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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 claims problems, that is, the constrained equal-awards, the proportional, and the constrained equal-losses rules. To do this, we first let subjects play three games designed such that the unique equilibrium allocation coincides with the recommendation of one of these three rules. Moreover, we also 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. We also administered a questionnaire to a different group of students, asking them to act as an impartial arbitrator to solve (among others) the same claims situations played in the lab. Also in this case, the proportional solution 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? This question is an example of the so-called *claims* (or *bankruptcy*) *problems* (or *situations*) that provide a simple framework for studying the most adequate way of distributing losses when the claims of the agents involved cannot be fully covered. Another good example of a claims situation, and probably the oldest one in the literature on rationing, is the division of an estate: i.e., a person dies and the debts left behind are found to exceed the worth of his estate. How then should the estate be divided? [See O'Neill (1982) or Rabinovitch (1973), among others, citing examples from the Babylonian Talmud]. Tax schemes can also be interpreted as claims problems: i.e., a certain amount of money should be collected from individual gross incomes. What should the net income of everyone in society be? Or equivalently, what should the contribution of each individual be? [Young (1988, 1990)]. Rationing occurs when commodities have fixed prices, and it also gives rise to claims problems. A clear example of this is medical triage, when the financial resources available are not sufficient to cover individual medical needs. What sort of needs should then be rationed? [Winslow (1992)]. In the literature on arbitration, [e.g., Elkouri (1952), Spielmans (1939)], rights arbitration refers to situations covered by pre-existing rules or customs. When a dispute arises as a result of unclear rules, the arbitrator makes a judgement on the meaning of the rules, and thus decides on the opposing parties' rights.

Claims problems are major practical issues and, as such, have quite a long history, from both the legal and the economic viewpoints. In general, claimants are of diverse types (e.g., senior creditors, junior creditors and shareholders, in the case of a bankrupt firm), and, accordingly, some sort of priority of claims is established. In some cases, bankruptcy regulations respect absolute priority (i.e., senior creditors are paid first, followed by junior creditors and, finally, the shareholders), but in other cases, a proportion of the total worth of the liquidation value is reserved for the shareholders (10%-20%) [Hart (1999)]. The remaining amount is then shared among the other claimants in different groups, according to some established method (e.g., proportional to the claims).

In the case of taxes, however, proportionality is not the method most commonly employed for allocating losses. In general, progressive schemes are used, so that agents with larger incomes contribute relatively more. One such scheme is the so-called levelling tax [Young (1988)], the aim of which is to equalize after-tax income across all agents, without any subsidies.

Likewise, we can consider the case of a farming community that depends on an irrigation program and are suddenly faced with a drought. The proportional method is not generally employed in such a case, but rather an alternative scheme in which some sort of priority is established among the largest claimants.

The above-mentioned examples indicate that not all claims problems are, in practice, solved in the same way. In other words, different claims situations may well require different distribution schemes to ensure that justice is adequately administered. Consequently, from practical cases, researches turned to the search for well-behaved methods or rules to solve families of claims problems when agents are of the same type, so that they only differ in their claims [see Moulin (2002) or Thomson (2003) for recent surveys of this literature]. The oldest formal principle of distributive justice follows Aristotle's Maxim:

"Equals should be treated equally, and unequals, unequally in proportion to relevant similarities and differences".

The direct application of this maxim to claims situations gives rise to the best-known rule for solving claims problems: the *proportional* rule, which recommends that awards be proportional to claims. This is the rule that is generally employed in bankruptcy regulations. Its rationale is that proportionality amounts to awarding each share equally (as in the case of shareholders for example).

A different idea of equality underlies another well-known rule: the *constrained equal-awards rule.* It makes the awards to all claimants as equal as possible, subject to the condition that no one receives more than her claim. A dual formulation of equality, focusing on the losses that the creditors incur, as opposed to what they receive, underlies the *constrained equal-losses rule.* It proposes that claimants' losses should be as equal as possible, subject to the condition that no one ends up with a negative award. This rule corresponds to the previously-mentioned levelling tax in the case of tax schemes. In this case, its rationale is to look for the most egalitarian after-tax income distribution. The constrained equal awards rule gives priority to agents with small claims. They are reimbursed relatively more than agents with larger claims. It seems a natural procedure to apply when agents' claims are correlated with their incomes. The constrained equal-losses rule, on the contrary, gives priority to agents with larger claims. They start receiving money before the agents with smaller claims, who are only reimbursed if their losses are equal to the losses suffered by the agents with larger claims. It seems to be a natural procedure for cases in which claims are related to needs, as in the case of public support of health care expenses, for example. These two distinct concepts of equality have a long history and both have been advocated by many authors, including Maimonides (12th Century) [Aumann and Maschler (1985)]

The behavior of the different rules depends on the properties they fulfil. The analysis and formulation of properties and the search for a combination of properties to characterize a single rule is the subject of an important branch of the claims literature: the so-called *axiomatic approach.* The proportional, the constrained equal-awards and the constrained equal-losses rules all satisfy several different and basic properties, so that the consideration of these three solutions is by no means arbitrary. Firstly, because they are among the most common methods employed for solving practical problems. Secondly, because of their long tradition in Economic history, and, last but by no means least, because they are the only ones that satisfy the four basic invariance axioms within the family of solutions that treat equal claims equally [Moulin (2000)].

Another approach to solving claims problems is that of *cooperative game theory,* in which claims problems are formulated as either TU coalitional games, or as bargaining problems, and the rules are derived from solutions to coalitional games and from bargaining solutions, respectively. Examples of this sort of approach are presented in the papers of O'Neill (1982), Aumann and Maschler (1985), Curiel *et al.* (1988) and Dagan and Volij (1993). Both the axiomatic and the cooperative game-theory approach share a common view with regard to the analysis of claims problems: i.e., they look at fairness and cooperative aspects to support certain rules.

Finally, a limited number of papers applies the *non-cooperative game theory* to deal with claims problems [Chun (1989), Dagan, Serrano and Volij (1997), Moreno-Ternero (2002) and Herrero (2003)]. These papers apply to claims problems the same methodology known as the *Nash program* for the theory of bargaining. In other words, they construct specific procedures as non-cooperative games with the property that the unique equilibrium allocation corresponds to the one dictated by a specific rule [Nash (1953), Binmore *et al.* (1992), Roemer (1996)]. In other words, the literature provides theoretical support to certain rules by constructing specific strategic situations for which such rules are self-enforcing.

There is another aspect that makes this non-cooperative approach interesting for the analysis of claims situations. As in the case of bargaining theory, the theoretical debate is far from unanimous in identifying a *unique* optimal solution to claims problems. Consequently, there are many situations in which an arbitrator, or the outside authority in charge of designing the procedure for solving a claims problem, may not have, a priori, any strict preferences regarding which rule should be employed for the problem in hand. Under these circumstances, the arbitrator may resort to a (non-cooperative) procedure, which may lead to alternative rules for the outcome of strategic interaction among the claimants.

The aim of this paper is to bring the theoretical debate on the selection of rules to solve claims problems into an experimental lab. Our main question here can be summarized as follows:

is there any particular rule that is salient in the subjects' perception of the optimal solution to a claims situation?

In attempting 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 claims situations and ask them to solve those problems from an *outside observer's* point of view. The results of such questionnaires provide experimental evidence that can then be compared to that of the axiomatic theoretical debate. Another feasible approach is to fully exploit the experimental methodology and provide the subjects with *an active role* in the claims situation. That is to say, to design hypothetical situations in which they are *actual claimants* rather than mere *outside observers*. This alternative approach is clearly more in line with the non-cooperative literature mentioned above. The results of such an experiment may provide experimental evidence of how agents play when they are personally involved in real claims problems.

In this paper we examine both approaches and the results we obtain should be considered as complementary. In both cases, we focus on a claims problem involving three agents and ask the subjects to choose one of three different ways of dividing the estate that correspond, respectively, to the recommendations of the constrained equal awards, the constrained equal losses, and the proportional rules.

We first selected 120 students to play a sequence of games in the lab, (10 sessions with 12 subjects each). To be more specific, we asked the subjects to play for money the (non-cooperative) procedures of Chun (1989), Moreno-Ternero (2002) and Herrero (2003) applying them to *the same bankruptcy problem.* We focused on these three procedures because they share the same game-form (i.e., claimants are required to simultaneously propose a rule) and because they display very similar strategic properties (i.e., there is always a player with a weakly dominant strategy by which she can force an outcome to the game that is in her favour). If the subjects recognize the strategic incentives induced by each game, the choosing of a particular procedure may be the equivalent of choosing a particular rule to solve the problem.

We then considered an additional procedure, (i.e., 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 just coordination incentives. Thus, we used this game to investigate more compellingly which rule might emerge as the optimal solution to the strategic situation that the subjects are involved in.

In addition, we also wanted to verify whether the subjects that participated in games with such strong strategic properties would be sensitive to *framing effects*. As we mentioned earlier, different rules are to be considered as being more appropriate, depending on the problem in hand. We therefore explained each procedure to subjects, but with a different "story", (somehow consistent with the rule supported by the procedure), and compared the results with those obtained when 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 different frames may have induced subjects to behave differently.

We now briefly summarize the main findings of this experiment. While, in the first three procedures, the subjects' plays easily converge to the unique equilibrium rule, even in the first rounds, in the majority procedure, the proportional rule overwhelmingly prevails as a coordination device. Regarding the framing issue, we find that frames only exert some effect on the subjects' behavior in the majority game. As for the other procedures, strategic considerations appear to be so compelling that they render framing effects negligible.

The alternative approach consisted of selecting a different group of 120 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 claims situations played out previously in the lab by the other group of subjects. Consistent with our experimental findings, the proportional solution prevailed as the modal choice for 90% of the respondents. Nonetheless, the individuals also proved to be sensitive to the particular situation at hand.

Despite the extensive experimental literature on related issues such as bargaining [see Ochs and Roth (1989), and the literature cited therein], or arbitration [see Ashenfelter and Bloom (1984), or Ashenfelter *et al.* (1992), and the literature cited therein], this is, to the best of our knowledge, the first experiment on bankruptcy games. The closest reference to our work would be the paper presented by 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 proportional and the constrained equal losses rule), using the perspective of an "impartial judge" in the context of health care problems, the subjects displayed a slight preference for the constrained equal losses solution. Another related paper would be that of Yaari and Bar-Hillel (1984), in which different bargaining solutions are also investigated by means of questionnaires.

The remainder of this paper is organized as follows: In Section 2, we formally introduce claims problems, the three rules, and the non-cooperative procedures, which is the object of our experiment. Section 3 is devoted to the design of the experiment. In Section 4, we report on our experimental results. In section 5, we report on the results of the questionnaire. Our conclusions, comments and further proposals are then presented in Section 6. An Appendix contains the proofs of some theoretical results related to our study and the instructions for the experiment and the questionnaire.

2 Claims problems, rules and procedures

Let $N = \{1, 2, \ldots, n\}$ be a set of agents with generic elements i and j. A *claims (or bankruptcy) problem* [O'Neill (1982)] is a pair (c, E), where $c \equiv \{c_i\} \in \Re^n_+$ and $C = \sum_{i \in N} c_i > E > 0$. In words, c_i is the claim of agent i on a certain amount (the *estate*) E. Let $\mathbb{B}$ denote the class of such problems. Without loss of generality, let $c_1 \geq c_2 \geq ... \geq c_n$.[1]

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

(i) $0 \leq r(c, E) \leq c$.

(ii) $\sum_{i \in N} r_i(c, E) = E$.

(iii) For all $i, j \in N$, if $c_i \geq c_j$ then $r_i(c, E) \geq r_j(c, E)$ and $c_i - r_i(c, E) \geq c_j - r_j(c, E)$.

The allocation $r(c, E)$ is interpreted as a desirable way of dividing E among the agents in N. Requirement *(i)* is that each agent receives an award that is non-negative and bounded above by her claim. Requirement *(ii)* is that the entire amount must be allocated. Finally, requirement *(iii)* is that agents with higher claims receive higher awards and face higher losses.[2] We denote the set of all such rules by $\mathcal{R}$.

We then introduce the three rules that are the focus 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* $\sum_{i \in N} \max\{0, c_i - \lambda\} = E$*.*

[1] 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.*

[2] While conditions (i) and (ii) are standard in the definition of a rule, requirement (iii) is considered in the claims 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".

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* $\mathcal{R}$.

As mentioned in the introduction, such rules are salient in the theoretical debate on the best way of resolving claims problems. This may induce one to select such rules over other alternatives. On the other hand, in the case of bargaining problems, for example, the literature seems far from unanimous with regard to proposing a single rule to resolve claims situations relying on axiomatic properties only. This opens up the possibility of approaching claims problems with the use of alternative techniques.

2.1 Noncooperative solutions to claims problems

Let us now focus on some of the noncooperative *procedures* proposed for resolving claims situations. All of these procedures share the same game-form: i.e., agents simultaneously propose a rule belonging to the set $\mathcal{R}$, and the procedure selects a particular division of the estate accordingly. Moreover, all procedures share another common feature: i.e., that if all agents agree on a particular allocation, it is then selected as the solution to the problem.

In the *diminishing claims procedure*, if agents do not agree on a particular allocation, their claims are reduced by substituting them with the highest amount assigned to every agent by the chosen rules. The agents' rules are then applied to the resulting problem after the claims have been adjusted. If they coincide in their allocation to the new problem, this is chosen as the solution the procedure provides. If not, the claims are reduced again, and if the process does not end in a finite number of steps, the limit of the resulting claims vectors (if it exists) is chosen as the solution to the problem. Otherwise, nobody gets anything.

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

Step k+1. For all $i \in N$, let $c_i^{k+1} = \max_{j \in N} r_i^j(c^k,E)$. For all $j \in N$, calculate $r^j(c^{k+1},E)$. If $r^j(c^{k+1},E) = r^i(c^{k+1},E)$, for all $i,j \in N$, then $dc[r,(c,E)] = r^i(c^{k+1},E)$. Otherwise, move on 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 the agents do not agree on the proposed allocation, they will receive the proportional share of half of the liquidation value. Agents' rules are then applied to divide the remainder after adjusting claims. If they coincide in the allocation to the new problem, the solution that the procedure provides is the allocation plus the concessions awarded in the first stage. Otherwise, the process starts all over again. If it does not end 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.

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 the agents do not agree on the allocation proposed, they will receive the minimum amount assigned by the chosen rules. The agents' rules are then applied to the residual problem, after adjusting the claims and the liquidation value. If they agree on the allocation for the new problem, the procedure then provides the allocation plus the concessions stipulated in the first stage. If not, the process starts 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.

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 $r = \{r^i, r^{-i}\}$ be the profile of rules reported. The division proposed by the unanimous concessions procedure, $u[r, (c, E)]$ is obtained as follows:

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

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

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

Lemma 1 *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. Finally, all Nash equilibria of P_1 are outcome equivalent to cea.*

Proof. See Chun (1989). ■

Lemma 2 *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.*

Proof. See Moreno-Ternero (2002). ■

Lemma 3 *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. Finally, all Nash equilibria of P_3 are outcome equivalent to cel.*

Proof. See Herrero (2003). ■

The previous lemmas indicate that the 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 favour by selecting her weakly dominant strategy. This may render these procedures inadequate if we were genuinely interested in the rule selection problem, that is to say, in collecting experimental evidence on how subjects arrive at an agreement on claims problems in the lab. This is why we also consider an additional procedure that takes the form of a coordination game, which we call the *majority procedure*.

In the majority procedure, a claimant obtains the share of the liquidation value proposed by her chosen rule only if it has been selected by a single majority of the agents (that is, all other rules have been chosen by a strictly smaller number of players). 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 4 *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 ten experimental sessions in July, 2001 and May, 2003. A total of 120 students (mainly, undergraduate Economy students) with no prior exposure (or very limited exposure) to game theory, who were recruited from among the undergraduate population at the University of Alicante.

3.2 Frames

In the first six sessions the claims 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 claims problem was presented by the hypothetical situation of a *bank in bankruptcy.*

- **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 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 has 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 occurs (in equilibrium) with procedure P_3.
- **Frame 0: No frame**. We also run four unframed sessions. In this case, the subjects were only provided with the payoff tables and were required to play the four games without any story behind.

3.3 Treatments

The ten sessions were run in a computer lab.[3] In the first six sessions, the subjects were assigned to groups of 3 individuals each and played twenty rounds

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

of a *framed* procedure, P_1, P_2 or P_3, followed by twenty rounds of P_0 presented under the same framework. In the last four sessions, the 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 10 sessions.

treat 1		treat 2		treat 3		treat 4		treat 5	
ses1	ses4	ses2	ses5	ses3	ses6	ses7	ses8	ses9	ses10
P1	P1	P2	P2	P3	P3	P1	P1	P3	P3
P0	P0	P0	P0	P0	P0	P2	P2	P2	P2
						P3	P3	P1	P1
						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 of the sessions, the subjects played anonymously in groups of three players with randomly matched opponents. The subjects were informed that their *player position* (i.e., their individual claims in the problem) would remain constant throughout the session, while the composition of their group would change in every round.

Instructions were provided by a self-paced, interactive computer program that introduces and describes the experiment. The 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. The instructions were presented in Spanish. The complete set of instructions, translated into English, can be seen in the Appendix. At the end of each round, every player was informed about the outcome of the game and of the monetary payoff associated with it.

3.4 Group size

Our decision to focus on a claims problem with three players was taken for by several reasons. An interesting feature to note is that the procedures presented in Section 2 work not only with two agents, but also with any arbitrary number of agents. This is not the case with bargaining procedures of a related nature, most significantly van Damme (1986), which only converges in the two-person case. Furthermore, the situation is quite different from the two-agent case when more than two agents are involved. With just two agents, any amount that is not assigned to a given agent is allotted to the other one. When more than two agents are involved, however, whatever is left over must be distributed among the remaining agents. Consequently, agents may care not only about the amount they receive, but also about the way in which the leftovers are distributed among the remaining agents. By choosing three agents, we moved away from the two-person case, but endeavoured to keep the size of the population at a minimum. Finally, as our objective was to test the three salient rules (i.e., proportional, constrained equal-awards and constrained equal-losses), by considering three agents, we can construct the problem in such a way that each agent has a rule that proposes his preferred division of the estate. Thus, a priori, all of the division methods have an equal chance of being chosen.

3.5 The claims problem

As we mentioned earlier, all four procedures were constructed upon *the same* claims problem (c^*, E^*), where $c^* = (49, 46, 5)$ (i.e., $\sum c_i = 100$) and $E^* = 20$.[4] 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, the subjects played more than one procedure in sequence, we decided to focus on a single claims problem to reduce the variability in the environment and facilitate the 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. This does not guarantee, however, that p will be the most preferred rule for any medium-sized claimant, unless we imposed some conditions on the claims problem that were analogous to the ones above.[5]

There is another feature of the experimental design of the framed sessions that is worthy of mention at this stage. As can be seen in the instructions, the three rules were presented to the subjects without using any technical terminology (i.e., simply referring to them as rules "A", "B" and "C"). However, the distributive properties of *cea* and *cel*, that is, the two rules whose simple definitions might have been less transparent to any subjects who were not familiar with to claims problems, were explicitly mentioned in their descriptions. It was stated that they were meant to "... *benefit the agent with the lowest (highest) claim*". In contrast, we omitted any mention of the fact that p was indeed the first-best option for Player 2, the medium-sized claimant, (which is a property that we know to be peculiar to the specific parameterization of our problem (c^*, E^*)). The reason for this asymmetry in the description of the rules was twofold. On the one hand, we preferred to make sure that the distributive properties of *cea* and *cel* were common knowledge to all of the subjects, in particular, with respect to the role they might have played in procedures P_1 and P_3. On the other hand, we wanted to see whether omitting this information in the case of p would have produced a significant change in the behavior of the medium-sized claimant -in particular, with respect to her choice in P_2.

3.6 Game-forms and payoffs

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

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

[5]There were other reasons for choosing problems that were sufficiently "close" to (c^*, E^*) for our experiment, which we explain in more detail in the Appendix.

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) at sometime in the past. Distributing allocations as vectors of non-negative amounts of money (as they are presented in this paper and in all of the literature on claims) would have simply reproduced in the lab a particular *bargaining* (as opposed to a *claims*) game in which subjects bargain, under a given protocol, for a particular distribution of the estate.

To some extent, the simple fact that the 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 bakkruptcy. To (at least partially) ameliorate this dilemma, we constructed our monetary payoff functions in such a way that, in each round, (for a predetermined endowment, known in advance), the subjects lost *the difference* between their claim and the share of the estate's division assigned to them, given the ruling procedure and the group's strategy profile.

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

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

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

(2)

Insert Table 2 about here.

Table 2 is identical to the one used to explain the game-procedure P_1 to the subjects. Player 1 (2) [3] selects the row (column) [matrix]. Each cell that corresponds to a strategy profile $r = (r^1, r^2, r^3)$ contains the payoffs for Players 1 (first row) 2 (second row) and 3 (third row).

The following payoffs were obtained: 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 a 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 Lemmas 1-3, 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 the diminishing claims procedure P_1, the pivotal player is player 3 (the lowest claimant), whose weakly dominant strategy corresponds to rule *cea* . However, given the reduced form used in the experiment (subjects could only choose among *cea*, p and *cel*), also player 1 has a weakly dominant strategy (*cel*), while player 2 has no weakly dominant strategies in this game.

Analogous considerations hold for the proportional concessions procedure P_2, whose payoff matrix is drawn in Table 3.

(3)

Insert Table 3 about here

Payoffs for this game were obtained as follows: From Lemma 2, if $r^i = p$ for some $i \in \{1, 2, 3\}$, then the allocation is $p(c^*, E^*) - c^* = (-39.2, -36.8, -4)$. 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 correspond to $(-39.2, -36.8, -4)$, that is, to the proportional allocation.

Here we notice that all players have a weakly dominant strategy at their disposal: p is weakly dominant for the pivotal Player 2; *cea* is weakly dominant for Player 3; *cel* is weakly dominant for Player 1.

The payoff matrix of the unanimous concessions procedure (P_3) is reported in Table 4.

(4)

Insert Table 4 about here

Payoffs for this game were obtained as follows: From Lemma 3, if $r^i = cel$ for some $i \in \{1, 2, 3\}$, then the allocation is $cel(c^*, E^*) - c^* = (-37.5, -37.5, -5)$. 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 by using a recursive algorithm, based on the definition of P_3 that leads to $(9.4, 9.4, 1.3) - c^* = (-39.6, -36.6, -3.7)$.

In this case, *cel* is weakly dominant for the pivotal Player 1; *cea* is weakly dominant for Player 3 while Player 2 has no weakly dominant strategies.

To summarize, among the three procedures, *cea* (*cel*) always corresponds to a weakly dominant strategy for Player 3 (1), while Player 2 has only a weakly dominant strategy (p) in P_2.

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 bankruptcy 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)

Insert Table 5 about here

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 have mentioned earlier on, the payoffs reported in Tables 2-4 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, the subjects who were selected as Players 1 and 2 received 500 pesetas as a show-up fee in the framed sessions, and 1,000 pesetas in the unframed sessions. The 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' were. This asymmetry in the show-up fees, intended mainly to also provide 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 subjects' decisions. 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 Results

In analyzing the data, we first look at the six framed sessions (Treatments 1 to 3 in Table 1). We then compare this evidence with that of the unframed sessions (Treatments 4 and 5 in Table 1) to check for framing effects.

4.1 Framed Sessions

With regard to the six framed sessions, we first focus on the allocations and then on the subjects' behavior.

4.1.1 Allocations

Table 6 reports the relative frequencies of allocations in the six framed sessions of P_1, P_2 and P_3.

PROC. \ ALLOC.	OBS.	*cea*	*p*	*cel*	Others
P_1	160	**.98**	0	0	.02
P_2	160	0	**1**	0	0
P_3	160	0	0	**.98**	.02

(6)

Table 6: Allocation distributions of P_1, P_2 and P_3 in the framed sessions.

Table 6 reports the relative frequency of allocations that corresponds to each rule for each procedure, P_1, P_2 and P_3. The remaining category (labelled as "Others") pools all allocations that do not correspond to any particular rule. We begin by noting that *virtually all* matches yielded the allocation associated with the corresponding equilibrium rule. We also know, from Lemmas 1-3, that every Nash equilibrium is outcome equivalent to the corresponding rule of that procedure. 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.[6]

This striking evidence must be compared to the allocation distributions of the framed versions of P_0, as shown in Table 7.

FRAME \ ALLOC.	OBS.	*cea*	*p*	*cel*	Others
1	160	.01	**.82**	0	.17
2	160	0	**.69**	.01	.30
3	160	0	**.75**	.01	.24
TOTAL	480	0	**.75**	.01	.24

(7)

Table 7: Allocation distributions of P_0 in the framed sessions.

It must be remembered that, in all framed sessions, P_0 was played after one of the other procedures, P_1, P_2 or P_3, in the corresponding frame. Table 7 shows the allocation distributions of P_0 depending on under which frame it was played in.

We observe in Table 7 that the proportional rule is salient in describing the allocation distributions in all sessions, with an average frequency of 75% across all treatments. As Table 7 shows, when the subjects managed to agree on an equilibrium allocation, they did so by way of the proportional rule (i.e., for each frame, coordination on *cea* or *cel* never exceeds 1% of the total observations). Moreover, we also observe a significantly higher frequency of non-equilibrium allocations (i.e., 24% of the total observations) as compared to those of the framed sessions of P_1, P_2 and P_3), that do not correspond to any particular rule. As it turns out, these allocations correspond mainly to situations in which two out of three players select the proportional rule.[7]

The presence of such a significant proportion of non-equilibrium allocations in P_0 is due mainly to two different reasons. On the one hand, in P_0 a rule dictates the game allocation if and only if *all players* (as opposed to a *single one*) select it. On the other hand, learning effects are much stronger in P_0 than

[6]We should also notice that, in procedures P_1-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 (which would occur with a probability of $1 - p = 2/3$) if the other two players select the equilibrium rule (which, under random playing, would occur with a probability of $1/9$). The expected probability of a Nash equilibrium under random playing is therefore $1/3 + 2/3 * 1/9 \simeq .4$. As Table 6 shows, the relative frequencies of equilibrium outcomes are significantly higher than that value to exclude the possibility that they come as results of random playing by the subjects.

[7]In particular, the frequency with which two out of three subjects selected the proportional rule under frame 1 (2) [3] was 13% (18%) [19%], with an average of 17% (that is, 71% of the total of non-equilibrium allocations).

in any other procedure: i.e., the average frequency of proportional allocations rises from 75% to 90% if we consider only the last 10 rounds. We shall discuss learning effects more in detail in Section 4.2 below.

4.1.2 Behaviors

Table 8 shows the relative frequencies (disaggregated for procedure and player position) with which subjects used the three available rules in the six framed sessions.

PLAYERS	P_1			P_2			P_3		
1	.08	.28	.64	.02	.22	.76	.02	.06	**.92**
2	.15	.66	.19	.07	**.76**	.17	.06	.45	.49
3	**.97**	.02	.01	.82	.14	.04	.54	.3	.16
RULES	*cea*	*p*	*cel*	*cea*	*p*	*cel*	*cea*	*p*	*cel*

(8)

Table 8: Aggregate behavior in the framed sessions of P_1, P_2 and P_3.

We can observe from Table 8 that pivotal players used mainly their weakly dominant strategies. More precisely, Player 3 selects her weakly dominant strategy (*cea*) in P_1 97% of the times; in P_3 Player 1 selects her weakly dominant strategy (*cel*) 92% of the times; in P_2 the relative frequency with which Player 2 selects her weakly dominant strategy p is somehow lower (76%), but still significantly higher than any other available choice. The difference in behavior seen here might well have been caused by the fact that it was not explicitly mentioned that p was the first-best option for Player 2, as was done in the case of *cea* and *cel*.

As far as non-pivotal players are concerned, we notice that weakly dominant strategies are again always selected more than 50% of the time, although not as frequently as in the case of pivotal players. Moreover, Player 1 (3) selects her weakly dominant strategy in a non-pivotal position more frequently in P_2 than in P_1 (P_3). This may be due to the fact that P_2 is the procedure in which pivotal Player 2 dictates her preferred allocation less often than in the other procedures and, in doing so, raises the incentive of non-pivotal players to use their weakly dominant strategies.[8]

Once again, things change significantly when we look at the aggregate behavior in the framed sessions of P_0, as shown in Table 9.

PLAYERS	*FRAME* 1			*FRAME* 2			*FRAME* 3		
1	.01	**.95**	.04	0	**.81**	.19	.02	**.88**	.10
2	.04	**.93**	.03	.02	**.86**	.12	.04	**.92**	.04
3	.12	**.88**	0	.07	**.87**	.06	.08	**.9**	.02
RULES	*cea*	*p*	*cel*	*cea*	*p*	*cel*	*cea*	*p*	*cel*

(9)

Table 9: Aggregate behavior in the framed sessions of P_0.

As Table 9 shows, the subjects selected the proportional rule at least 80% of the time, independently of their player positions, with an average frequency of use of 88.5%.

[8]More precisely, player 1 played *cel* 64% (resp. 76%) of the times in P_1 (resp. P_2) and player 3 played *cea* 54% (resp. 82%) of the times in P_3 (resp. P_2).

4.2 Framing effects

We shall now look at the experimental evidence of the four unframed sessions to check for framing effects. By analogy to Section 4.2, we first focus on allocations and then on the subjects' behavior.

4.2.1 Allocations

The allocation distributions in the four unframed sessions are summarized in Table 10.

RULES / PROCEDURES	OBS.	*cea*	*p*	*cel*	Others
P_0	320	.01	.54	0	.45
P_1	320	.97	.01	0	.02
P_2	320	0	.99	.01	0
P_3	320	0	0	.98	.02

(10)

Table 10: Allocation distributions in the unframed sessions.

As for procedures, P_1, P_2 and P_3, Table 10 reports almost identical allocation distributions to those of the framed sessions, yielding the corresponding equilibrium allocation in virtually every match.[9]

When we look at P_0 (i.e., the first row of Table 10), the proportional rule is again salient in describing the allocation distributions in all of the sessions. Moreover, if subjects coordinated on an equilibrium of P_0, as in the framed sessions, they coordinated on the equilibrium supported by the proportional rule. However, the relative frequencies of the proportional allocations (54%, 76% if we consider the last 10 rounds) are significantly lower compared to those of the framed sessions (75% and 90% respectively). By the same token, the relative frequency of (non-equilibrium) allocations in P_0 is significantly higher than those of the framed sessions (45% versus 24%).[10]

Table 11 confirms this evidence by testing for homogeneity in the allocation distributions of framed and unframed sessions of P_0 by means of standard chi-square statistics.[11]

[9] We run standard χ^2 statistics (see footnote 11 below) to test for any difference in the allocation distributions between framed and unframed sessions of P_1, P_2 and P_3. In all three cases, the null hypothesis (no difference in the allocation distribution) was never rejected at any reasonable significance level.

[10] As in the case of the framed sessions, these non-equilibrium outcomes correspond mainly to situations in which two out of three players select the proportional rule (27% of the total observations).

[11] Consider the case of sampling from p populations, $p \geq 2$, partitioned in $k \geq 2$ different categories. We wish to test the null hypothesis (H_0) that they all have the same distribution. Let $X_j \equiv \{X_{1j}, ..., X_{kj}\}$ be a sample from population $j = 1, ..., p$, where X_{kj} denotes the number of observations on X_j that belong to category $i = 1, ..., k$. Let $n_1, ..., n_p$ be the number of observations on $X_1, ..., X_p$, respectively. Finally, let

$$\widehat{p}_i = \frac{\sum_{j=1}^{p} X_{ij}}{\sum_{j=1}^{p} n_j}.$$

If $n_1, ..., n_p$ are large enough, and under H_0, then the random variable

$$\chi_0^2 = \sum_{j=1}^{p} \sum_{i=1}^{k} \left[\frac{(X_{ij} - n_j \cdot \widehat{p}_i)^2}{n_j \cdot \widehat{p}_i} \right],$$

	ALL ROUNDS		LAST 10	
H_0	χ_0^2	$p-$val	χ_0^2	$p-$val
$\mu^1 = \mu^2 = \mu^3$	7.33	.29	7.3	.29
$\mu^0 = \mu^1 = \mu^2 = \mu^3$	45.39	0	36.9	0
$\mu^0 = \mu^1$	31.54	0	23.12	0
$\mu^0 = \mu^2$	11.7	.01	15.16	0
$\mu^0 = \mu^3$	22.04	0	7.85	.04

(11)

Table 11: Testing for homogeneity of the allocation distributions of P_0

It must be remembered that we have three different framed treatments (treatments 1, 2 and 3 of Table 1) for P_0, since P_0 was played within each frame, and two unframed treatments (treatments 4 and 5), which only differed in the order of procedures. As it turns out, there is no significant difference in the allocation distributions of P_0 between the two unframed treatments . In other words, our data do not show the presence of order effects in the unframed treatments. All unframed observations of P_0 are, therefore aggregated under the "FRAME 0" category. For all $i = 0, ..., 3$, let μ^i be the allocation distribution of P_0 that corresponds to frame i. The first row of Table 11 tests for homogeneity in the three allocation distributions that correspond to the three framed treatments of P_0: μ^1, μ^2 and μ^3. Here the null hypothesis is not rejected, whether we consider the entire data-set ("ALL ROUNDS") or we restrict our sample to the observations that correspond to rounds 11-20 ("LAST 10"). We should also notice that the chi-square statistics are essentially the same (7.33 and 7.3 respectively). This implies that, despite the presence of learning effects, allocation distributions are always sufficiently close over time. Things change substantially when we also consider μ^0, that is, when we test for homogeneity in the set of framed and unframed distributions. As Table 11 shows, in this case, we always reject the null hypothesis of no difference in allocation distributions, both at the aggregate level (second row) and for each treatment pair independently (rows 3-5). This result does not depend on whether we consider the entire data-set or whether restrict our sample to the last 10 rounds. In other words, unlike the case of the three procedures P_1, P_2 and P_3, for the majority procedure P_0 framing effects seem to play a role in determining the outcome distributions and enhancing coordination when the game is played in the context of a hypothetical claims situation.

4.2.2 Behaviors

Table 12 reports, disaggregated for player position and procedure, subjects' aggregate behavior in the four unframed sessions.

is approximately a standard chi-square variable with $(p-1)(k-1)$ degrees of freedom (e.g., Rohatgi (1976)). We therefore reject H_0 at level α if the computed value of χ_0^2 is above $\chi^2_{(p-1)(k-1),\alpha}$, or what is equivalent, if the corresponding $p-$value is below α. Throughout the paper, we shall fix $\alpha = .05$, as the significance level.

PLAYERS	P_1			P_2			P_3		
1	.05	.2	.75	.02	.07	.91	.01	.03	**.96**
2	.1	.63	.27	.06	**.86**	.08	.14	.13	.73
3	**.97**	.01	.02	.8	.11	.09	.72	.18	.1
RULES	*cea*	*p*	*cel*	*cea*	*p*	*cel*	*cea*	*p*	*cel*

(12)

Table 12: Aggregate behavior in the unframed sessions of P_1, P_2 and P_3

Here we notice that the pivotal players choose their weakly dominant strategies with a frequency that is even higher than in the framed sessions. More precisely, pivotal Player 3 selects her weakly dominant strategy (*cea*) in P_1 97% (versus 97%) of the time; in P_3 the pivotal Player 1 selects her weakly dominant strategy (*cel*) 96% (versus 92%) of the time; in P_2 the pivotal Player 2 selects her weakly dominant strategy p 86% (versus 76%) of the time. As far as the weakly dominant strategy used by the non-pivotal players is concerned, we notice that it is always selected more than 72% of the time. This frequency is also higher here than it is in the framed sessions.

We test the statistical significance of these differences (only as far as pivotal players are concerned) in Table 13.

H_0:	$\nu_1^F = \nu_1^U$ (P_3)		$\nu_2^F = \nu_2^U$ (P_2)		$\nu_3^F = \nu_3^U$ (P_1)	
ROUNDS	χ_0^2	p-val	χ_0^2	p-val	χ_0^2	p-val
1-10	1.95	.38	5.09	.08	2.51	.29
11-20	3.07	.22	5.95	.06	0	1

(13)

Table 13: Testing for homogeneity in pivotal players' aggregate behavior

For all $j = 1, ..., 3$, let ν_j^F (resp. ν_j^U) denote pivotal player $j's$ aggregate behavior in the framed (resp. unframed) version of the corresponding procedure (reported under parenthesis in Table 13). Given this notation, $H_0 : \nu_j^F = \nu_j^U, j = 1, 2, 3$. As Table 13 shows, pivotal players' behavior seem not to be sensitive to framing effects in all procedures P_1, P_2 and P_3 (the null hypothesis is not rejected either if we consider the entire dataset ("ALL ROUNDS"), or if we restrict our sample to the observations of rounds 11-20 ("LAST 10"). This reinforces the evidence of Section 4.2.1: i.e., that strategic considerations seem predominant in the subjects' perception of procedures P_1, P_2 and P_3. The absence of a frame leads subjects even closer to an equilibrium play, although this difference in behavior is never significant.

We now move to analyze the role of framing effects in the context of the majority procedure P_0. As we noticed earlier, framing effects may interact with learning effects in this case, since coordination increases significantly over time. This is in contrast with what we found in the case of procedures P_1, P_2 and P_3, where the corresponding equilibrium rule distribution emerges from the very beginning.

FRAMES		Frame 0			Frame 1			Frame 2			Frame 3		
Player	Rounds	*cea*	*p*	*cel*	*cea*	*p*	*cel*	*cea*	*p*	*cel*	*cea*	*p*	*cel*
1	1-20	.06	**.75**	.19	.01	**.95**	.04	0	**.82**	.18	.02	**.88**	.1
1	1-10	.13	**.6**	.27	.02	**.89**	.09	0	**.7**	.3	.05	**.79**	.16
1	11-20	0	**.9**	.1	0	**1**	0	0	**.93**	.07	0	**.96**	.04
2	1-20	.08	**.87**	.05	.04	**.93**	.03	.03	**.85**	.12	.03	**.92**	.05
2	1-10	.13	**.78**	.09	.07	**.9**	.03	.03	**.76**	.21	.06	**.85**	.09
2	11-20	.02	**.97**	.01	.01	**.96**	.03	.01	**.95**	.04	.01	**.99**	0
3	1-20	.25	**.69**	.06	.12	**.88**	0	.07	**.88**	.05	.08	**.9**	.02
3	1-10	.34	**.55**	.11	.24	**.76**	0	.14	**.8**	.06	.12	**.84**	.04
3	11-20	.16	**.82**	.02	0	**1**	0	.01	**.94**	.05	.04	**.96**	0

(14)

Table 14: Aggregate behavior in P_0

Each cell of Table 14 reports the relative frequency of **the** use of each strategy, disaggregated for player position, under the four frames. We calculate these distributions over the entire dataset (rounds 1-20) but also considering the first (1-10) and the last (11-20) rounds respectively. If we consider only the first 10 rounds, the subjects have selected the proportional rule at least 55% of the time, with an average frequency of use of 77%. If we consider only the last 10 rounds, however, then the subjects have selected the proportional rule at least 82% of the time, with an average frequency of use of 95%. These differences are always significant, for all frames and player positions. We also notice that Player 2 "learns less" than 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 P**layers 1 and 3 gradually "joining" Player 2 in the choice of their second-best option (the proportional outcome). 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)). 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.

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.

As Table 15 shows, this conjecture is rejected by our data.

	PLAYERS	Player 1		Player 2		Player 3	
H_0	ROUNDS	χ_0^2	p-val	χ_0^2	p-val	χ_0^2	p-val
$\nu_j^0 = \nu_j^1 = \nu_j^2 = \nu_j^3$	$1-20$	39.5	0	22.86	0	49.61	0
$\nu_j^0 = \nu_j^1 = \nu_j^2 = \nu_j^3$	$11-20$	9.8	.13	3.23	.78	35.96	0
$\nu_j^0 = \nu_j^1$	$1-20$	25.26	0	3.81	.15	23.08	0
$\nu_j^0 = \nu_j^1$	$11-20$	8.52	.01	.22	.89	15.64	0
$\nu_j^0 = \nu_j^2$	$1-20$	10.48	.01	11.65	0	20.55	0
$\nu_j^0 = \nu_j^2$	$11-20$	.37	.83	.9	.64	12.68	0
$\nu_j^0 = \nu_j^3$	$1-20$	9.54	.01	2.71	.26	24.67	0
$\nu_j^0 = \nu_j^3$	$11-20$	2.71	.26	1.41	.49	8.74	.01

(15)

Table 15: Testing for framing effects in the players' aggregate behavior in P_0

For all $j = 1, 2, 3$, and $i = 0, ..., 3$, let ν_j^i denote pivotal player $j's$ aggregate behavior under frame i (with $i = 0$ meaning "NO FRAME"). As Table 15 shows, framing effects are almost always significant when we consider the entire dataset. If we consider just the last ten rounds, we observe that they are always significant for Player 3 and sometimes so for Player 1. The situation is quite different for Player 2 (but we have already noticed that, for whatever the reason might be, she has been playing p with frequencies that are comparable to those of P_2 from the very beginning). In any case, (as we know from Table 11) even if the framing effects decrease over time when we look at them at the level of each player's behavior, the overall impact on outcome distributions continues to be substantial, even in the last rounds.

We shall now conclude this section by briefly summarizing its main findings. Framing effects do not seem to play any significant role in the case of procedures P_1, P_2 and P_3, which are games whose strategic properties are so strong that they seem to overcome any other consideration. A totally different scenario appears in the analysis of P_0. In this case, players need a coordination device to achieve efficiency and, when they do coordinate, they do it by way of the proportional rule. Finally, frames seem to help coordination, even when we control for the learning effects that are typical of all repeated coordination situations.

5 Taking the viewpoint of outside observers: survey results

Our previous results concerning to 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 considered as a *social norm* for solving claims problems. 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 the 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 claims problems. First, however, we must verify the subjects' perception of the adequacy of the proportional rule as the best way of solving claims problems under different frames, even in the absence of strategic considerations.

To do so, 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 used by Bar-Hillel and Yaari (1993) and by Cuadras-Morató *et al.* (2001), among others.

More specifically, we distributed 120 questionnaires among undergraduate students at the University of Alicante, none of whom had had any prior exposure to bankruptcy 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 in which a certain amount of money had to be allocated among three agents with conflicting claims. By analogy to our experimental design, all six situations referred to the same claims problem (c^*, E^*). 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 were presented as Frames 1-3 in Section 3.2 and the remaining three situations are now described below:[12]

- **Frame 4: Estate division and debts**. Under this frame, a person dies and leaves an estate that is insufficient to cover the claims on three legally contracted debts. Then, E^* is interpreted as the estate and the claims vector c^* as the debts contracted with each creditor.

- **Frame 5: Estate division and bequests**. Under this frame a man dies after having promised each one of his three sons, to leave him 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.

Frames / Rules	1	2	3	4	5	6
cea	0.06	0.06	0.14	0.15	0.37	0.11
p	0.89	0.69	0.46	0.76	0.61	0.56
cel	0.06	0.25	0.41	0.10	0.02	0.33

(16)

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

Table 16: Results of the questionnaire

Table 16 summarizes the choice of rules made in the questionnaire's responses. Each column denotes the frequency of each of these three rules under the corresponding frame. In Frame 4, for instance, 15% of the respondents chose the constrained equal awards rule, 76% selected the proportional rule and only 10% of them selected the constrained equal losses rule.

We first observe that the respondents' choices vary, depending on the frame. Nevertheless, the proportional rule continues to be the solution that receives the highest support in all of the six cases, not only at the aggregate level (as Table 16 shows) but also at individual respondent level, at 90%. Furthermore, 15% of the respondents chose the proportional rule in all of the six cases, whereas, no other rule was ever chosen for every case by any of the respondents.

If we restrict our attention to the (minoritarian) rules *cea* and *cel*, we observe that they are chosen with rather similar frequencies, with a slight bias towards *cel* (15% and 19% respectively). In terms of significance, however, *cea* and *cel* are given identical support under frame 1 (in which the claimants are depositors). The *cea* rule is preferred under frames 4 and 5 (i.e., the heritage situations), while *cel* is the most preferred rule in all of the other cases. In other words, the subjects perceived *cea* as being more appropriate than *cel* in the context of dividing up an estate, but not in situations where NGOs or taxation is concerned, when the preferred rule is *cel*. It is significant the support received by *cel* under Frames 3 and 6 (i.e., non-governmental organizations and taxation), where 41% and 33% of the respondents choose the constrained equal losses rule. The significant support for *cel* under Frame 3 is in keeping with the results presented by Cuadras-Morató *et al* (2001), in the health care context, where *cel* receives a slightly majoritarian support. This may be in consonance with the idea that *cel* is a solution perceived as fair when claims are related to needs. The support of *cel* under Frame 6 (taxation), also may respond 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 (37%) 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.

6 Conclusions

In this paper, we have presented the results of an empirical study on the society's perception of the different well-known rules employed for solving claims problems. The analyses were done 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 rule) 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 of our subjects made the same comment:

- *"In P_3 everything was determined by my own choice."*[13]

This is far more evident for pivotal players, who can force the outcome of a game in their own favour by selecting their weakly dominant strategies. This certainly confirms that compliance with equilibrium is high (in our case, it is practically complete) in normal game-forms that are solvable in just one round with the deletion of weakly dominated strategies [Costa-Gomes *et al.* (2001)].

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.

The relevance of this result is two-fold. On the one hand, it lends strong support to the idea of having just one solution for all claims problems and, on the other hand, it provides a clear-cut answer to our original question:

Is the proportional solution from both points of view, that of the subjects involved in claims problems and that of the outside observers?

We should probably seek the answer in some of the explanations given by the subjects who participated in our study for choosing the proportional rule in P_0:

- *"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."*[14]
- *"I chose the option that seemed to be the most equitable one for the three agents involved."* [15]

These two quotes suggest two different but complementary explanations of the coordinating power of the proportional rule. First, because the proportional rule tends, in general, to favour middle-sized claimants and, therefore, to ease coordination when the choice of the rule is made by majority. Nonetheless, this *median voter effect* is probably not the only thing that acts as a coordinating device. Indeed, as the second quote suggests, the proportional rule may well have been selected on grounds of social norms, if individuals perceived the proportional solution as *the right one* for claims problems.[16]

But do the results of our study have any interesting implications for the analysis of real-life situations? Indeed, many rules have been defended in the

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

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

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

[16] Another explanation might be related to the properties that the proportional solution enjoys, in particular, its immunity to strategic manipulations. In this respect, de Frutos (1999) has already shown that the proportional rule is the only rule that fulfils this condition.

literature on the grounds of their ability to reflect different notions of fairness, which suggests that, depending on the situation involved, one of these different ideas would be more in keeping than the others with what is generally consider as fair-play [Herrero and Villar (2001)]. Our results, however, indicate that a great majority of our subjects perceived the proportional solution as being the fairest way of solving claims problems, regardless of the sort of claims problem involved or of their own particular situation in the game (strategic or non-strategic). As such, we may well ask ourselves whether we really need alternative rules for solving different types of claims problems, or whether the proportional solution should not be applied to all claims cases. Further research is obviously required before we can arrive at any conclusive decision, but the results we present here should at least alert us to the danger of discarding, before hand, the applying of the proportional solution in solving any given sort of claims problem.

As mentioned in the introduction, this is, to the best of our knowledge, the first empirical study on claims problems that considers both the experimental evidence and the outside observer's impressions. Our conclusions clearly state that rational players systematically coordinate on a particular solution that, simultaneously, is the one perceived as the fairest way of solving the problem. Even when all of the specific features of our study are taken into account, (i.e., the choice of a single claims problem and our focus on the three-player case), we are quite convinced that the results would be quite similar under other experimental conditions.

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7 Appendix

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 if the process does not terminate in a finite number of stages, then the limit cases is always well defined.

7.1.1 Convergence of P_1

Let $(c, E) \in \mathbb{B}$ be a given problem. Let $r = \{r^j\}_{j \in N}$ be the profile of rules chosen by the agents to solve the problem, where $r^j \in \mathcal{R}$ for all $j \in N$. For the sake of simplicity in the proof we assume that all of the chosen rules are continuous with respect to claims.[17]

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

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

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 $x_1 = \max_{j \in N}\{r_i^j(x, E)\} = r_i^{j_0}(x, E)$. Thus, since $r \in \mathcal{R}$,

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

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

7.1.2 Convergence of P_2

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

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

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

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

[17] 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.

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:

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

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

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

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

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

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

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

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

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

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

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

7.3 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.

7.3.1 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.[18] 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.
- 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 PAY-OFF 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.[19]

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

[19] 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.*

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

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

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

PLAYER	CLAIM
1	49
2	46
3	5

The liquidation value is 20.

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

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

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

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

[20]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).

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.[21] That is to say, people who have deposited money in accounts at the bank. As you will notice, on your computer screen, neither the players' claims nor the liquidation value

[21]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.

have changed. Just as before, you must arrive at an agreement with the other members of your group on how the liquidation value should be divided among you. Remember that, just as before, 1,000 pesetas will be assigned to you at the beginning of the session.

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

7.3.2 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.[22] 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 PAY-OFF 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.[23]

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

SCREEN 3: THE FIRST GAME.[24]

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,

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

[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 was the third game in Sessions 9 and 10.

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

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

Screen 4: The Second Game.

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

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.[25]

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.

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

7.4 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. In this first experiment, you and all of the other participants in the experiment are the bank's creditors. 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. 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.

>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 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 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 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 our second problem, you, 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 our 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?

7.4.1 Payoff tables

	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