A DECENT PROPOSAL*

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WP-AD 95-25

* The authors wish to express their gratitude to a large number of people who contributed with their comments to the developement of this paper: John Roemer, whose advise in an early stage proved to be very helpful, Sandeep Baliga, Carmen Beviá, Subir Chattopadhyay, Ignacio Ortuño-Ortín, Antonio Rangel and Jim Schummer whose criticisms forced us to reformulate some parts of the paper, Nick Baigent, Michael Maschler, Tomas Sjostrom and William Thomson for very good suggestions and the participants in seminars in Alicante, Hakone (Japan), Harvard, Pompeu Fabra, Rochester and Studienzentrum at Gerzenzee (Switzerland), especially V. Baskhar, C. Matutes and P. McAfee for stimulating comments. The usual caveat applies. This research has been partially supported by grants PB92-0342 and PB93-0940. This paper is dedicated to Bob Aumann, from whom we learnt so much.

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Editor: **Instituto Valenciano de Investigaciones Económicas, S.A.**
Primera Edición Diciembre 1995.
ISBN: 84-482-1176-6
Depósito Legal: V-5159-1995
Impreso por Copisteria Sanchis, S.L.,
Quart, 121-bajo, 46008-Valencia.
Printed in Spain.

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A B S T R A C T

In this paper we explore the notion that players are decent, in the sense that their choices are bound by certain unwritten social rules. We apply this idea to two cases: bankruptcy and bargaining in exchange economies. We characterize the results that are generated by such a behavior in the cases of bankruptcy and in two person bargaining in exchange economies.

Keywords: Bankruptcy; Bargaining; Non Cooperative Foundations of Cooperative Solutions; Implementation.

1.- INTRODUCTION

Not many years ago, theoretical models based on the *neoclassical* tradition used to assume (sometimes implicitly) that people were honest: they always behaved according to their true preferences. Then it came the *incentives* point of view and agents were assumed to cheat and to take any possible advantage as long as this was profitable. In this paper we attempt to model situations that lie in between complete honesty and total dishonesty: we assume that agents act strategically but their behavior is bound by certain self-imposed rules. "Norms of behavior entail .... self-imposed standards of conduct such as honesty and integrity.." (D. North (1989). See also Milgrom, North and Weingast (1988))(1).The quintessential problem that we have in mind is that of a department meeting where some painful duties (teaching, service, etc.) will be assigned: Even though it may be public knowledge that people will try to compromise, it is very rare that somebody comes up with a proposal like "I am not willing to do anything for the department". Instead, each agent ask herself: What is the best proposal that I can put on the table without being blamed to be indecent?. This explains the title of the paper, since in these meetings proposals must respect certain decency constraints in order to be taken seriously.

The impact of these constraints on resource allocation can not be dismissed as secondary: "The plain fact is, however, that the costs of measurement and enforcement of contracts in the impersonal world of specialization that we have created offer ample opportunity for antisocial behavior; and without rules being supplemented by self-imposed standards of conduct which constrain maximization at some margins it is hard to believe

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[1] It is commonly accepted among the psychologists that it is odd to assume that one's conscience reliably serves one's self interest. Rather, actions are shaped by values, rules and principles [cf. Prelec & Herrstein (1991)]. Also, the existence and internalization of external rules of decent behavior has been invoked as a way of explaining apparent inconsistencies in rational choice. See Sen (1983) (1993).

that such complex societies would be viable. But the economic models we employ have little room for such behavioral complexity. Trust, ethical standards of conduct, and moral precepts do influence the cost of contracting and the performance of economies,.." (D. North (1989))[2].

Having set the general direction of the paper there are two primary questions: where these constraints come from and what they imply. It is important to make it clear right from the start that the objective of the paper is not to investigate the first question, i.e. why these rules are binding[3]. Instead, we want to analyze the second question, i.e. the consequences on resource allocation imposed by the existence of such decency constraints: "A major challenge to the social scientist is to develop political-economic models that both are institutionally rich and can take into account more complex behavior than has been done heretofore" (D. North (1989)).

But, what are these decency constraints?. This is a difficult question to answer in full generality. Therefore, at this stage of our knowledge on this matter all we can say is that decent behavior can be defined in a natural way in some particular models. In this paper we present two such a models: the model of bankruptcy (see O' Neill (1982) and Aumann and Maschler (1985)) and the model of bargaining in exchange economies. The structure that we impose on both models is similar. Agents make demands. We assume that, for these demands

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2 The importance of decency in politics is epitomized by the sentence "Don't you have any decency?", which effectively ended an era of modern american history.

3 We think that it would be unfair to dismiss the approach taken by this paper because we do not provide an adequate foundation to the idea of decency. After all, models of price-taking agents were used for many years before an explanation of this behavior was investigated. The same argument applies to Game Theory's postulate on the rationality of agents. We doubt that a complete answer to the foundation of decent behavior can be found in the realm of Economics. Henceforth we skip this matter just remarking that any society has unwritten rules of right and wrong. And that violators of these rules may face ostracism and/or remorse.

to be considered as decent proposals, they have to lie on a certain set. Decent proposals are aggregated into a feasible allocation by means of what we call a compromise function (in the standard literature on implementation this function is called the outcome function). Knowing such a function, i.e. how messages are transformed into allocations, agents look for the best decent proposal that they can put on the table. Thus, a Decent Dominant Strategy for, say, agent i, is a decent proposal, that for any decent proposals made by the rest of agents is better for i than any other decent proposal she can make. Similarly, a Nash Equilibrium in Decent Strategies is a list of decent proposals such that no agent can increase her utility by making a different decent proposal. Our task will be to characterize in two specific models the allocations that can be implemented as decent dominant strategies (DDS in the sequel) and as Nash Equilibrium in decent strategies (NDS in the sequel).

In the two agents bankruptcy model, we give an (almost) complete characterization of the solutions to the bankruptcy problem that can be implemented in DDS (Theorem 1). Among prominent solutions to the bankruptcy problem, we find that the proportional solution and the Constrained Equal Award are the only solutions that can not be implemented in DDS (Proposition 4). Furthermore, the remaining standard solutions are implemented in DDS by taking the compromise function to be the average of the proposals made by the agents (Proposition 3).

When there are more than two agents, there is not a unique way in which decency can be defined. The difficulty arises because there are many reasonable ways in which an agent may want to distribute a given amount of money among her fellows (an equal amount to everybody?, proportional to their claims?, etc). We analyze the case in which the compromise function is the average, by reference to the two-person case. This compromise function defines a family of solutions. Each solution corresponds to a rule by means of which an agent suggest how the money left after her claim has been satisfied has to be shared by others. We show by means of examples that, no matter how this rule is chosen, we can not implement any standard solution (Theorem 2). Given that, for a given family of such rules the average compromise function implements some solution, this result implies that we have found a new (family of) solution(s) that in the case of two agents coincides with some standard solutions but that in the general case it does not.

Next, we study the case of bargaining between two agents in an exchange economy. We first prove that in the domain of strictly concave and quasilinear economies (i.e. transferable utility) the average compromise function implements in NDS the Shapley value that in this domain coincides with other standard solutions like Nash, Raiffa and Kalai-Smorodinsky (Proposition 5). Several difficulties arise when trying to extend previous result to larger families of economies. In fact we show that that any weakly anonymous solution which is implementable in NDS in a sufficiently large set of economies can not be Pareto efficient (Proposition 6).

The paper ends by suggesting possible extensions of our results and alternative procedures to the ones used here. An Appendix gathers some basic facts about standard solutions to the bankruptcy problem.

This paper can be understood from a twofold perspective. On the one hand, from the point of view of the bargaining theory our paper can be regarded as the study of the non-cooperative foundations of two specific cases (keeping in mind that we only deal with "decent" strategies). Instead of looking at reasonable axioms that a solution must satisfy, we look for "natural" procedures and identify the solutions that come up as non-cooperative equilibria. These solutions sometimes coincide with other proposed in the literature but sometimes do not. On the other hand, from the implementation point of view our paper can be regarded as a (possibly crude) formalization of the idea that in addition to resource and incentive compatibility constraints, some organizations face fairness constraints. The latter implies that agents must perceive the working of the organization as fair, or at least decent. If they do not, they might rebel, or behave in unexpected, outrageous ways. The history of the world abounds in examples of this kind of behavior (for some experimental evidence that fairness matters in bargaining see Roth (1995), pp. 287-8).

We believe that the results obtained in this paper show that the combination of the ideas of decency and rationality is not hopeless and it can produce analytical results (see Rabin (1993) for an alternative theory of how decency and rationality can be mixed together). Although it is very early to tell if the approach that we put forward in this paper will produce useful results, there is one encouraging thing: For simple environments (i.e. when there are two agents in the bankruptcy problem and when we have two agents and Transferable Utility in the case of bargaining) the solutions proposed by us replicate well-known solutions (i.e. the Shapley value). In more complicated environments our solutions do not replicate the extensions of the standard solutions proposed in the literature. This might suggest that the theory developed here may add something to the understanding of these solutions. In any case, since our approach is new and it may easily give rise to misunderstandings, we decided to follow an unorthodox procedure: at the beginning of each section we tell a story that (hopefully) will help the reader to motivate what we are doing.

2.- DECENT IMPLEMENTATION OF SOLUTIONS TO THE BANKRUPTCY PROBLEM.

2.1 The Story

Consider two departments (say Economics and Mathematics) in an university. The Dean has to decide how to allocate a budget (money, etc.) between the two departments. Suppose that there is a reference budget that allocates 60 to Economics and 40 to Mathematics. This may be last year budget or some draft about the current budget. Now a disaster strikes the university and the reference budget is reduced by, say 15%. If there is a written rule (i.e. a solution) on how to share the 15% losses, that's it: the dean communicates the disaster to the two chairmen making very clear how much appreciation he feels for their departments and tells them the new allocation of the budget. Since the way in which losses are split is in the rules of the university there is not much to discuss.

However, in certain cases, there is no written rule. There are several explanations for this. Firstly, it is clear that written university regulations can not exceed certain number of pages if they want to be taken seriously. Secondly, these rules may be difficult to evaluate a priori. People may disagree about which rule to use, although they might agree on a procedure to solve the discrepancies. Thus people may end up in endless discussions about whether a monotonicity-like property is preferable to an independent of irrelevant alternatives-like property, although they may agree on a simple procedure that solves discrepancies. In our case this procedure takes the following form: both chairmen meet (jointly or separately) with the dean and make their case. After having heard all the relevant information, the dean makes a final decision (i.e. he acts as a judge)[4].

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[4] Other possibilities are : 1) The dean computes directly what he thinks is a fair solution (i.e. the Shapley value). And 2) Agents submit allocation rules that determine the allocation rule that is actually used [see Van Damme (1986) and Anbarci & Yi (1992)]. The procedure considered in this paper has the advantage on the former that it may be more easily understood by people who are not game theorists and on the latter of paying more attention to agents' incentives.

Suppose that in order to keep frictions to a minimum the dean decides to have a separate meeting with each chair. Let us observe closely the meeting with the chair of the Economics department whose name is Ann. What kind of demands is Ann going to make?. For instance, anticipating that the dean will try to average somehow she might ask for more than she had before the 15% reduction. But clearly this strategy will not work. In fact, it may even harm her cause. The problem for Ann is: what is the best demand she can do that cannot be dismissed on the grounds of being unreasonable, i.e. not decent?. A possible answer is that she might try to convince the dean how important this money is for her department and how important her department is for the prestige of the university. Any penny removed from the department of Economics will jeopardize the smooth working of this department!. Summing up, she might convey the message that any reduction in the budget allocated to the department of Economics is impossible. Consequently, she might ask for the amount that Economics had in the old budget (after all, a claim that you can not claim, is not a claim!) and that the remaining money be allocated to the department of Mathematics. Under certain circumstances and with the due amount of savoir faire such a proposal might not be dismissed by the dean[5]. Analogously, the chairman of the department of Mathematics, call him Bob, will claim 40 for Mathematics and will award 45 for Economics. After having heard both the dean he might reason as follows: Ann asked for 60 for the department of Economics and Bob offered 45 for this department. Let us give Ann (60 + 45)/2 = 52.5. Bob asked for 40 for his department and Ann conceded him 25, thus let us give Bob (40 + 25)/2 = 32.5. Now, let us formalize this story.

2.2. The Case of Two Agents.

An *economy* is a triple $e = (M,c_1,c_2)$ also denoted by $(M,\mathbf{c})$, where $\mathbf{c} = (c_1,c_2)$. We shall consider a family E of economies such that $E \subseteq \mathbb{R}^3_{++}$, and

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[5] We understand that this is not the only sensible way to model decent behavior. However our proposal for what a decent proposal is has the advantage of being clear-cut and easily formalized. It might be regarded as a kind of benchmark, limiting case whose properties have to be investigated before more complicated models of decent behavior are put forward.

for any $e = (M,c_1,c_2) \in E$, $c_i \leq M$[6], $i = 1, 2$. The interpretation of (M,c_1,c_2) is as follows: There are 2 agents, each one having claims on an specific amount of money, c_1 and c_2. The total amount at hand (M) might not be enough to cover all the claims. These claims are (possibly) publicly known but there might be not verifiable. Let $C \equiv c_1 + c_2$.

We will assume that E is *claims-comprehensive*, i.e.,

$$[e = (M,c_1,c_2) \in E, \text{ and } e' = (M,c'_1,c'_2), \text{ with } c'_i \leq c_i, i = 1, 2] \longrightarrow [e' \in E]$$

Notice that claims-comprehensiveness implies that in E we have not only "normal" bankruptcy problems, but also "feasible" bankruptcy problems for which $c_1 + c_2 \leq M$.

Let us look for reasonable rules of dividing the estate M among the creditors. This rules will be called *solutions*. Among them the following are prominent: Shapley value, Nucleolus, Proportional, Constrained Equal Award, Constrained Equal Loss, Adjusted Proportional and Adjusted Equal Award. In Appendix 1 we provide a complete description of these solutions. Formally, a *solution* is a function $\Phi: E \longrightarrow \mathbb{R}^2_+$ such that $\forall$ $e = (M, \mathbf{c}) \in E$, $\phi(e) \leq \mathbf{c}$ and $\Phi_1(e) + \Phi_2(e) = M$ whenever $C > M$, and $\Phi(e) = \mathbf{c}$ if $C \leq M$. The latter property can be motivated by assuming that there is an "external good" in which money can be spent (thus in the story in Section 2.1 above money can be used to make repairs, etc.) and that no agent is entitled to more than her claim. By the reasons explained in Section 2.1 (incomplete contracting, impossibility of an agreement on what constitute a good set of axioms underlaying ϕ, etc) we

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[6] This restriction puts some 'natural' limits to individual claims, making it easier the analysis of different solutions to the bankruptcy problem, avoiding distinctions among game theoretic and non game theoretic solutions. See Curiel, Maschler & Tijs (1988) or Dagan & Volij (1993).

assume that no solution can be achieved directly. Hence a decentralized procedure to reach decisions is needed[7].

A *strategy (message)* for i, $m_i \in \mathbb{R}^2$ is a pair $m_i = (m_{ii}, m_{ij})$, i, j = 1, 2. m_{ij} is interpreted as the allocation to individual j suggested by individual i. A *strategy* m is a pair (m_1, m_2). Let $S = \mathbb{R}^4$ be the set of strategies.

Definition 1: *A list of strategies is decent in economy* $e = (M, \mathbf{c})$ *if* $0 \leq m_{ii} \leq c_i$, *and* $m_{ii} + m_{ij} = \min \{M, C\}$, *i, j = 1, 2. The set of decent strategies in e will be denoted by* $D(e)$[8].

Notice that it is decent for i to ask less than her claim (i.e. to be frugal) but it is not decent to refuse any remaining money to j (≠ i) in order to satisfy j's claim (i.e. to impose an unnecessary frugality on j).

We will assume that once agents have spoken a decision will be reached. This decision can be taken by a real person (as in the case of the dean) or it

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7 Implementation problems are usually motivated by the existence of informational asymmetries between agents and the designer (see e.g. see next section). In this section no such asymmetry is postulated and the need to implement arise either from incomplete contracting or from the inability of the designer to single out a solution. Another interpretation of the model of this Section is that it belongs to the area of Non-Cooperative Foundations of bargaining. The aim of this exercise is to describe "reasonable" mechanisms that mimic actual procedures by which bargaining takes place and not to model how asymmetrical information is dealt with.

8 In some cases to demand more than a claim based on historical rights, may be not indecent. For instance suppose that two professors give each six hours of classes each week. One of the professors, say A, makes a lot of research and the other, say B, makes no research at all. Now suppose that they have to give not 12 but 20 hours overall each week and that if both give 10 hours a week none of them can do any research. In this case it would not be completely indecent if A would ask B to give, say 16 hours every week. The reason for this being that given the new teaching load, at least one of the professors can not do any research. Given that the choice of B for the non research assignment seems natural, why not concentrate the classes on him and allow the research-oriented professor to increase his scientific output?.

might reflect how agreements are reached among people living in a community. We formalize this notion by means of the concept of a compromise function:

Definition 2: *A Compromise Function is a mapping* $F: S \longrightarrow \mathbb{R}^2_+$ *such that*

(a) $F_i(m) = F_i(m_{ii}, m_{ji}), \ i = 1, 2.$

(b) $F_1(m) + F_2(m) \leq M$, *for any* $m \in D(e)$, $e = (M, \mathbf{c})$.

Notice the following: Firstly, whenever $m \in$ D(e) for some e = (M, **c**), condition (a) in Definition 2 reduces to $F_i(m) = F_i(m_{ii}, \min(M, C) - m_{jj})$, i, j = 1, 2. Secondly, F_i depends only on m_{ii} and m_{ji}, i.e. the amount of money allocated to i depends only on what i and j think i should get, and not on what, say, i thinks that j should get. If F_i depended on m_{ij} or on m_{jj} the interpretation of strategies as suggested allocations of the money would be unattainable and thus it would be unconvincing to attach any decency requirement to the strategies. Thirdly, it is easy to construct a utility function such that the allocation chosen by the compromise function in an economy in the admissible domain maximizes this utility function for this economy. This accounts for the case in which a real person has to make the compromise.

Let us now model strategic behavior of agents. We will assume that each agent knows the compromise function, the quantity of money to be distributed and her own claim but she does not necessarily know the claim of the other agent. Therefore we look for an equilibrium in (decent) dominant strategies:

Definition 3: *The Solution* Φ *is Implementable in Decent Dominant Strategies (DDS) if there exist a compromise function F such that* $\forall \ e = (M, \mathbf{c}) \in E$,

(i) $\Phi(e) = F(m^*), \ m^* \in D(e).$

(ii) $F_i(m^*_i, m_j) \geq F_i(m_i, m_j), \ \forall \ (m_i, m_j) \in D(e)$, *with strict inequality if* $m^*_i \neq m_i$, $i = 1, 2$.

There are three reasons why we insist in the inequality in ii) above be strict. Firstly it gives agents real incentives to choose the equilibrium strategy since any deviation hurts the welfare of the deviating agent.

Secondly it guarantees that there are no other equilibria than the one yielding the required allocation. In particular it precludes the existence of Nash equilibria yielding allocations different from the one prescribed by ϕ. Finally, regarded as a Nash equilibrium, it is strict, so it passes all known refinements. We present now our first result:

Proposition 1.- *Suppose that Φ is a solution such that*

(a) Φ_i is strictly increasing on c_i, and
(b) for any $e \in E$ such that $C > M$, $\Phi_i(e) = \Phi_i(c_i, M - c_j)$, $i = 1, 2$.

Then, Φ is implementable in decent dominant strategies.

Proof: *We shall limit the definition of F to those strategies that are decent for some $e \in E$. We need to consider two different cases:*

(1) Let $e = (M, \mathbf{c}) \in E$, such that $C > M$, and let $m \in D(e)$. Thus, $m_{ii} \leq c_i$, $m_{ji} = M - m_{jj}$. By claim-comprehensiveness, $e' = (M, m_{11}, m_{22}) \in E$. Now, for any $m \in D(e)$, define $F(m) = \Phi(M, m_{11}, m_{22})$. In consequence, if $m_{11} + m_{22} > M$, $F_i(m) = \Phi_i(M, m_{ii}, m_{jj}) = \Phi_i(m_{ii}, M - m_{jj}) = \Phi_i(m_{ii}, m_{ji})$, $i = 1, 2$, and $F_1(m) + F_2(m) = M$. On the other hand, if $m_{11} + m_{22} \leq M$, $F_i(m) = m_{ii}$, and $F_1(m) + F_2(m) = m_{11} + m_{22} \leq M$. Thus, for any $m \in D(e)$, (a) and (b) are satisfied in Definition 2.

(2) Consider now the case in which $e = (M, \mathbf{c}) \in E$ is such that $C \leq M$, and let $m \in D(e)$. Thus, $m_{ii} \leq c_i$, $m_{ji} = C - m_{jj}$. Again, $e' = (M, m_{11}, m_{22}) \in E$. Define then $F(m) = \Phi(M, m_{11}, m_{22}) = (m_{11}, m_{22})$. Trivially, (a) and (b) in definition 1 are also satisfied in this case.

Let us now show that such F implements Φ in DDS:

(1) For $e \in E$, $e = (M, \mathbf{c})$ with $C > M$, take $m^*_i = (c_i, M - c_j)$, $i, j = 1, 2$. $m^* \in D(e)$; $F(m^*) = \Phi(M, \mathbf{c}) = \Phi(e)$. Now, $F_i(m^*_i, m_j) = \Phi_i(M, m^*_{ii}, m_{jj}) = \Phi_i(M, c_i, m_{jj}) \geq \Phi_i(M, m_{ii}, m_{jj}) = F_i(m_i, m_j)$ $\forall (m_i, m_j) \in D(e)$ (with an strict inequality if $m^*_i \neq m_i$), $i = 1, 2$, because of the strict incresingness of Φ_i on c_i.

(2) For $e \in E$, $e = (M, \mathbf{c})$, with $C \leq M$, take $m^*_i = (c_i, c_j)$, $i, j = 1, 2$. $m^* \in D(e)$; $F(m^*) = \Phi(e)$, and $F_i(m^*_i, m_j) = m^*_{ii} \geq m_{ii} = F_i(m_i, m_j)$ $\forall (m_i, m_j) \in D(e)$ (with an strict inequality if $m^*_i \neq m_i$), $i = 1, 2$. ■

In order to obtain a partial converse to Proposition 1 we first present the following two Lemmas:

Lemma 1.-*If a solution Φ is implementable in decent dominant strategies, Φ_i is increasing on c_i, $i = 1, 2$.*

Proof: *Suppose not. Then, there exist M, c_i, c'_i, c_j , $c_i < c'_i$, $e = (M, c_i, c_j)$, $e' = (M, c'_i, c_j)$, $e, e' \in E$, such that $\Phi_i(M, c_i, c_j) > \Phi_i(M, c'_i, c_j)$. Since Φ is implementable in DDS, there exist $m^* = (m^*_i, m^*_j)$, $m^* \in D(e)$, $\bar{m} = (\bar{m}_i, \bar{m}_j) \in D(e')$, such that $F(m^*) = \Phi(e)$, $F(\bar{m}) = \Phi(e')$. Furthermore, $F_i(m^*_i, m_j) = F_i(m^*_{ii}, m_{ji}) \geq F_i(m_{ii}, m_{ji}) = F_i(m_i, m_j)$, $\forall$ $(m_i, m_j) \in D(e)$, and $F_i(\bar{m}_i, m_j) = F_i(\bar{m}_{ii}, m_{ji}) \geq F_i(m_{ii}, m_{ji}) = F_i(m_i, m_j)$, $\forall$ $(m_i, m_j) \in D(e')$. Consider now the following cases:*

(1) $c_i + c_j > M$. Thus, $c'_i + c_j > M$, and $(m^*_i, \bar{m}_j) \in D(e) \cap D(e')$. Then $F_i(m^*_{ii}, m^*_{ji}) = \Phi_i(e) > \Phi_i(e') = F_i(\bar{m}) = F_i(\bar{m}_{ii}, \bar{m}_{ji}) \geq F_i(m^*_{ii}, \bar{m}_{ji})$. Notice that $F_j(m_{ij}, m^*_{jj}) > F_j(m_{ij}, m_{jj})$ for any $m_j \in D_j(e)$, $m_{jj} \neq m^*_{jj}$, $m_i \in D(e)$. Furthermore, $F_j(m_{ij}, \bar{m}_{jj}) > F_j(m_{ij}, m_{jj})$, any $m_i \in D_i(e')$, $m_{jj} \neq \bar{m}_{jj}$. Since $D_i(e) \subset D_i(e')$, it follows that $m^*_j = \bar{m}_j$. But in such a case, $\bar{m}_i$ is not the dominant strategy of individual 1, unless $\bar{m}_i = m^*_i$, since otherwise $F_i(\bar{m}_i, \bar{m}_j) < F_i(m^*_i, m^*_j)$. So, $m^* = \bar{m}$, and $\Phi(e) = \Phi(e')$. Contradiction.

(2) $c'_i + c_j \leq M$. Then, $c_j + c_j < M$. Because of the implementability hypothesis, $\Phi_i(e) = c_i < c'_i = \Phi_j(e')$. Contradiction.

(3) $c_i + c_j < M$, $c'_i + c_j > M$. Then, $c_i = F_i(m^*) = \Phi_i(e)$. If $c_i > F_i(\bar{m}) = \Phi_i(e')$, we have: $\Phi_j(e) = c_j = C - F_i(m^*) < C - F_i(\bar{m}) < M - F_i(\bar{m}) = F_j(\bar{m}) = \Phi_j(e')$. Contradiction. ■

Lemma 2- *Let Φ a solution implementable in decent dominant strategies by means of a compromise function F. If Φ_i is strictly increasing on c_i, then F_i is also strictly increasing on m_{ii}.*

Proof: *Since Φ is implementable by F, for any $e = (M, \mathbf{c}) \in E$, $\exists$ $m^* \in D(e)$ such that $F(m^*) = \Phi(e)$. In consequence, if we fix (M, c_j), for any $c_i \leq M$ such that*

$(M, c_i, c_j) \in E$, $\arg\max_{m_{ii} \leq c_i} F(m_{ii}, \bar{m}_{ji}) = m^*_{ii}(c_i)$ *is well defined and unique for any* $\bar{m}_{ji} \in D_j(e)$. *If* $m^*_{ii}(c_i) = c_i$, $F_i(x, m_{ji})$ *is increasing on [0, M] for any* $m_{ji} \in D_j(e)$. *If* $m^*_{ii}(c_i) = c'_i < c_i$, *then* $m^*_{ii}(c'_i) = c'_i$. *Therefore,* $\Phi_i(e) = \Phi_i(e')$ $[e' = (M, c'_i, c_j)]$, *which contradicts that* Φ_i *is strictly increasing on* c_i. ■

Proposition 2. *Let* Φ *a solution implementable in decent dominant strategies by means of a compromise function F. If* Φ_i *is never constant on* c_i, $i = 1, 2$, *then for any* $e = (M, \mathbf{c}) \in E$ *such that* $C > M$,

a) Φ_i *is strictly increasing on* c_i.
b) $\Phi_i(M, \mathbf{c}) = \Phi_i(c_i, M - c_j)$, $i = 1, 2$.

Proof: a) *By Lemma 1* Φ_i *is increasing on* c_i, $i = 1, 2$. *Since it is never constant, it is strictly increasing on* c_i, $i = 1, 2$.
b) *By lemma 2 and a) above,* F_i *is strictly increasing on* m_{ii}. *In consequence, for any problem* $e = (M, \mathbf{c})$, $m^*_{ii} = c_i$, $m^*_{jj} = c_j$. *Thus, if* $C > M$, $\Phi_i(M, \mathbf{c}) = F_i(m^*_{ii}, m^*_{ij}) = F_i(m^*_{ii}, M - m^*_{jj}) = F_i(c_i, M - c_j)$. ■

From Propositions 1 and 2, the following characterization is obtained:

Theorem 1. *Let* Φ *a solution such that* Φ_i *is never constant on* c_i, $i = 1, 2$. *Then* Φ *is implementable in decent dominant strategies iff for any* $(M, \mathbf{c}) \in E$ *with* $C > M$, $\Phi_i(M, \mathbf{c}) = \Phi_i(c_i, M - c_j)$ *and* Φ_i *is strictly increasing on* c_i.

A first consequence of Theorem 1 is that the Proportional solution is not implementable in DDS. The Shapley value, Nucleolus, Constrained Equal-Loss, Adjusted Proportional and Adjusted Equal Award all yield the allocation $\left[\frac{M+c_1-c_2}{2}, \frac{M+c_2-c_1}{2}\right]$. All these solutions satisfy the conditions of Theorem 1 and thus are implementable in DDS. In fact they are implementable by means of a very simple form of the compromise function, namely the average. This is recorded in the following Proposition whose proof is straightforward and it is omitted.

Proposition 3.- *For any* $e = (M, c_1, c_2) \in E$ *with* $C > M$, *the allocation* $[\frac{M+c_1-c_2}{2}, \frac{M+c_2-c_1}{2}]$ *(which coincides with the Shapley value and the nucleolus of the associated game, and with the adjusted proportional, adjusted equal award and constrained equal-loss solutions) is implementable in DDS by the average compromise function* $f(m_1, m_2) = (m_1 + m_2)/2$.

Finally, the Constrained Equal Award does not satisfy the conditions in Theorem 1. This solution is not implementable in DDS, as we see below:

Lemma 3.- *Let* Φ *be a solution implementable in DDS by a compromise function* F. *Suppose there exist* $e = (M, c_i, c_j)$, *and* $e' = (M, c'_i, c_j)$ *such that* $c_i > c'_i$, *and* $F(m^*_i, m^*_j) = \Phi_i(e) = \Phi_i(e') = F(\bar{m}_i, \bar{m}_j)$. *Then,* $c'_i + c_j \geq M$, $\phi_j(e) = \Phi_j(e')$ *and* $(m^*_i, m^*_j) = (\bar{m}_i, \bar{m}_j)$.

Proof: *Since* Φ *is implementable in DDS,* Φ_i *has to be weakly increasing on* c_i. *Now, if* $\Phi_i(e) = \Phi_i(e')$, *taking into account the definition of a solution, it turns out that* e *and* e' *have to be such that* $c_i + c_j > M$, *and* $c'_i + c_j \geq M$. *Notice that in such a case,* $\Phi_i(e) = \Phi_i(e')$ *implies that* $\Phi_j(e) = \Phi_j(e')$.
Suppose that $m^*_{jj} \neq \bar{m}_{jj}$. *Then,* $F_j(\bar{m}_{jj}, \bar{m}_{ij}) > F_j(m^*_{jj}, \bar{m}_{ij}) > F_j(\bar{m}_{jj}, \bar{m}_{ij})$, *since* Φ *is implementable in DDS and* $D(e') \subset D(e)$. *Thus, we get a contradiction, and therefore,* $m^*_{jj} = \bar{m}_{jj}$. *In a similar way we get that* $m^*_{ii} = \bar{m}_{ii}$, *and in consequence,* $(m^*_i, m^*_j) = (\bar{m}_i, \bar{m}_j)$.■

Proposition 4.- *The Constrained Equal Award is not implementable in DDS.*

Proof: *Suppose it is. Fixed* M, c_j *such that* $c_j \geq M/2$, *and consider* $m^*_{ii}(c_i) = \arg\max_{0 \leq m_{ii} \leq c_i} F_i(m_{ii}, m_{ji})$, $M - c_j \leq m_{ji} \leq M$. *By lemmas 2 and 3, it turns out that* $m^*_{ii}(c_i) = Min\{c_i, M/2\}$. *Furthermore, for all* m_{ji} *such that* $M - c_j \leq m_{ji} \leq M$, $F_i[m^*_{ii}(c_i), m_{ji}] > F_i[m_{ii}, m_{ji}]$, *for all* $m_{ii} \neq m^*_{ii}(c_i)$, $0 \leq m_{ii} \leq c_i$.
Now, consider two problems, $e_1 = (M, c_i, c_j)$ *[with* $c_i > M/2$, $c_j > M/2$*], and* $e_2 = (M + \varepsilon, c_i, c_j + \varepsilon)$, *and such that* $\varepsilon > 0$ *has been chosen in such a way that* $c_i > (M + \varepsilon)/2$, $(c_j + \varepsilon) > (M + \varepsilon)/2$. *Notice that* $D_i(e_1) = D_i(e_2)$. *On the other hand, if* $m_{ji} \in D_j(e_1)$, *then* $m_{ji} \in D_j(e_2)$. *In consequence, if we*

choose $m_{ji} \in D_j(e_1)$, $\arg\max_{0 \leq m_{ii} \leq c_i} F_i(m_{ii}, m_{ji}) = M/2$, *but at the same time, since* $m_{ji} \in D_j(e_2)$, $\arg\max_{0 \leq m_{ii} \leq c_i} F_i(m_{ii}, m_{ji}) = (M + e)/2$. *Contradiction. Thus, CEA is not implementable in DDS.* ■

2.3 The Case of Three or More Agents.

The definitions of an *economy*, and a *solution* are straightforward generalizations of those presented in 2.2.1 and we will omit them. A message (strategy) for i is a list $(m_{i1},..., m_{ii},..., m_{in})$ where m_{ij} is interpreted as the quantity of money that i adjudicates to j. A list of *strategies* $m = (m_1, m_2,..., m_n)$ is *decent in economy* e = (M, **c**) if $0 \leq m_{ii} \leq c_i$, and $\sum_{j=1}^{n} m_{ij} = \min\{M, C\}$, i = 1, 2, ..., n. Let us call D(e) the set of decent strategies in e. Let $S_i = \mathbb{R}^n_+$ be the message space of i and $S = \mathbb{R}^{nn}_+$ be the message space.

Definition 2'. *A Compromise Function is a mapping* $F: S \longrightarrow \mathbb{R}^n_+$ *such that*

(a) $F_i(m) = F_i(m_{1i},..., m_{ii},..., m_{ni})$, $i = 1, 2,...,n$.

(b) $\sum_{i=1}^{n} F_i(m) \leq M$, *for any* $m \in D(e)$, $e = (M, \mathbf{c})$.

The essential difference between the case n = 2 and the case n > 2 lies on the fact that in the former a player, say i, does not need to specify how M - m_{ii} has to be shared by the others but in the latter this specification needs to be made. We will call this specification a *Sharing Function.* Since there is a large number of sharing functions, it is not clear how they are chosen by the agents. However we will show the following. Let us assume that the compromise function is the average. The motivation for it, besides its simplicity is Proposition 3 a) above: it implements most of the solutions considered in the literature when n = 2. Since we do not specify how each player wants the rest of the money to be shared by others, the above compromise function defines a family of solutions. We will show by means of examples that no element of this family coincides with any of the solutions studied in Proposition 3. We use the following abbreviations Sh = Shapley value, N = Nucleolus, CEA = Constrained Equal Award, AEA = Adjusted Equal Award, P = Proportional, AP = Adjusted proportional and CEL = Constrained Equal Loss.

Theorem 2: *No solution in the set { Sh, N, P, CEA, CEL, AP, AEA } coincides with any solution implementable in DDS if* $n > 2$ *and* $f = \frac{1}{n}(m_1 +, \ldots, + m_n)$.

Proof: *It is obvious that given a sharing function, there is some solution which is implemented in DDS. We will prove this solution does not correspond to any solution quoted above by means of three examples.*

Example 1: $M = 6$, $\mathbf{c} = (6, 5, 4)$. *For this example,* $Sh = (5/2, 2, 3/2)$; $AEA = CEA = N = (2, 2, 2)$; $P = AP = (12/5, 2, 8/5)$; $CEL = (3, 2, 1)$. *Decent dominant strategies are the following:* $m_1 = (6, 0, 0)$; $m_2 = (a, 5, 1 - a)$ $[0 \leq a \leq 1]$; $m_3 = (b, 2 - b, 4)$ $[0 \leq b \leq 2]$. *Thus, the associated allocation is* $[(6 + a + b)/3, (7 - b)/3, (5 - a)/3]$. *For* $x_2 = 2$, $b = 1$. *For* $x_3 = 2$, $a < 0$, *and in consequence N, CEA and AEA are not implementable. For* $x_3 = 1$, $a = 2$, *and therefore CEL is not implementable. For* $a = 1/2$, $b = 1$, *we implement Sh. For* $a = 1/5$, $b = 1$, *we implement* $P = AP$.

Example 2: Consider now the problem $M = 4$, $\mathbf{c} = (4, 2, 1)$. *For this example,* $Sh = N = AP = (5/2, 1, 1/2)$; $CEA = AEA = (3/2, 3/2, 1)$; $P = (16/7, 8/7, 4/7)$; $CEL = (3, 1, 0)$. *Decent dominant strategies take the form* $m_1 = (4, 0, 0)$; $m_2 = (a, 2, 2 - a)$, $[0 \leq a \leq 2]$; $m_3 = (b, 3 - b, 1)$, $[0 \leq b \leq 3]$, *respectively. The associated allocation is therefore,* $x_1 = (4 + a + b)/3$; $x_2 = (5 - b)/3$; $x_3 = (3 - a)/3$. *For* $x_2 = 1$, $b = 2$. *For* $x_3 = 1/2$, $a = 2/3$. *If* $a = 2/3$, $b = 2$, $x_1 = 20/9$. *Therefore, Sh, N and AP are not implementable. For* $x_3 = 0$, $a = 3$ *and thus, CEL is neither implementable. For* $a = 0$, $b = 1/2$, *we implement* $CEA = AEA$. *For* $a = 9/7$, $b = 11/7$, *we implement P.*

Example 3: $M = 2$, $\mathbf{c} = (2, 2, 1)$. *Then* $P = (4/5, 4/5, 2/5)$. *DDS take the following form* $m_1 = (2, 0, 0)$; $m_2 = (0, 2, 0)$; $m_3 = (a, 1 - a, 1)$. *Thus,* $x = 1/3$ *and in consequence, P is not implementable*[9]. ■

[9] It is clear that the non-implementability argument given above does not depend on the fact that we demand implementation in strict dominant strategies. The same argument goes through with a (weaker) definition of implementability which requires only dominant strategies.

3.- A THEORY OF DECENT IMPLEMENTATION IN BARGAINING

3.1. A Story.

Let us assume that in a Department there are two time-consuming, not enjoyable activities. Call them fund raising and paperwork. Suppose that two members of this Department, say Anthony and Barbara have to provide time to fulfill the targets of fund raising and paperwork. By taking the appropriate units let a be the leisure time of Anthony when he is not doing fund raising and 1 - a Barbara's consumption of leisure when she is not making fund raising. Similarly, let b denote Anthony's consumption of leisure when he is not making paperwork and 1 - b Barbara's consumption of leisure when she is not making paperwork.

This year's preferences of Anthony and Barbara are representable by the following utility functions. $u_1 = (a.b)^{1/2}$, $u_2 = 4(1 - a) + (1 - b) = 5 - 4a - b$. Last year they had different preferences and thus they found convenient that Anthony did all the paperwork and Barbara all the fund raising (i.e. $a = 1$, $b = 0$). But after this experience, their preferences have changed. Knowing each other very well, they are sure that there is room for improvement if they could rearrange their duties. An informal meeting with the chairman takes place. The chairman starts by recalling last year allocation (that according with today's preferences yield utilities of $u_1 = 0$, $u_2 = 1$). Anthony opens fire "Well, I am a bit tired of paperwork. I would like that Barbara makes it all. In return I am prepared to take some of her last year's duties. So, Barbara, why don't you make 3/4 of fund raising and all the paperwork?". Notice that this proposal has been carefully chosen to yield $u_2 = 1$. Thus this proposal, if effective, cannot harm Barbara. But she retorts "That's totally unfair: you should make all the paperwork and the fund raising. After all this is not worse for you than last year allocation". The chairman proposes a compromise: "Hey, guys, don't get excited. Anthony, why don't you take a leisure bundle of ((3/4 + 0)/2, (1 + 0)/2) = (3/8, 1/2) and Barbara why don't you accept ((1/4 + 0)/2, (1 + 0)/2) = (1/8, 1/2)?. This seems to me like a fair proposal". He had the comforting thought that, once more, he had found a solution to the deep problems of the Department. Now, let us formalize the story.

3.2 Exchange Economies with Two Agents.

Let us consider the case of two agents and n (≥ 2) goods (notice that in this Section n denotes the number of goods). Assume that the consumption set of any agent is $\mathbb{R}^n_+$. Let ω_i, assumed to be strictly positive, be the initial endowment of individual i. Let $\omega_1 + \omega_2 = \omega$. The set of feasible allocations denoted by A is defined as follows:

$$A = \{ (x_1, x_2) \in \mathbb{R}^{2n}_+ \mid x_1 + x_2 \leq \omega \}$$

where x_i stands for the consumption of individual i = 1, 2.

We will assume that consumption sets and endowments are fixed. Thus, A is fixed and the class of economies is described by the set of admissible utility functions for every agent denoted by $\mathcal{U}_i$, i = 1, 2. An economy, denoted by e, is is a pair $(u_1, u_2) \in \mathcal{U}_1 \times \mathcal{U}_2 \equiv \mathcal{E}$ where u_i stands for the utility function of individual i. We will denote by $\mathcal{E}^e$ the family of exchange economies with smooth and quasi-concave utility functions, by $\mathcal{E}^s$ the subdomain of $\mathcal{E}^e$ with strictly concave utility functions and by $\mathcal{E}^{sql}$ the subdomain of $\mathcal{E}^s$ with quasi-linear utility functions.

If the initial allocation of an economy is not Pareto efficient, agents may look for a mutually advantageous reallocation of the initial allocation. Thus, a bargaining problem arises in a natural way. As in Section 2, a solution is mapping $\phi : \mathcal{E} \longrightarrow A$. Examples of prominent solutions are those proposed by Nash (1950), Shapley (1953), Raiffa (1953) and Kalai-Smorodinski (1975). The set of these solutions will be denoted by $\mathcal{P}$ We assume that no solution can be achieved directly by an impartial umpire because she may not know the actual utility functions. Hence the need for a decentralized procedure to reach decisions, i.e. a mechanism.

A *Mechanism* is a pair $(S_i, f)_{i=1,2}$, where f: $S_1 \times S_2 \longrightarrow A$. In a *Quantity-guided mechanism* $S_i = A$, $\forall i = 1, 2$, and thus f: $A^2 \longrightarrow A$ (this class of mechanisms were called *Demand Mechanisms* by Sjöström (1990)). As in section 2, we will call such an f the *compromise function* (in the literature on implementation the name outcome function is used to denote such a function). In the sequel we will consider quantity-guided mechanisms only. A *strategy (message) for i*, $m_i \in \mathbb{R}^{2n}$ is a pair, $m_i = (m_{ii}, m_{ij})$, i, j = 1, 2. m_{ij} is interpreted as the allocation to individual j suggested by individual i. $m_{ij} = (m^1_{ij}, m^2_{ij}, \ldots, m^n_{ij})$, where m^k_{ij} is the amount of commodity k that individual i suggest individual j to consume. As we did in the Section dealing with the bankruptcy problem, we will assume that f^k_i (which denotes the amount of good k obtained by i) depends only on m^k_{ii} and m^k_{ji}, i.e. on what i and j think that she should consume of good k.

Let $D_i(e)$ denote the set of decent strategies in the economy e for individual i. We assume that is decent to ask for something that does not decrease the utility that the other person can guarantee for herself. Recall that this was what happened in the story in section 3.1 above. Notice that is the proposal, and not the resultant allocation, what is required to belong to $D_i(e)$. This means that no agent makes a proposal that "pushes the other agent against the wall". Formally:

Definition 4: *An strategy* $m_i = (m_{ii}, m_{ij}) \in D_i(e)$ *iff*

(a) m_i *is a feasible allocation [i.e.* $m_i \in A$*] and*

(b) $u_j(m_{ij}) \geq u_j(\omega_j)$ *for all* $j = 1, 2$[10].

There are several possible interpretations of this definition. On the one hand it may reflect the fact that any proposal that is not individually

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[10] All our results in this section hold if Condition b) in Definition 4 is replaced by the requirement that $\forall$ j = 1,2, $u_j(m_{ij}) \geq \bar{u}_j$, some $\bar{u}_j$ which can be obtained from the available endowments.

rational for somebody will not be taken seriously. On the other hand there is a moral justification for such a proposal. It embodies the idea that it is rightful to look for one's pleasure as long as one does not hurt others. A decent proposal is one that, were it put into practice, could not harm the welfare that agents can get in absence of an agreement. Since $D_1(e) = D_2(e)$ we may call $D(e) \equiv D_1(e) = D_2(e)$ the set of *decent strategies for* e.

Given the definition of a decent strategy that we employ in this section, it is clear that agents must be informed of each other's preferences in order to make decent proposals. Thus, in this section of the paper, we will focus our attention not on dominant strategies but in strategies that inside the set of decent proposals constitute a best reply to each other. This is formalized by the notion of a Nash Equilibrium in Decent Strategies:

Definition 5: *A Compromise function f implements on $\mathcal{E}$ the solution ϕ in Nash Equilibrium Decent Strategies (NDS) if for any $e \in \mathcal{E}$,*

(1) $\Phi(e) = f(m_1, m_2)$, where $m_i \in D(e)$ for all $i = 1, 2$.

(2) $u_i[f(m_i, m_{-i})] \geq u_i[f(t_i, m_{-i})]$ $\forall t_i \in D(e)$. And

(3) $\left[(\bar{m}_1, \bar{m}_2) \in D(e)^2 \text{ with } u_i[f(\bar{m}_i, \bar{m}_{-i})] \geq u_i[f(t_i, \bar{m}_{-i})]\ \forall t_i \in D(e), i = 1, 2\right] \longrightarrow f(\bar{m}_1, \bar{m}_2) = \Phi(e)$

Condition (1) says that the allocation prescribed by Φ can be achieved by some decent strategies. Condition (2) says that these strategies are a Nash equilibrium. Condition (3) says that any Nash equilibrium should yield the allocation prescribed by Φ.

Let us focus now on a particular subset of economies in which $\mathcal{U}_1 = \mathcal{U}_2 =$ the class of smooth, strictly concave, strictly increasing and quasilinear utility functions in which $D(e) \subseteq \mathbb{R}^n_{++}$. The latter condition will be referred to as "goods are essential". In this class, all solutions in the set $\mathcal{P}$ coincide. Also, let us assume a particular compromise function, namely, the average. Then we obtain the following:

Proposition 5.- *Let $\mathcal{E} \subseteq \mathcal{E}^{sql}$. Then any solution in $\mathcal{P}$ can be implemented in NDS by the following compromise function: $f(m_1, m_2) = (m_1 + m_2)/2$.*

Proof: *Consider the utility functions* $u_i(x_i^1, x_i^2,..., x_i^n) = v_i(x_i^1, x_i^2,..., x_i^{n-1}) + x_i^n$, *where* x_i^k *stands for the consumption of commodity k by individual* $i = 1, 2$.

Now, consider the following program:

$$(P_i\ 1)\begin{cases} Max\ u_i(x_i^1, x_i^2,..., x_i^n) \\ s.t.\ u_j(x_j^1, x_j^2,..\ \ x_j^n) \geq u_j(\omega_j) \end{cases}$$

Because utility functions are strictly increasing the restriction binds. Since goods are essential the solution is interior. Thus, the first order conditions (FOC) for problem $(P_i\ 1)$ *are the following:*

$$\begin{cases} \partial v_i / \partial x_i^k = \partial v_j / \partial x_j^k \quad for\ k = 1,...,n-1 \\ v_j(\omega^1 - x_i^1, ..., \omega^{n-1} - x_i^{n-1}) + \omega^n - x_i^n = u_j(\omega_j) \\ with\ x_j^k = \omega^k - x_i^k \end{cases}$$

Let us call $(P_j\ 1)$ *to the following program:*

$$(P_j\ 1)\begin{cases} Max\ u_j(x_j^1, x_j^2,..., x_j^n) \\ s.t.\ u_i(x_i^1, x_i^2,..\ \ x_i^n) \geq u_i(\omega_i) \end{cases}$$

As for problem $(P_j\ 1)$, *(FOC) are interior, i.e.:*

$$\begin{cases} \partial v_i / \partial x_i^k = \partial v_j / \partial x_j^k \quad for\ k = 1,..., n-1 \\ v_i(x_i^1, ..., x_i^{n-1}) + x_i^n = u_i(\omega_i) \\ with\ x_j^k = \omega^k - x_i^k \end{cases}$$

Notice that $(P_i\ 1)$ *and* $(P_j\ 1)$ *both have a unique solution such that the amounts of commodities 1 to (n-1) consumed by agent i (and therefore to agent j) coincide. Let us call* x^*_{ii} *the solution to* $(P_i\ 1)$, *and* x^{**}_{ji} *the solution to* $(P_j\ 1)$. *Furthermore, call* $x^*_{ij} = \omega - x^*_{ii}$, $x^{**}_{jj} = \omega - x^{**}_{ji}$. *As a consequence, the Pareto frontier turns out to be linear, and all symmetric bargaining solutions (and also the Shapley value) coincide, yielding the allocation* $F(e) = \left(\frac{x^*_{ii} + x^{**}_{ji}}{2}, \frac{x^*_{ij} + x^{**}_{jj}}{2} \right)$.

Let us now consider a fixed proposal $y_j = (y_{jj}, y_{ji})$ *from individual j such that* $y_{jj} + y_{ji} = \omega$, *and consider the following program:*

$$(P_i\ 2) \qquad \begin{cases} Max\ v_i\left[\frac{z_i^1 + y_{ji}^1}{2}, \ldots, \frac{z_i^{n-1} + y_{ji}^{n-1}}{2} \right] + \frac{z_i^n + y_{ji}^n}{2} \\ s.t.\ v_j(\omega^1 - z_i^1, \ldots, \omega^{n-1} - z_i^{n-1}) + \omega^n - z_i^n = u_j(\omega_j) \end{cases}$$

(FOC) for $(P_i\ 2)$ *are the following:*

$$\begin{cases} \partial v_i / \partial x_i^k = \partial v_j / \partial x_j^k \quad for\ k = 1, \ldots, n-1 \\ v_j(\omega^1 - z_i^1, \ldots, \omega^{n-1} - z_i^{n-1}) + \omega^n - z_i^n = u_j(\omega_j) \\ with\ x_i^k = \frac{z_i^k + y_{ji}^k}{2},\ x_j^k = \omega^k - x_i^k \end{cases}$$

In a similar way, by considering a fixed proposal from individual i, $y_i = (y_{ii}, y_{ij})$, *such that* $y_{ii} + y_{ij} = \omega$, *we consider the program:*

$$(P_j\ 2) \qquad \begin{cases} Max\ v_j\left[\frac{z_j^1 + y_{ij}^1}{2}, \ldots, \frac{z_j^{n-1} + y_{ij}^{n-1}}{2} \right] + \frac{z_j^n + y_{ij}^n}{2} \\ s.t.\ v_i(\omega^1 - z_j^1, \ldots, \omega^{n-1} - z_j^{n-1}) + \omega^n - z_j^n = u_i(\omega_i) \end{cases}$$

FOC for (P_j 2) are the following:

$$\begin{cases} \partial v_i / \partial x_i^k = \partial v_j / \partial x_j^k \quad \text{for } k = 1, \ldots, n-1 \\ v_i(\omega^1 - z_j^1, \ldots, \omega^{n-1} - z_j^{n-1}) + \omega^n - z_j^n = u_i(\omega_i) \\ \text{with } x_j^k = \dfrac{z_j^k + y_{ij}^k}{2}, \; x_i^k = \omega^k - x_j^k \end{cases}$$

Consider now (P_i 2), and take $z_{ii} = x^*_{ii}$. Then, notice that $z_i = (z_{ii}, \omega - z_{ii})$ satisfy (FOC) for problem (P_i 2) if $y_{ji} = x^{**}_{ji}$. Analogously, for problem (P_j 2), if we call $z_{ji} = x^{**}_{ji}$, then $z_j = (z_{ji}, \omega - z_{ji})$ satisfies (FOC) for problem (P_j 2) whenever $y_{ij} = x^*_{ij} = \omega - x^*_{ii}$. Furthermore, under strict concavity and smoothness, there are no any other simultaneous solutions to (P_i 2) and (P_j 2). Therefore, by setting $m_i = (x^*_{ii}, x^*_{ij})$, $m_j = (x^{**}_{ji}, x^{**}_{jj})$, then the average compromise function implements any solution in $\mathcal{P}$ in Nash Equilibrium decent strategies in the domain $\mathcal{E}^{sql}$. ■

The above Proposition can be proved, at the cost of some complications, if strict concavity is relaxed to concavity. We remark that we did not assume that the allocation generated by a NDS is Pareto efficient. Rather, we *derived* this from our assumptions (thus this Proposition can be viewed as a kind of Coase theorem). Unfortunately, relaxing quasilinearity has an undesirable implication, namely that no subcorrespondence of the Pareto correspondence can be implemented in Nash Decent Strategies. An argument to this fact is given in Proposition 6 below. First, let us introduce two new definitions.

Definition 6.- *A solution Φ on a set of economies $\mathcal{E}$ is weakly anonymous if whenever $e = (u_1, u_2) \in \mathcal{E}$ is such that $u_1 = u_2$, then $\phi_i(e) \neq 0$, $i = 1, 2$.*

Definition 7.- *A class of economies $\mathcal{E} = \mathcal{U}_1 \times \mathcal{U}_2$ is minimally rich if*

(a) If $u_i = x_i^1 \cdot x_i^2 \ldots x_i^n$, then $u_i \in \mathcal{U}_i$, $i = 1, 2$.

(b) *For some agent* $k = 1, 2$, *some* $\alpha_1, \ldots, \alpha_n$ *such that* $\alpha_i \geq 0$, $\alpha_1 + \ldots + \alpha_n = 1$ *with* $\alpha_r \neq \alpha_s$ $\forall\, r, s = 1, \ldots, n$,

$$u_k = (x_k^1)^{\alpha_1} (x_k^2)^{\alpha_2} \ldots (x_k^n)^{\alpha_n} \in \mathcal{U}_k.$$

Proposition 6.- *Let* Φ *a weakly anonymous solution on a minimally rich class of economies* $\mathcal{E}$ *and assume* Φ *is implementable in NDS. Then* Φ *cannot be a selection of the Pareto correspondence for all* (ω_1, ω_2)[11].

Proof: *Take* $\omega_1 = (1, 0, \ldots, 0)$ *and* $\omega_2 = (0, 1, \ldots, 1)$. *Consider two economies* $e = (u_1, u_2)$ *and* $e' = (v_1, v_2)$, *such that* $u_1 = v_1 = x_1^1 . x_1^2 \ldots x_1^n$, $u_2 = x_2^1 . x_2^2 \ldots x_2^n$ *and* $v_2 = (x_2^1)^{\alpha_1} (x_2^2)^{\alpha_2} \ldots (x_2^n)^{\alpha_n}$ *with* $\alpha_r \neq \alpha_s$ $\forall\, r, s = 1, \ldots, n$. *Since* $\mathcal{E}$ *is minimally rich,* $e, e' \in \mathcal{E}$

Let m_{ij}^k *the amount of good k agent i proposes agent j to consume* $(i, j = 1, 2)$. *A proposal is decent both in e and e' iff* $m_{ij}^1, \ldots, m_{ij}^n \geq 0$, *and therefore decency constraints are never binding*[12].

Since f_i^k *only depends upon* m_{ii}^k *and* m_{ji}^k, *we have that:*

$$u_i[f(m_i, m_j)] = f_i^1(m_{ii}^1, m_{ji}^1) \ldots f_i^n(m_{ii}^n, m_{ji}^n), \qquad (1)$$

$$v_i[f(m_i, m_j)] = [f_i^1(m_{ii}^1, m_{ji}^1)]^{\alpha_1} \ldots [f_i^n(m_{ii}^n, m_{ji}^n)]^{\alpha_n} \qquad (2)$$

A NDS in e is a pair (m_1^*, m_2^*), *such that* $m_i^* = \arg\max\, u_i[f(m_i, m_j^*)]$, $i, j = 1, 2$, $i \neq j$. *Furthermore, a NDS in e' is a pair* $(\bar{m}_i, \bar{m}_j)$, *such that* $\bar{m}_i = \arg\max\, v_i[f(m_i, \bar{m}_j)]$, $i, j = 1, 2$, $i \neq j$.

---

[11] The last condition can be easily skipped by strengthening the definitions of a weakly anonymous solution and a minimally rich set of economies.

[12] From now on the proof of this Proposition ressembles the proof of Theorem 2 in Saijo, Tatamitani and Yamato (1993).

Since f_i^k depends only upon m_{ii}^k and m_{ji}^k, if (m_i^*, m_j^*) is a NDS for e, it is a NDS in e'. This follows from (1) and (2) above and the definition of a NDS (since for a given m_j^* player i will try to get as much as possible of every good. Thus, her preferences do not play any role in the determination of her optimal decent proposal). By the same token, if $(\bar{m}_i, \bar{m}_j)$ is a NDS in e', it is a NDS in e. Since ϕ is implementable, $\Phi(e) = \Phi(e')$. But the only Pareto efficient allocations in both e and e' are [(1, 1,..., 1), (0, 0,..., 0)] and [(0, 0,..., 0), (1, 1,..., 1)] (an allocation like [(0, 1, ..., 0), (1, 0,..., 1)] can not be Pareto efficient). This contradicts the weak anonymity of Φ. ■

Proposition 5 says that outside the domain $\mathscr{E}^{sql}$ we cannot obtain weakly anonymous and Pareto efficient outcomes from a single bargaining round mechanism. Thus, none of the standard solutions to the bargaining problem with non transferable utility (i.e. Nash (1950), Harsanyi (1963), Tijs (1981) or Hart-Mas-Colell (1989) can be implemented in NDS. A way to solve this problem would be to consider multiple round mechanisms in which agents would be allowed to make (decent) proposals in different stages of the game (this procedure is reminiscent of one proposed by Anbarci and Yi (1991)). A Decent Subgame Perfect Nash Equilibrium of this game is a sequence of decent proposals that are a Nash equilibrium in each subgame. So far we have been unable to identify the social choice correspondences that can be implemented in that way.

4.- EXTENSIONS

In this paper we have developed two examples of how decency constraints may affect resource allocation. There are, nevertheless, many open problems and several ways of extending our results.

Recall from section 2.3 that in the case of bankruptcy with more than two agents, each player needs to specify a sharing rule. In some particular domains, it is the case that, by specification of a sharing rule, some solutions are recovered. Take the subset of economies E' such that for any $e' = (M, c_1,..., c_n) \in E'$, it turns out that $\lambda_j = M - \sum_{k \neq j} c_k \geq 0$. Now, suppose that all agents in the economy have identical sharing rule: they ask for themselves their claim (c_i), they concede to any other agent her minimal right (λ_j), and then they divide the remaining amount equally among the rest of the agents [i.e., $m_{ii} = c_i$, $m_{ij} = \lambda_j + \mu_i$, $j \neq i$, $i = 1,...,n$, where $\mu_i = (M - c_i - \sum_{k \neq i} \lambda_k)/(n - 1)$]. First, notice that $c_i = C - M + \lambda_i$, for all $i = 1, ..., n$, and, in consequence, $\lambda_i = c_i - (C - M)$. Now, observe that $(M - c_i - \sum_{k \neq i} \lambda_k) = M - c_i - \sum_{k \neq i} c_k + (n - 1)(C - M) = (n - 2)(C - M)$, and thus, $\mu_i = \frac{n-2}{n-1} (C - M)$ for any $i = 1,...,n$. Therefore, if we use the average as the compromise function, $x_i = \frac{m_{1i}+\ldots+ m_{ni}}{n} = \lambda_i + \frac{n-1}{n} (C - M) = Sh(e') = N(e') = AP(e') = AEA(e') = CEL(e')$. Thus, by specifying subclasses of economies and particular sharing rules we may implement some well-known solutions in DDS.

Another possible extension is the following: Suppose that we look for solutions such that, if all agents use the same sharing rule, the solution reproduces the sharing rule used by the agents. In other words, the private and the public concepts of fair distribution of the claims coincide. The existence and characterization of such a solution still an open question. The non existence of such a solution may reinforce our idea that it may be easier to agree on a procedure than on a solution.

Finally, it is clear that our results in the case of bargaining can be generalized to the case of incomplete information. The set of decent allocations for player i is now the set of allocations in which j's expected utility is no less than j's utility were she forced to consume her initial endowments (other definitions are also possible). Then, the analysis follows closely that of Section 3.2. However, in this case, even under quasi-linear preferences, the outcome is not necessarily Pareto efficient.

APPENDIX 1

This Appendix is devoted to explain the main solutions to the bankruptcy problem for the case of n agents. First notice that, for a given bankruptcy problem $e = (M, \mathbf{c})$, $\mathbf{c} \in \mathbb{R}^n_{++}$, we may define an n-person TU game in the following way[13]: For any coalition $S \subset N$, $v_e(S) = \max \{ 0, M - \sum_{j \notin S} c_j \}$, $v_e(N) = M$. Two prominent proposals appear from this point of view: the Shapley value (Sh) and the Nucleolus (N) of the associated TU game. Being a convex game, both proposals belong to the Core. In our case we obtain the following formulae:

(i) If $M - \sum_{j \neq i} c_j \geq 0$, then

$$Sh_i(M, \mathbf{c}) = r_i + \frac{n - 1}{n}(c_i - r_i) = r_i + \frac{n - 1}{n}(C - M), \text{ where } C = \sum_{j=1}^{n} c_j.$$

(ii) If $M - \sum_{j \neq i} c_j < 0$, then

$$Sh_i(M, c) = \frac{1}{n}\left[\sum_{s=2}^{n-2} \frac{1}{c(s)} \sum_{\substack{i \in S \\ |S| = s}} [v(S) - v(S \setminus \{i\})] + 2c_i\right].$$

Let us define $\lambda_S = M - \sum_{j \notin S} c_j$. Thus, we have the following possibilities:

(a) $\lambda_S \leq 0$, $\lambda_S - c_i \leq 0$, then $[v(S) - v(S\setminus\{i\}] = 0$

(b) $\lambda_S > 0$, $\lambda_S - c_i \leq 0$, then $[v(S) - v(S\setminus\{i\}] = \lambda_S$

(c) $\lambda_S > 0$, $\lambda_S - c_i \geq 0$, then $[v(S) - v(S\setminus\{i\}] = c_i$

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[13] This is the 'natural' TU game associated to a bankruptcy problem [see Curiel Maschler & Tijs (1988)]. Nonetheless, some other constructions are possible [see Herrero , Maschler & Villar (1995)].

As for the nucleolus of the game we have the following computation rules:

(i) If $M \leq C/2$, then $N_i(M, \mathbf{c}) = x_i$ where $x_i = \min\{\lambda, c_i/2\}$ and λ solves $\sum_{i=1}^{n} \min\{\lambda, c_i/2\} = M$.

(ii) If $M \geq C/2$, $N_i(M, \mathbf{c}) = x_i$ where $x_i = c_i - \min\{\lambda, c_i/2\}$ and λ solves $\sum_{i=1}^{n} \min\{\lambda, c_i/2\} = C - M$.

Since the bargaining with claims problem can be looked at as an extension of the bankruptcy problem, some solutions (or adequate modifications of them) to the bargaining with claims problem provide with proposals for solving the bankruptcy problem. The most familiar solutions are the following(14):

Proportional: $P(M, \mathbf{c}) = \lambda\, \mathbf{c}$ s.t. $\lambda\, C = M$

Constrained Equal Award: $CEA(M, \mathbf{c}) = \mathbf{x}$ s.t. $x_i = \min\{\lambda, c_i\}$ and λ solves $\sum_{i=1}^{n} \min\{\lambda, c_i\} = M$.

Constrained Equal Loss: $CEL(M, \mathbf{c}) = \mathbf{x}$ s.t. $x_i = \max\{0, c_i - \lambda\}$ and λ solves $\sum_{i=1}^{n} \max\{0, c_i - \lambda\} = M$.

Finally, a natural reference point can be associated to any agent, namely $r_i(e) = \max\{0, M - \sum_{j \neq i} c_j\}$. Previous solutions can be modified by giving $r_i(e)$ to i and dividing the remaining money according to the chosen rule. In this way, we obtain the so called *adjusted rules* [see Dagan & Volij (1993)]:

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14 For a reinterpretation of bargaining solutions in the bankruptcy case, see Dagan & Volij (1993). Solutions to the bargaining with claims problem are in Chun & Thomson (1992) and Bossert (1993). See also O'Neill (1982), Chun (1988) and Young (1987).

Adjusted Proportional: AP(M, **c**) = **r** + λ (**c** - **r**), s.t. λ (C - R) = M.

Adjusted Equal Award: AEA(M, **c**) = **r** + **x** s.t. $x_i = \min\{\lambda, c_i - r_i\}$. λ solves $\sum_{i=1}^{n} \min\{\lambda, c_i - r_i\} = M - R$

Adjusted Equal Loss: AEL(M, **c**) = **r** + **x** s.t. $x_i = \max\{0, c_i - r_i - \lambda\}$. λ solves $\sum_{i=1}^{n} \max\{0, c_i - r_i - \lambda\} = M - R$

The latter solution coincides with CEL.

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