects are able to coordinate on some equilibrium (in this case, the one supported by the proportional rule). Also notice that in our game, unlike the literature cited above, equilibrium selection cannot be due to "efficiency" considerations, since all equilibria are equally Pareto efficient.

4.3 Learning and frame effects in P_0

The evidence we just presented 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' evolution of play in our coordination procedure P_0.

Since our panel is balanced with respect to both time and frame dimensions (i.e. the four subsamples contain the same number of observations), testing for the existence of learning and frame effects is equivalent to test for homogeneity in the distributions of outcomes and behaviors in the corresponding subsamples. There is a caveat here. Since we deal with a panel dataset (i.e. our observations are taken from a sequence of actions performed by the same experimental subjects, randomly matched more than once with other subjects belonging to the same subject pool), we have to take into account that our four subsamples contain observations that are likely to be statistically dependent to each other (as they refer to actions taken by the same subject, interacting occasionally with the same subjects of her session pool). To partially ameliorate this problem, in the statistical analysis that follows we shall consider, for each subsample, *only one* (as opposed to ten) observation, drawn at random, belonging to the same subject.[12]

According to the above procedure, Table 9 tests the relevance of learning and frame effects for our experimental evidence as far as outcome distributions are concerned.

H_0	χ^2_0	$p-$value
$\mu^{(F,F)} = \mu^{(F,L)}$	.137	.712
$\mu^{(U,F)} = \mu^{(U,L)}$	5.6	.061
$\mu^{(F,F)} = \mu^{(U,F)}$	18.4	0
$\mu^{(F,L)} = \mu^{(U,L)}$	5.94	.051

(9)

Table 9

Learning and frame effects in the allocation distributions of P_0

Let $\mu^{(x,y)}$ be the allocation distribution of (the "reduced") subsample $(x, y); x \in \{U, F\}, y \in \{F, L\}$. Each row of Table 9 reports the (standard) χ^2 test-statistics (and the associated $p-$value) of the corresponding null hypothesis. In particular, the first (last) two rows of Table 9 test for learning (frame) effects partitioning the dataset with respect to the frame (time) dimension. As Table 9 shows, the null hypothesis (of no significant difference in outcome distributions) is always rejected (at 10% confidence level), except for the case of learning effects in the framed sessions. This confirms the evidence of Figure 1 we already discussed: frame (learning) effects are stronger in earlier matches (unframed sessions).

[12] We thank two anonymous referees for pointing out this problem, together with useful suggestions on how to fix it.

	Player 1		Player 2		Player 3	
H_0	χ_0^2	p-val	χ_0^2	p-val	χ_0^2	p-val
$\nu_i^{(F,F)} = \nu_i^{(F,L)}$	9.6	.008	5.58	.061	9.6	.008
$\nu_i^{(U,F)} = v_i^{(U,L)}$	8.1	.017	5.8	.053	8.8	.012
$\nu_i^{(F,F)} = \nu_i^{(U,F)}$	6.24	.044	3.04	.218	7.15	.028
$\nu_i^{(F,L)} = \nu_i^{(U,L)}$	3.86	.145	2.51	.113	8.336	.004

(10)

Table 10

Learning and frame effects in players' aggregate behavior in P_0

We now move to subjects' aggregate behavior, whose corresponding statistics are reported in Table 10. By analogy with Table 9, $\nu_i^{(x,y)}$ denotes player i's rule distribution of P_0 of (the reduced) subsample (x, y). As Table 10 shows, learning effects are always significant for all players. As for framing effects, they are significant only for player 3 (and player 2 in the first rounds). This confirms the evidence of Figure 1 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.

It is quite probable that some other factors may have influenced the coordination pattern. First, as we noticed above, convergence on the proportional solution 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. If this were the only effect in 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 that framing effects do occur. Even if players seem sensitive to frames to a different extent, the aggregate effect (i.e. the impact on outcome distributions) is always significant. In the conclusive remarks, we shall briefly discuss some alternative explanations that may have caused this observed pattern in the data.

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. We have also observed that frames help coordination. Given that the different allocation rules are often justified, in the axiomatic literature, on the grounds of their fairness properties, we may then ask if, in our problem, a majority of subjects perceived the proportional allocation as being *more just or socially appropriate* than their alternatives. In other words, we might well ask ourselves whether the proportional rule may be considered as a *social norm* for solving claims problems. According to this view, the choice of the proportional rule as a coordinating device may 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)]. In this regard, it may well be worthwhile to explore the potential of the proportional rule as a social norm for solving problems of adjudicating conflicting claims. First, however, we must verify 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 Gatcher and Riedl (2004), 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 Section 3.2, while the remaining three situations are described as follows.[13]

- **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.

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

- **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.

Figure 2 summarizes choice frequencies by our respondents under the six proposed frames.

Figure 2: Questionnaire results

We first observe from Figure 2 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 Figure 2 shows) but also at the level of individuals (since p represented the modal 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 a similar rate across frames, with a slight bias towards *cel* (19.2% vs. 14.8%). 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. It is interesting the support (about 36%) received by *cel* under Frames 3 and 6 (i.e., 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. Both evidences are 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. 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 11 we perform the same statistical analysis we carried out in Section 4.3, to test for the impact of frames on the respondents' rule distributions.

	Frame 1	Frame 2	Frame 3	Frame 4	Frame 5
Frame 2	18.1 (0)				
Frame 3	53.6 (0)	14.6 (.001)			
Frame 4	7.42 (.02)	13.6 (.001)	32.5 (0)		
Frame 5	37.7 (0)	54.8 (0)	60.4 (0)	21.3 (0)	
Frame 6	34.5 (0)	5.14 (.08)	2.75 (.25)	19.1 (0)	51.7 (0)

(11)

Table 11: Testing for frame effects on the survey's rule distributions

Each cell of Table 11 contains the associated χ^2 test-statistics (p-value within parenthesis), where the null hypothesis is no difference between the rule distributions of the corresponding frame pairs.[14] As Table 11, all pairwise comparisons reject the null, with one sole exception, Frame 3 vs. 6, we 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. This consideration notwithstanding, 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 studied problems of adjudicating conflicting claims from two distinct, but complementary, perspectives. 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. In other words, for the three procedures $P_1 - P_3$ employed in the experiment, *the Nash program is completely successful.* This claim is supported by the fact that the majority

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

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."*[15]

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.

By stark contrast, in the majority procedure P_0 coordination on the proportional solution overwhelmingly prevails. Furthermore, in this case, framing 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, which is (only partially) consistent with the existing experimental literature:

- *"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."*[16]

- *"I chose the option that seemed to be the most equitable one for the three agents involved."* [17]

These two quotes suggest two different, but complementary, explanations for the coordinating power of the proportional rule. First, this may be due to the fact 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).[18] Nonetheless, this *median voter effect* 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*

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

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

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

[18] 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., (2005) 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.

may have acted as coordinating device, exactly where incentives did not provide a clear-cut solution to the coordination problem subjects were facing.[19] Not surprisingly, this effect is stronger in the framed sessions, where moral considerations are easier to apply.[20]

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 could not 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 we already discussed. 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 maxmin 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.

References

[1] Aumann, R.J. and Maschler, M. (1985), Game Theoretic Analysis of a Bankruptcy Problem from the Talmud, *Journal of Economic Theory* , 36: 195–213.

[19] This interpretation is very much in line with Gauthier's (1986) view of social norm behavior.

[20] 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's (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 look at net transfer (i.e., we do not substract claim to monetary payoffs) the preference ranking is reversed.

[2] Ashenfelter, O. and Bloom, D.E. (1984), Models of Arbitrator Behavior: Theory and Evidence, *American Economic Review* 74: 111-124.

[3] Ashenfelter, O., Currie, J., Farber, H.S., and Spiegel, M. (1992), An Experimental Comparison of Dispute Rates in Alternative Arbitration Systems, *Econometrica,* 60: 1407-1433.

[4] Bar-Hillel, M. and Yaari, M. (1993) *Judgments of Distributive Justice*, in Barbara Mellers and Jonathan Baron (eds.), Psychological Perspectives on Justice: Theory and Applications, New York: Cambridge University Press.

[5] Binmore, K., Osborne, M. and Rubinstein, A. (1992), Noncooperative models of bargaining, in Aumann, R. and Hart, S. (eds.) *Handbook of Game Theory I*, North-Holland.

[6] Binmore, K. (1998), *Game Theory and the Social Contract. Volume II: Just playing.* Cambridge, Ma: MIT Press.

[7] Cuadras-Morató, X., Pinto-Prades, J.L. and Abellán-Perpiñán J.M. (2001), Equity Considerations in Health Care: The relevance of Claims, *Health Economics,* 10: 187-205.

[8] Chun, Y. (1989), A Noncooperative Justification for Egalitarian Surplus Sharing, *Mathematical Social Sciences,* 17: 245-261.

[9] Cooper, R. and John, A. (1988), "Coordinating Coordination Failures in Keynesian Models", *Quarterly Journal of Economics*, 103: 441-463.

[10] Cooper, R. and Ross, T. W. (1985), "Product Warranties and Double Moral Hazard", *Rand Journal of Economics*, 16: 103-113.

[11] Costa-Gomes, M., Crawford, V. and Broseta, B. (2001), Cognition and Behavior in Normal-Form Games: An Experimental Study, *Econometrica,* 69: 1193-1235.

[12] Dagan, N. Serrano, R. and Volij. O. (1997), A Noncooperative view of consistent bankruptcy rules, *Games and Economic Behavior*, 18: 55–72.

[13] Fehr, E. and K.M.Schmidt (1999), "A theory of fairness,competition and cooperation",*Quarterly Journal of Economics*, 114: 817 –868.

[14] Fischbacher, Urs (1999), *z-Tree. Toolbox for Ready-made Economic Experiments*, IEW Working paper 21, University of Zurich.

[15] Frolich, N., Oppenheimer, J. A. and Eavey, C. L. (1987), "Choices of Principles of Distributive Justice in Experimental Groups", *American Journal of Political Science*, 31, 606-636.

[16] Gachter, S. and Riedl, A. (2004), *Dividing justly in bargaining problems with claims: Normative judgements and actual negotiations*, mimeo.

[17] Gauthier, D. (1986), *Morals by agreement.* Oxford: Clarendon Press.

[18] Ju, B.-G., Miyagawa E., Sakai T. (2005) Non-Manipulable division rules in claim problems and generalizations, *Journal of Economic Theory*, forthcoming.

[19] Hart, O. (1999) Different Approaches to Bankruptcy, in Governance, Equity and Global Markets, *Proceedings of the Annual Bank Conference on Development Economics in Europe*, June 21-23, 1999.

[20] Herrero, C. (2003) Equal Awards Vs. Equal Losses: Duality in Bankruptcy, in M.R. Sertel and S. Koray (eds.), *Advances in Economic Design*, Springer-Verlag, Berlin, pp.413-426.

[21] Herrero, C. and Villar A. (2001) The Three Musketeers: Four Classical Solutions to Bankruptcy Problems, *Mathematical Social Sciences*, 42: 307-328.

[22] Herrero, C. Moreno-Ternero, J.D. and Ponti G. (2003) An Experiment on Bankruptcy, *IVIE Discussion Paper*, WP-AD 2003-03.

[23] Kaminski, M. (2006) Parametric Rationing Methods, *Games and Economic Behavior* 54, 115–133.

[24] Moreno-Ternero, J.D. (2002) Noncooperative Support for the Proportional Rule in Bankruptcy Problems, Mimeo, Universidad de Alicante.

[25] Moulin, H. (2000) Priority rules and other asymmetric rationing methods, *Econometrica* 68: 643-684

[26] Moulin, H. (2002) Axiomatic cost and surplus sharing, in *Handbook of Social Choice and Welfare, Vol I,* edited by Arrow, K.J., Sen, A.K., and Suzumura, K., Elsevier Science B.V.

[27] Nash, J. (1953) Two-person cooperative games, *Econometrica*, 21: 128-140.

[28] O'Neill, B. (1982), A Problem of Rights Arbitration from the Talmud, *Mathematical Social Sciences*, 2 : 345–371.

[29] Ochs, J. and Roth, A. (1989), An Experimental Study of Sequential Bargaining, *American Economic Review* 79: 355-384.

[30] Roemer J.E. (1996), *Theories of Distributive Justice.* Harvard University Press. Cambridge Ma.

[31] Skyrms, B. (1996), *Evolution of the Social Contract,* Cambridge, Cambridge University Press.

[32] Sugden, R. (1986), *The Economics of rights, cooperation and welfare,* Oxford: Basil Blackwell, Inc.

[33] Thomson, W. (2003), Axiomatic and Game-Theoretic Analysis of Bankruptcy and Taxation problems: a survey, *Mathematical Social Sciences*, 45: 249-297.

[34] Van Huyick, J. Battalio, R. and Beil, R. (1990a), "Tacit Coordination Games, Strategic Uncertainty, and Coordination Failure", *American Economic Review*, 80: 234-248.

[35] Van Huyick, J. Battalio, R. and Beil, R. (1990b), "Strategic Uncertainty, Equilibrium Selection principles, and Coordination Failure in Average Opinion Games", *Quarterly Journal of Economics*, 106: 885-910.

[36] Yaari, M. E. and Bar-Hillel, M. (1984), On Dividing Justly, *Social Choice and Welfare*, 1: 1-24.

7 Appendix 1. Proofs

7.1 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.

7.1.1 Convergence of P_1

Let $(c, E) \in \mathbb{B}$ be a given problem. Let $r = \left\{r^j\right\}_{j \in N}$ 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.[21]

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

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

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

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

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

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

Note that, since $c_1 \geq c_2 \geq ... \geq c_n$, it is straightforward to show that $c_1^k \geq c_2^k \geq ... \geq c_n^k$ for all $k \in \mathbb{N}$, and therefore $x_1 \geq x_2 \geq ... \geq x_n$. 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 $r \in \mathcal{R}$,

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

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

[21] 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.

7.1.2 Convergence of P_2

Let $(c, E) \in \mathbb{B}$ be a given problem. Let $r = \left\{r^j\right\}_{j \in N}$ 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:

$$(c_i^1, E^1, m_i^1) = (c_i, E, p_i(c^1, \frac{E^1}{2}))$$

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

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

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

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

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

which proves the convergence. ■

7.1.3 Convergence of P_3

Let $(c, E) \in \mathbb{B}$ be a given problem. Let $r = \left\{r^j\right\}_{j \in N}$ 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:

$$(c_i^1, E^1, m_i^1) = (c_i, E, \min_{j \in N} \left\{r_i^j(c^1, E^1)\right\})$$

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

By definition, $m_1^1 = \min_{j \in N} \left\{r_1^j(c^1, E^1)\right\}$. 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:

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

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

7.2 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:

$$p_2(c, E) = c_2 \cdot \frac{E}{C},$$

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

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:

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

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

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

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

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.

8 Appendix 2. Instructions

8.1 Instructions for the experiments

We shall now present the instructions given for the experiments, but only for Sessions 1 and 7. The remaining sessions go along the same lines, except for some differences that are explained in footnotes.

8.1.1 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 of 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 decision 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.[22] Furthermore, at the beginning of each session, an initial endowment of 1000 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.

[22] This sentence did not appear 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 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.[23]

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.

In other words, for this session only, you, the creditors, are depositors with accounts in the bankrupt company.[24] 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.

[23] 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.*

[24] 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).

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:

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

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.

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 one: 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., $(\mathbf{7.5}, \mathbf{7.5}, \mathbf{5})$. As such, and taking the above claims into account, Player 1 loses $\mathbf{7.5} - \mathbf{49} = -\mathbf{41.5}$, which is the first number in that particular cell. Player 2, therefore, loses $\mathbf{7.5} - \mathbf{46} = -\mathbf{38.5}$, and Player 3 loses $\mathbf{5} - \mathbf{5} = \mathbf{0}$.

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.[25] 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

[25] 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.

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, 1000 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 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.

8.1.2 Instructions for an Unframed Session (Session 7)

Screen 1: Welcome to the Experiment

It 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 1000 pesetas for participating in this experiment.[26] Furthermore, at the beginning of each session, an initial endowment of 1000 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.

- 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 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 1000 pesetas.[27]

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

[26] This sentence was not included 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.

Screen 3: The First Game.[28]

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. If all 3 players choose Rule A, and the 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 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.

[28] This was the third game in Sessions 9 and 10 and the second game in Sessions 11 and 12.

Screen 4: The Second Game.[29]

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.

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.[30]

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.

[29] This was the first game in Sessions 11 and 12.

[30] This was the first game in Sessions 9 and 10.

8.2 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 at hand, the allocations awarded by each of the above rules are as follows:

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

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 is 20.

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

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

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?

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 is 20.

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

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

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?

	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	¡ 41.5 ¡ 38.5 0
B	¡ 41.5 ¡ 38.5 0	¡ 38.3 ¡ 37.6 ¡ 4.1	¡ 38.3 ¡ 37.6 ¡ 4.1
C	¡ 41.5 ¡ 38.5 0	¡ 38.3 ¡ 37.6 ¡ 4.1	¡ 37.5 ¡ 37.5 ¡ 5

C

Table 2: Procedure P_1

	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	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	¡ 37.5 ¡ 37.5 ¡ 5

C

Table 3: Procedure P_2

	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	C
A	¡ 37.5 ¡ 37.5 ¡ 5	¡ 37.5 ¡ 37.5 ¡ 5	¡ 37.5 ¡ 37.5 ¡ 5
B	¡ 37.5 ¡ 37.5 ¡ 5	¡ 37.5 ¡ 37.5 ¡ 5	¡ 37.5 ¡ 37.5 ¡ 5
C	¡ 37.5 ¡ 37.5 ¡ 5	¡ 37.5 ¡ 37.5 ¡ 5	¡ 37.5 ¡ 37.5 ¡ 5

C

Table 4: Procedure P_3

	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	C
A	¡ 41.5 ¡ 38.5 ¡ 6	¡ 50 ¡ 47 ¡ 6	¡ 50 ¡ 37.5 ¡ 5
B	¡ 50 ¡ 47 ¡ 6	¡ 39.2 ¡ 36.8 ¡ 6	¡ 50 ¡ 37.5 ¡ 5
C	¡ 37.5 ¡ 47 ¡ 5	¡ 37.5 ¡ 47 ¡ 5	¡ 37.5 ¡ 37.5 ¡ 5

C

Table 5: Procedure P_0

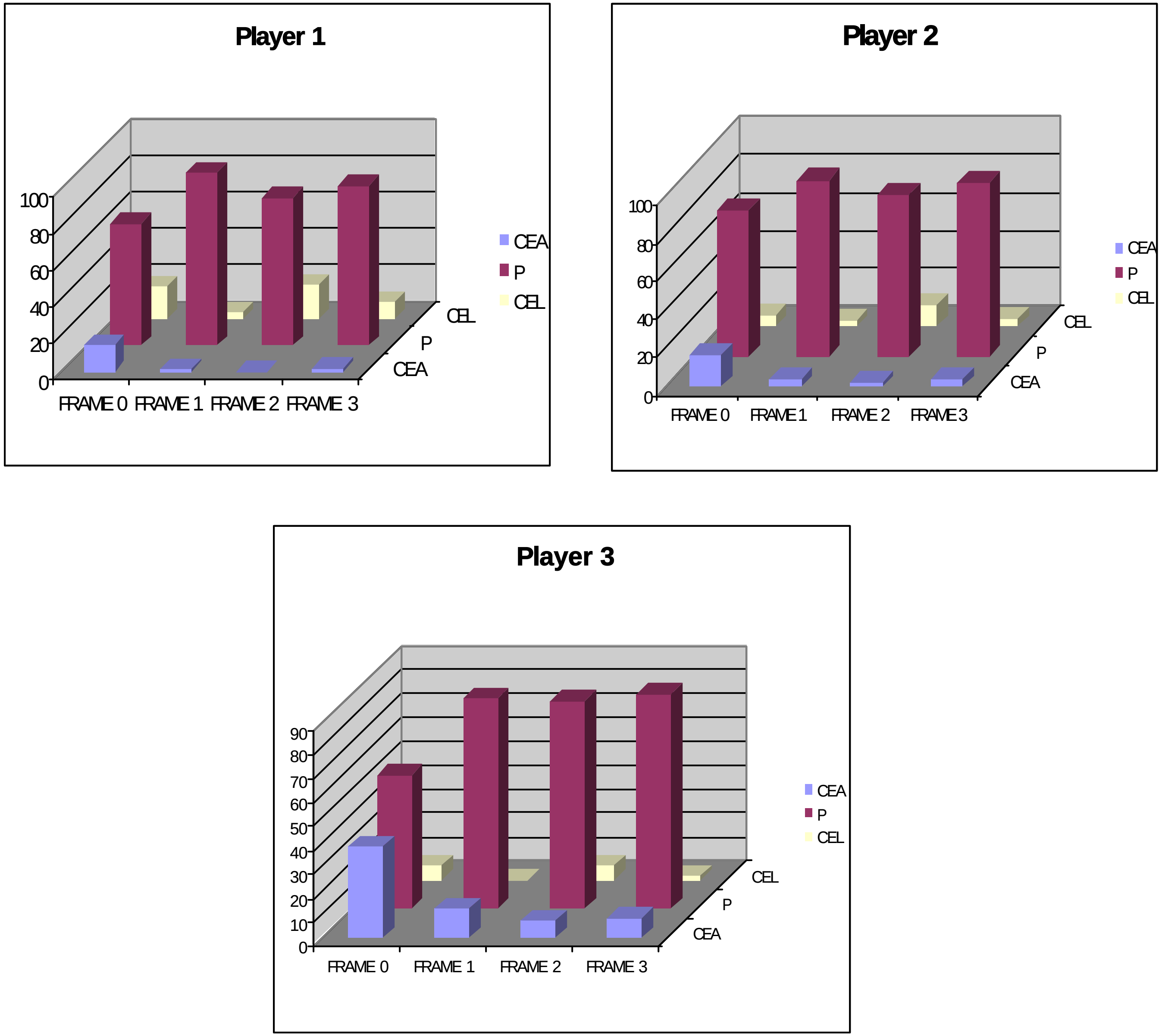

Figure 1: Aggregate behavior in the sessions of P_0. This figure shows the frequencies of choices in P_0, for each frame, and disaggregated for player position. For instance, in Frame 1, player 1 selects p 95% of the times, whereas she selects cel and cea only 4% and 1% of the times, respectively.

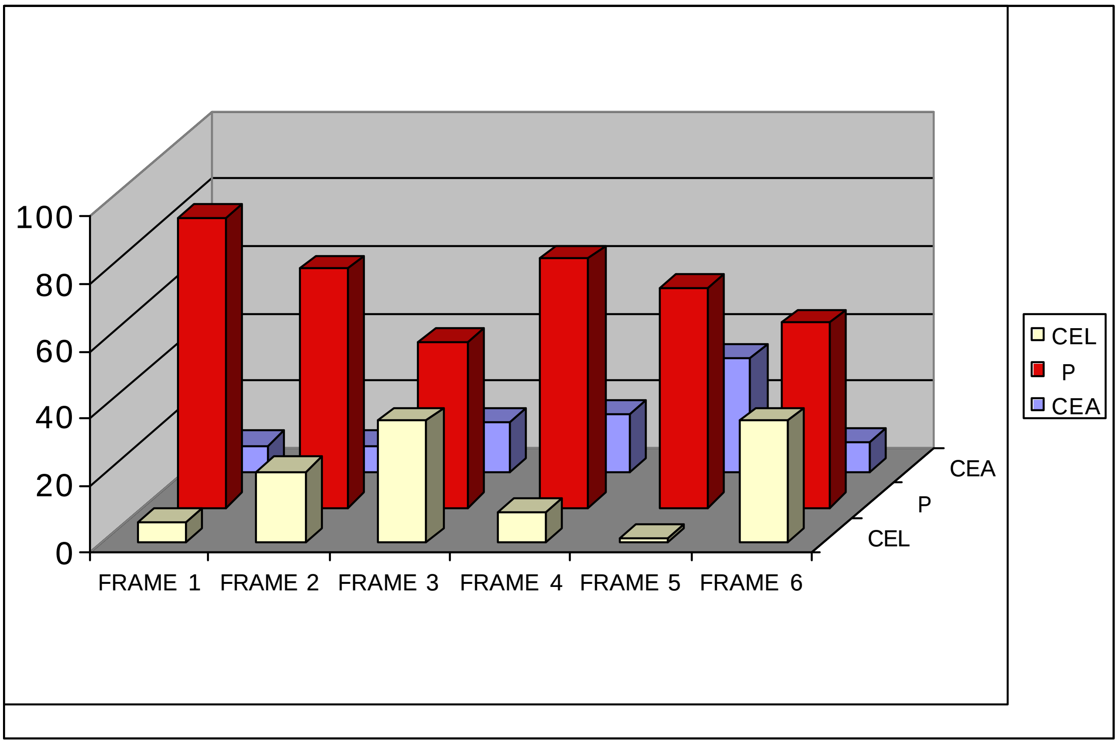

Figure 2: Results of the questionnaire. This figure shows the histograms corresponding to the choices for each of the six questions/frames appearing in the questionnaire. For instance, in Frame 1, p is selected in 86% of the responses, whereas cea and cel are selected only in 8% and 6% of the responses, respectively.