ENDOGENOUS REFERENCE POINTS AND THE ADJUSTED PROPORTIONAL SOLUTION FOR BARGAINING PROBLEMS WITH CLAIMS*

Carmen Herrero**

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A B S T R A C T

A modification of the proportional solution for bargaining with claims problems is proposed. This solution is constructed by considering an endogenous reference point. Characterization results are provided when the feasible set is not necessarily convex.

1.-INTRODUCTION

The axiomatic approach to the "Bargaining with Claims" Problem has deserved some attention in the literature since its introduction by Chun & Thomson (1992). These authors enriched the traditional bargaining problem by adding to the feasible set S, and the disagreement point d, a third element, namely, the *claims point*. This point describes the claims (or expectations) the agents may have when they come to the bargaining table. They also assume the claims point to be outside of the feasible set: the claims are incompatible. Then, Chun & Thomson present and characterize the so called *proportional solution*, which associates with each problem the maximal point of the feasible set on the line segment connecting the disagreement point to the claims point. Alternative proposals to the proportional solution appear in Bossert (1992), (1993), and Marco (1993).

As Chun & Thomson (1992) pointed out the disagreement point could be interpreted in various ways. It can be the alternative at which the agents will end up in the case of no agreement, or it can be a "reference point" from which they find it natural to measure their utility gains in order to evaluate a proposed compromise.

This paper provides a suitable modification of the proportional solution for the problem of bargaining with claims, with two distinctive features:

(i) A "natural way" of defining a *reference point* is proposed. This reference point is neither independent of the claims point nor of the feasible set, i. e., it appears endogeneously in every bargaing with claims problem. Thus, it seems natural to take it into consideration when proposing ways of solving the conflict. The interdependence between the claims and the reference points requires the reinterpretation of those conditions appearing in the traditional case, when we come to characterize the corresponding solutions.

(ii) The class of bargaining problems with claims considered here is wider than that in Chun & Thomson (1992), Bossert (1993) or Marco (1993), since the convexity of the utility possibility set is not assumed.

The rationale of the proposed reference point goes back to the *contested garment principle* for bankruptcy problems, appearing in the Babylonian Talmud (Baba Metzia 2a) [see Aumann & Maschler (1985)], and appears also in the generalized contested garment principle for n creditors, as was introduced by Curiel, Maschler & Tijs (1988).

By suitably choosing the reference point, a modification of Chun & Thomson's proportional solution arises in a natural way. We shall call this proposal the *adjusted proportional solution*, by reference to the adjusted proportional rule for bankruptcy problems [see Curiel, Maschler and Tijs (1988) and Dagan & Volij (1993)].

Section 2 presents the reinterpretation of the bargaining with claims problems by introducing the "natural" reference point. Section 3 provides with several characterizations of the adjusted proportional solution. A few final comments are gathered in Section 4. In order to facilitate the exposition we shall present all the results for $n = 2$. The extension for an arbitrary number of agents turns out straigtforward.

2.- BARGAINING WITH CLAIMS. A REINTERPRETATION

A *2-person bargaining problem with claims,* is a triple (S,d,c), where S is a subset of $\mathbb{R}^2$, d and c are points in $\mathbb{R}^2$, such that[1]:

(i) S is closed and comprehensive[2]

(ii) there exist $p \in \mathbb{R}^2_{++}$ and $r \in \mathbb{R}$ such that for all $x \in S$, $\sum p_i x_i \leq r$.

(iii) there exists $x \in S$, $x >> d$

S is the *feasible set.* Each point x of S is a *feasible alternative.* Points d and c are the *disagreement point* and the *claims point,* respectively. The intended interpretation of (S,d,c) is as follows: the agents can achieve any point x of S if they unanimously agree on it. The coordinates of x are the utility values, measured in some Von Neumann-Morgenstern scales, attained by the agents through the choice of some joint action. Point d is the alternative at which the agents end up in the case of no agreement. Finally, each coordinate of the claims point may represent a promise made to the corresponding agent. If $c \notin S$, then the

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(1) Notice that the class of bargaining with claims problems we consider is wider than the class in Chun & Thomson (1992) or Bossert (1993), since we do not ask for the feasible set to be convex.

(2) Vector inequalities: given $x, y \in \mathbb{R}^2$, $x \geq y$, $x > y$, $x >> y$. $\mathbb{R}^2_{++} \equiv \{ x \in \mathbb{R}^2 | \ x >> 0 \}$. S is comprehensive if for all $x \in S$, for all $y \in \mathbb{R}^2$, if $y \leq x$, then $y \in S$.

promises made to the agents are impossible to comply. In this case, we face a problem, and the only way of solving it is by choosing some compromise.

Let us call $\sum$ the class of problems satisfying conditions (i), (ii) and (iii) above.

A *solution* is a function $F:\sum \longrightarrow \mathbb{R}^2$ associating with each $(S,d,c) \in \sum$, a unique point of S, F(S,d,c), called the *solution outcome of* (S,d,c).

Associated with a problem (S,d,c), a natural *reference point* can be defined. Suppose $c = (c_1,c_2)$ is not feasible [see Figure 1]. For agent 1, it could be that c_1 is feasible. Thus, agent 1 would agree with point A. Analogously, if c_2 is feasible, agent 2 would agree with point B. So, agent 1 conceeds a certain amount to agent 2 and viceversa. Those concesions give raise to point r, a *natural reference point* for the problem (S,d,c).

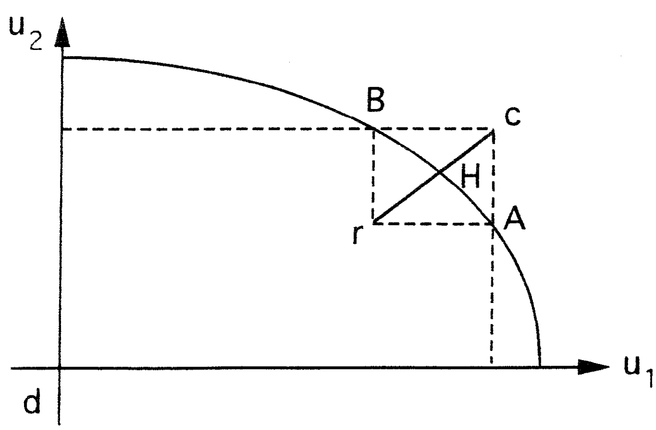

Figure 1

In the case either c_1 or c_2 (or both) are not feasible, agent 1 (respectively, agent 2, or both) would agree only with getting the whole cake, and the *natural reference point* turns out to be located at axis u_1, (respectively u_2, or to coincide with d). See figures 2 and 3.

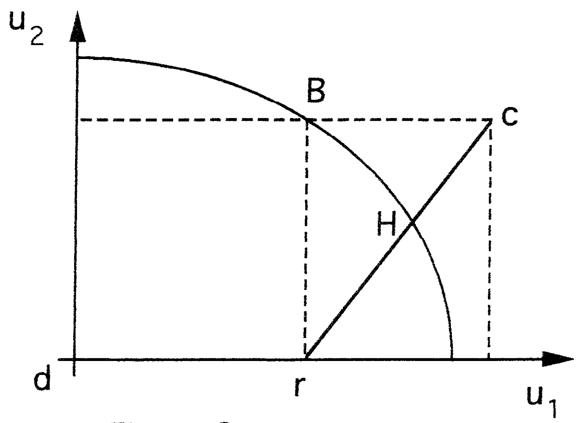

Figure 2

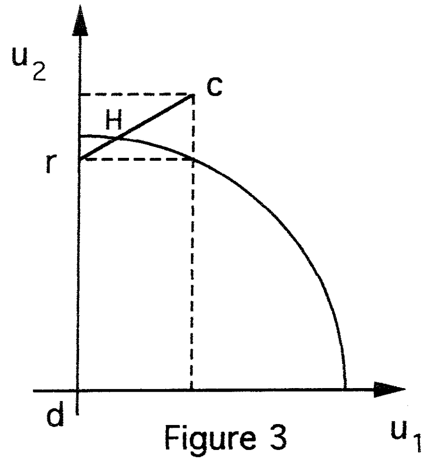

Figure 3

Given a bargaining problem with claims, $(S,d,c) \in \Sigma$, let us call r(S,d,c) the *natural reference point* defined above. The following solution, illustrated in figures 1, 2 and 3, is our proposal for solving the conflict:

Definition. The *adjusted proportional solution*, H: for all $(S,d,c) \in \Sigma$, H(S,d,c) is the maximal point in S connecting r(S,d,c) and c.

Solution H can be viewed as a modification of the proportional solution P proposed by Chun & Thomson (1992), in the sense that it coincides (in the convex case) with P either when both c_1 and c_2 are not feasible or when c coincides with the utopia point of (S,d). Alternatively, it can be viewed as a suitable modification for the case of bargaining with claims of the solution f* proposed by Gupta & Livne (1988) in classical bargaining, but with the particularity of having a precise rule for the determination of the reference point, which, in the bargaining with claims case seems to be specially appealling.

3.- CHARACTERIZATION OF THE ADJUSTED PROPORTIONAL SOLUTION

In order to characterize the proposed solution, let us consider the following axioms:

Weak Pareto Optimality (WPO). For all $(S,d,c) \in \Sigma$ and for all $x \in \mathbb{R}^2$, if $x \gg F(x,d,c)$, then $x \notin S$.

WPO requires that there be no feasible alternative that all agents strictly prefer to the solution outcome.

Let $WPO(S) = \{ x \in S \mid \forall x' \in \mathbb{R}^2, x' > x \Rightarrow x' \notin S \}$ be the set of weakly Pareto optimal points of S.

Similarly, let $PO(S) = \{ x \in S \mid \forall x' \in \mathbb{R}^2, x' > x \Rightarrow x' \notin S \}$ be the set of Pareto-optimal points of S.

Symmetry (SY). For all $(S,d,c) \in \Sigma$, if S is symmetric, $c_1 = c_2$, $d_1 = d_2$, then $F_1(S,d,c) = F_2(S,d,c)$.

SY requieres that if the agents are identical, they have to be treated identically.

Scale Invariance (SC.INV.). For all $(S,d,c) \in \Sigma$, a_1, $a_2 > 0$, b_1, $b_2 \in \mathbb{R}$, if $S' = \{ (v_1,v_2) \mid v_i = a_i u_i + b_i, (u_1,u_2) \in S \}$; $c'_i = a_i c_i + b_i$; $d'_i = a_i d_i + b_i$, $i=1,2$, $F_i(S',d',c') = a_i F_i(S,d,c) + b_i$.

SC.INV. says that applying a positive linear transformation acting independently on each coordinate, leads to a new problem that should be solved as the image under this transformation of the solution outcome of the original problem. It can be justified by the fact that agents' utilities are of the von Neumann-Morgenstern type.

Continuity (CONT.). For any sequence $\{(S^{\nu},d,c)\}$ in $\sum$, if $\{S^{\nu}\}$ converges to S in the Hausdorff topology, then $\{F(S^{\nu},d,c)\}$ converges to F(S,d,c).

CONT. says that 'small' variations in the feasible set, while the claims and the disagreement points remain fixed, causes 'small' variations in the solution outcome.

Restricted Monotonicity (R.MON.). Let (S,d,c), (S',d'c') $\in \sum$ such that $S \subset S'$; c = c', and r(S,d,c) = r(S',d',c'). Then, F(S,d,c) $\leq$ F(S',d',c').

R.MON. says that an expansion in the set of opportunities, with the claims and the reference points being equal, benefits all agents. As a consequence of R.MON., we get that if S = S', c = c' and r(S,d,c) = r(S,d',c), then F(S,d,c) = F(S,d',c). This consequence indicates that if the only change in a situation is the disagreement level, in such a way that no change in the reference point is involved, then the solution outcome does not change. In this sense, confront the property LSCCP in Gupta & Livne (1988) and the ideas in Rosenthal (1976), Roth (1977) and Thomson (1981), when the disagreement point is replaced by the maximal feasible outcome for which the ideal point is identical to the original ideal point.

Then we get the following result:

Theorem 1.- H is the only solution function $F:\sum \longrightarrow \mathbb{R}^2$ satisfying WPO, SY, SC.INV., CONT. and R.MON.

Proof. It is obvious that H satisfies the four axioms. Conversely, let F be a solution satisfying the four axioms. Let $(S,d,c) \in \sum$. First, suppose that $H(S,d,c) \in PO(S)$. By SC.INV., we can assume $c = (1,1)$ and $r_1(S,d,c) = r_2(S,d,c)$. Thus, $H(S,d,c) = (a,a) = x^*$ for some a. Let now $S' = \{(x,y) \mid (y,x) \in S\}$, and let $T = S \cap S'$. By SY and PO, $F(T,r(S,d,c),c) = x^*$, and by R.MON., $x^* \leq F(S,d,c)$. Since $x^* \in PO(S)$, $x^* = F(S,d,c)$.

Suppose now that $H(S,d,c) \in WPO(S) \setminus PO(S)$. Then we can find a sequence of sets, $\{S_q\}$, such that $S_q \subset S$ $\forall q$, $\lim S_q = S$, $r(S_q,d,c) = r(S,d,c)$, and $H(S_q,d,c) \in PO(S_q)$. Because of the previous argument, $F(S_q,d,c) = H(S_q,d,c)$ for all q. By CONT., $F(S_q,d,c)$ converges to $F(S,d,c)$, and therefore, $H(S,d,c) = F(S,d,c)$.■

Consider now the following property:

Homogeneity in Step by Step Negotiation (H.SSN.). Let (S,d,c), $(S',d,c) \in \sum$ such that $r(S,d,c) = 0$, $S \subset S'$, and $r(S',d,c) = F(S,d,c)$. Then, $F(S',d,c) = \lambda F(S,d,c)$.

H.SSN. specifies the way in which the solution behaves when the feasible set increases in such a way that the reference point of the bigger set coincides with the solution of the smaller set. In such a case, we expect proportionality in the solutions.

Now, the following result is obtained:

Theorem 2.- H is the only solution function on $\sum$ satisfying WPO, SY. SC.INV. and H.SSN.

Proof: Obviously, H satisfies the four properties. Conversely, let now F a solution satisfiyng the four axioms. Let $(S,d,c) \in \sum$ [see Figures 4 and 5]. Construct the straight lines from c paralell to the axis, s and t, respectively. Let us consider the rectangle defining the reference point, A,c,B,r, and consider another rectangle, similar to the previous one, by using s and t and the intersection of one of these lines with the axis. Let this rectangle be J,c,E,G. Now, by SC.INV., let c = (1,1) and G = (0,0). Then, r = (a,a). Consider now the problem (S',d',c), where S' = Com{J,r,E}, d' = G = (0,0). By SY, and WPO, F(S',d',c) = r. By H.SSN., F(S,d,c) = λF(S',d',c) =λ(a,a) = H(S,d,c).■

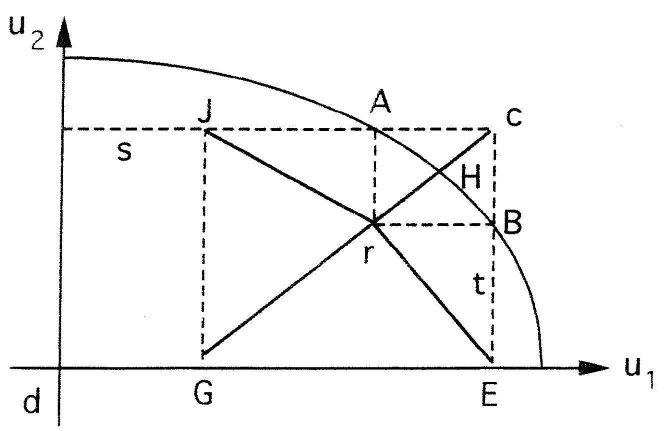

Figure 4

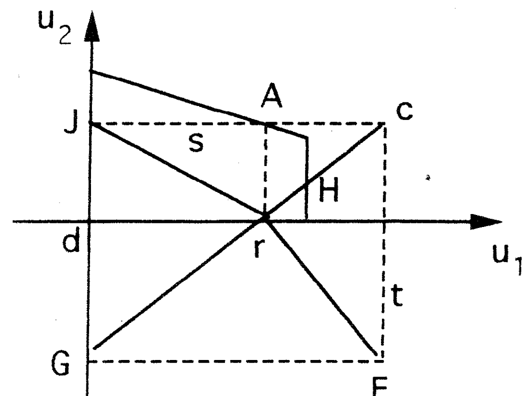

Figure 5

4.- FINAL REMARKS

In a recent paper, Dagan & Volij (1993) presented a reinterpretation of some bankruptcy rules following a bargaining approach. For a given bankruptcy problem (E,c), E being an amount of money, and $c \in \mathbb{R}^n$ the claims of the creditors, they define a bargaining problem, by considering $S(E,c) = \{ x \in \mathbb{R}^n |\ x \leq c, \sum x_i \leq E \}$. Choosing d as the point of concesions (in money) for every creditor, they proved that the Kalai-Smorodinski solution gives raise to the adjusted proportional rule outcome. Our result can be viewed as an extension of this result for more general bargaining with claims problems.

It is worth mentioning that in our characterization results, we do not impose convexity of the feasible sets. Rather, we only ask for comprehensiveness. Thus, our approach seems to be a first step in avoiding convexity of the feasible set [for some criticisms about the convexity assumption, see Rubinstein, Safra & Thomson (1992)]. Moreover, a similar technique can be used in order to provide a characterization for the Kalai-Smorodinski solution in classical bargaining for nonconvex utility possibility sets.

Throughout the paper we have focused on two person conflicts only. The model and the proposed solution can be extended straightforwardly to the n-person case.

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