A CHARACTERIZATION OF THE EXTENDED CLAIM-EGALITARIAN SOLUTION*

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WP-AD 93-03

* Thanks are due to C. Herrero for helpful comments. Any mistakes are my exclusive responsibility.

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Editor: **Instituto Valenciano de Investigaciones Económicas, S.A.**
Primera Edición Mayo 1993.
ISBN: 84-482-0178-7
Depósito Legal: V-1520-1993
Impreso por KEY, S.A., Valencia.
Cardenal Benlloch, 69, 46021-Valencia.
Impreso en España.

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A B S T R A C T

Some monotonicity conditions for bargaining problems with claims are presented. They are used in providing a characterization of the extended claim-egalitarian solution.

1.- INTRODUCTION

Bargaining problems with claims have been introduced in a recent paper by Chun and Thomson (1992). They propose a generalization of Nash's (1950) bargaining model by adding a third element to the disagreement point and the feasible set, namely, a point representing the claims of the agents, (also in terms of utilities). In this setting, a solution specifies exactly one feasible outcome for each triple of feasible set, disagreement point and claims point. As is usual in axiomatic bargaining theory, the traditional way of defending a solution concept relies on the properties satisfied by this solution, from a normative point of view.

We concentrate on the application of the so-called "equal-loss principle"(1) to the framework of bargaining with claims. In this way, a first solution concept arises in a natural way, namely, the *claim-egalitarian solution*, by equalizing losses from the claims point for all agents [see Bossert (1992a)]. This solution is the counterpart of the *equal-loss solution* in the classical bargaining problem [see Chun (1988)], which equalizes losses from the ideal point. In the same way as the equal-loss solution itself may fail to be individually rational for more than two agents, the claim-egalitarian solution may also present lack of

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1 The consideration of equal losses in utility from the ideal point gave rise to several bargaining solutions in the classical framework [see Yu (1973), Freimer and Yu (1976), Chun (1988), Chun and Peters (1991) and Herrero and Marco (1992a, 1992b)].

individual rationality. In consequence, it is natural to also consider the individually rational extension of the claim-egalitarian solution, namely, the *extended claim-egalitarian solution*, [see Bossert (1992a)], which turns out to be the counterpart of the *rational equal-loss solution* in the classical bargaining framework [see Herrero & Marco (1993)]. In Bossert (1992a), the behaviour of both the claim-egalitarian and the extended claim-egalitarian solutions, with respect to some monotonicity requirements is analyzed. Moreover, the existence of a characterization result in an unpublished paper [Bossert (1992b)], is mentioned.

In the present paper we formulate axioms specifying how the solution outcome should respond to certain changes, both in the feasible set and in the claims point. These axioms are different from those presented in Bossert (1992a). Moreover, by means of these requirements, together with some standard conditions, we provide an alternative characterization of the extended claim-egalitarian solution.

2.- PRELIMINARIES

A bargaining problem with claims is a triplet (S,d,c), where $S \subseteq \mathbb{R}^n$, $d \in S$, and $c \in \mathbb{R}^n \setminus S$. $\mathbb{R}^n$ is the utility space, S the feasible set, d the disagreement point and c the claims point. The agents could achieve any point in S if they agree on it unanimously, otherwise they will end up at d.

Let $\sum^n$ the class of n-personal bargaining problems with claims (S,d,c) such that:

(i) S is convex, closed and comprehensive[(2)]

(ii) $\exists\ p \in \mathbb{R}^n_{++}$, $r \in \mathbb{R}$ such that $\forall\ x \in S$, $px \leq r$

(iii) $\exists\ x \in S$ with $x >> d$

(iv) $c \notin S$, $c > d$

Sometimes, it is also required that c be weakly dominated by the ideal point of (S,d) [see Chun and Thomson (1992)]. The class we consider here coincides with that which appears in Bossert (1992a).

For any $(S,d,c) \in \sum^n$, we use IR(S,d) to denote the set of individually rational points, that is, $IR(S,d) = \{x \in S \mid x \geq d\}$. PO(S) will denote the set of Pareto optimal outcomes, and WPO(S) the set of weakly

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2 $S \subseteq \mathbb{R}^n$ is comprehensive if, for all $x \in S$ and all $y \in \mathbb{R}^n$, $y < x$ implies $y \in S$. Notation for vector inequalities is $\geq, >, >>$.

Pareto optimal outcomes, that is, $PO(S) = \{ x \in S \mid \text{if } y \geq x \Rightarrow y \notin S\}$ and $WPO(S) = \{ x \in S \mid \text{if } y \gg x \Rightarrow y \notin S \}$.

A solution on $\sum^n$ is a function $F: \sum^n \longrightarrow \mathbb{R}^n$ such that $F(S,d,c) \in S$ for all $(S,d,c) \in \sum^n$.

Bossert (1992a) introduces the equal-loss principle for bargaining problems with claims, by means of two solution concepts, namely, the claim-egalitarian and the extended-claim egalitarian solutions.

Definition 1 [Bossert (1992a)]: For all $(S,d,c) \in \sum^n$, the claim-egalitarian solution, $E(S,d,c)$ is the weakly Pareto Optimal point in S such that $|c_i - y_i| = |c_j - y_j|$ $\forall i,j \in N$.

Definition 2[3]: For all $(S,d,c) \in \sum^n$, the extended claim-egalitarian solution, $E^*(S,d,c)$ chooses the alternative:

$$E^*_i(S,d,c) = \begin{cases} d_i & \text{if} \quad E_i(\bar{S},d,c) < d_i \\ E_i(\bar{S},d,c) & \text{if} \quad E_i(\bar{S},d,c) \geq d_i \end{cases}$$

where $\bar{S}$ stands for the comprehensive hull of the set $IR(S,d)$.

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3 It is easy to check that this definition is equivalent to that appearing in Bossert (1992a).

The interpretation of the extended claim-egalitarian solution is the following: the agents' losses are equal with respect to their claims if doing this represents an agreement which is acceptable to all individuals. If it does not, it is because there are some agents that, at the claim-egalitarian solution are worse off than at the disagreement point. In this event, we will accept smaller losses for these agents, keeping them at their level of disagreement, and we will only level off losses with relation to the rest of the agents' claims. In this way, a compromise between the equal-loss principle and the possibility of agreement among the agents is found.

3.- CHARACTERIZATION OF E^*.

Consider the following axioms for bargaining problems with claims:

(WPO) *Weak Pareto Optimality:* $\forall(S,d,c) \in \sum^n$, $F(S,d,c) \in WPO(S)$.

(AN) *Anonymity:* $\forall(S,d,c) \in \sum^n$, and for all permutations $\pi:\{1,..,n\} \longrightarrow \{1,..,n\}$ $F(\pi(S),\pi(d),\pi(c)) = \pi(F(S,d,c))$.

(T.INV) *Translation Invariance:* $\forall$ $(S,d,c) \in \sum^n$, $\forall$ $t \in \mathbb{R}^n$, $F(S+\{t\}, d+t, c+t) = F(S,d,c) + t$.

(CONT) *Continuity:* $\forall$ sequences $\{(S^\upsilon,d^\upsilon,c^\upsilon)\}$ of elements of $\sum^n$,$\forall(S,d,c)$ of $\sum^n$, si S^υ converges to S in the Hausdorff topology, $d^\upsilon=d$ y $c^\upsilon=c$ $\forall\upsilon$, thus $F(S^\upsilon,d^\upsilon,c^\upsilon)$ converges to $F(S,d,c)$.

(B.D.D) *Boundedness:* $\forall$ $(S,d,c) \in \sum^n$, $d \leq F(S,d,c) \leq c$

(ST.MON) *Strong Monotonicity:* $\forall$ (S,d,c), $(S',d',c') \in \sum^n$, such that $S' \subset S$, $c' = c$, then $F(S',d',c') \leq F(S,d,c)$.

(R.ST.MON) *Rational Strong Monotonicity:* $\forall(S,d,c)$, $(S',d',c') \in \sum^n$, such that $S' \subseteq S$, $d \leq d'$ and $c=c'$, if $F(S,d,c) \geq d'$, then $F(S',d',c') \leq F(S,d,c)$.

(ST-c-MON) *Strong c-Monotonocity*: $\forall$ (S,d,c), (S',d',c') $\in \sum^n$, for all $i \in N$, if $S = S'$, $d = d'$, $c'_i > c_i$, and $c'_j = c_j$ $\forall j \neq i$, then $F_i(S',d',c') \geq F_i(S,d,c)$ and $F_j(S',d',c') \leq F_j(S,d,c)$.

(C.MON) *Claims Point Monotonicity:* $\forall$(S,d,c),(S',d',c') $\in \sum^n$, such that S=S', d=d' and $c_j=c'_j$ $\forall j\neq i$ $c_i\geq c'_i$,then $F_i(S,d,c)\geq F_i(S',d',c')$.

WPO requires that there be no feasible alternative at which all agents are better off than they are at the solution outcome. AN says that the names of the agents do not affect the solution outcome. T.INV requires the choice of origin of the utility functions to be irrelevant. CONT implies that small variations in the opportunity set, with changes neither in the disagreement point nor in the claims point, cause small variations in the solution. B.D.D. requires that no agent may be worse off at the solution outcome than at the disagreement point, and also, that no agent may enjoy more utility at the solution outcome than that utility corresponding to her/his claim. WPO, AN, T.INV, CONT and B.D.D. are borrowed from Chun & Thomson (1992).

ST.MON means that, given an increase in the feasible set without any changes in the claims, no agent loses. This axiom is an adaptation of the property *"Strong Monotonicity other than the ideal point"* [introduced by Chun (1988) for the classical bargaining problem] to one of bargaining with claims. R.ST.MON says that if the set of agreements acceptable to all agents shifts, and if the agents' claims remain unchanged, nobody will benefit, unless the new disagreement point represents an improvement for some individual as far as the solution to the initial problem is concerned. This axiom may be considered as a weak version of ST.MON.

ST-c-MON was introduced by Bossert (1992a). C.MON is a weakening of the axiom ST.c-MON. Our version requires that an increase in the utility level to which the agent has a claim should not damage him as long as the rest of the claims, the feasible set and the disagreement point remain fixed. This condition is an adaptation of the property *"Ideal Point Monotonicity"* [introduced by Chun (1988)], to one of bargaining with claims.

The next lemmata are used in our main result (Theorem 1):

Lemma 1: The extended claim-egalitarian solution satisfies rational strong monotonicity.

Proof: Let (S,d,c), (S',d',c') $\in \sum^n$ such that S'$\subseteq$ S, d $\leq$ d'[1], c = c' and E*(S,d,c) $\geq$ d' [2].

Let $\bar{S}$ = Com[IR(S,d)] , $\bar{S}$' = Com[IR(S',d')], thus, considering S'$\subseteq$ S and inequality [1], we have $\bar{S}$'$\subseteq$ $\bar{S}$. Bearing in mind that the claim-egalitarian solution E verifies strong Monotonicity (see Chun (1988)), we can apply this property to the pair ($\bar{S}$,d,c) ($\bar{S}$',d',c'), concluding that

$$E(\bar{S}',d',c') \leq EL(\bar{S},d,c) \qquad [3]$$

Let us analyze two possible cases:

(i) If $E_i(\bar{S},d,c) \geq d_i \;\; \forall i \in N$, then $E^*_i(S,d,c) = E_i(\bar{S},d,c) \;\; \forall i \in N$. Furthermore,

$$E^*_i(S',d',c') = \begin{cases} E_i(\bar{S}',d',c') \leq E_i(\bar{S},d,c) = E^*_i(S,d,c), \text{ by [3]} \\ d'_i \leq E^*_i(S,d,c), \text{ by [2]} \end{cases}$$

(ii) If $\exists \; i \in N$ such that $E_i(\bar{S},d,c) \geq d_i$ and $j \in N$ such that $E_j(\bar{S},d,c) < d_j$. Let $Q = \{ i \in N \mid EL_i(\bar{S},d,c) \geq d_i \}$. Then $\forall \; i \in Q$ we can obtain $E^*_i(S',d',c') \leq E^*_i(S,d,c)$ by reasoning in the same way as in (i) for $Q \subset N$. $\forall j \in N \setminus Q$, we will have $E_j(\bar{S},d,c) < d_j$, and $E^*_j(S,d,c) = d_j$. Considering [1] and [2] we obtain $d'_j = d_j \;\; \forall j \in N \setminus Q$, and bearing in mind [3], we get $E_j(\bar{S}',d',c') < d_j = d'_j$. Therefore, $E^*_j(S',d',c') = d'_j = d_j$. $\blacksquare$

As a direct consequence of Theorem 2 in Bossert (1992a), we get:

Lemma 2: The extended claim-egalitarian solution satisfies claims point monotonicity.

Now we can present our main result:

Theorem 1: The extended claim-egalitarian solution is the only one in $\sum^n$ satisfying Weak Pareto Optimality, Anonymity, Translation Invariance, Boundedness, Rational Strong Monotonicity, Claims Point Monotonicity, and Continuity.

Proof: Obviously, E* satisfies WPO, AN, T.INV, B.D.D. and CONT. Furthermore, it verifies ST.R.MON and C.MON (Lemmas 1 and 2). In order to prove uniqueness let F be a solution that verifies all the axioms, and consider a problem $(S,d,c) \in \sum^n$ such that WPO(S)=PO(S).

We will distinguish between two cases:

(i) If $E(S,d,c) \in IR(S,d)$, because of T.INV we can assume $c=(1,..,1)$. Let $E^*(S,d,c)=x$, $S^1= Com\{x\}$[(4)], $d^1 \leq d$ / $d^1_i = d^1_j$ $\forall i,j$. By WPO and SY we will have $F(S^1,d^1,c) = x$. Given that F verifies B.D.D, we can apply ST.R.MON twice to the pairs $(S^1,d^1,c),(S\ ,d^1,c)$ and $(S\ ,d^1,c),(S\ ,d\ ,c)$ in order to conclude $F(S,d,c)=x$.

(ii) If $E(S,d,c) \notin IR(S,d)$ we will apply mathematical induction. We will use Q to denote $\{i \in N \ / \ E_i(S,d) \geq d_i\}$

(ii)-(a) Let $P = N/Q = \{j\}$.

If n=2, we assume j=2 by AN. We now take $c_1=1$ by T.INV, we then have $E^*(S,d,c) = (x_1,d_2)$. Once again by T.INV we assume that $d_2= x_1$, so $E^*(S,d,c) = (x_1,x_2) = x$, with $x_1= x_2$. Let c' such that $c'_1= c_1$ and $c'_2= c_1$, so by (i) $F(S,d,c') = x$ and applying B.D.D. and C.MON we will have $F_2(S,d,c) = x_2$ and now, by WPO $F_1(S,d,c) = x_1 \Rightarrow F(S,d,c) = x$.

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4 Com (A) stands for the comprehensive hull of set A. CoCom (A) stands for the Convex and comprehensive hull of set A.

If $n \geq 3$, we assume that $j=n$ by AN. We now take $c_i = 1$ $\forall i \neq n$ by T.INV, so $E^*(S,d,c) = (x_1,x_2,..,x_{n-1},d_n)$ with $x_1 = x_2 =..= x_{n-1}$. Once again by T.INV we assume $d_n = x_i$, thus $E^*(S,d,c) = (x_1,..,x_n) = x$. Let d' so that $d' \leq d$ and $d'_i = d'_k$ $\forall i,k \in Q$, $d'_j = d_j$. Let $c' = (1,..,1)$ and $S' = CoCom\{ x, (d'_1,d'_2,..d'_{n-1},a_n(S,d) \}$. Thus $F(S,d',c') = x$ by (i). Applying C.MON on (S,d'c') and (S,d',c) we will have $F_n(S,d',c) \leq x_n$ and by B.D.D. we get $F_n(S,d',c) = x_n$. By ST.R.MON on the pair (S,d',c) and (S',d',c) we will have that $F(S,d',c) \leq F(S',d',c)$ and by B.D.D, $F_n(S',d',c) = x_n$. Now by AN and WPO on (S',d'c) we conclude that $F_i(S',d',c) = x_i$ $\forall i \in Q \Rightarrow F(S',d',c)=x$. Applying ST.R.MON twice to the pairs (S',d',c),(S,d',c) and (S,d',c),(S,d,c) we get F(S,d,c)=x.

(ii)-(b) If p = cardinal of P is k, we assume that F(S,d,c)= x where x = EL*(S,d,c).

(ii)-(c) Let now p=k+1. Assume that $j \in P$ $j = 1,2,..,k+1$ by AN. We take $c_i = 1$ $\forall i \in Q$ by T.INV, so $E^*(S,d,c) = (d_1,d_2,..,d_{k+1}, x_{k+2},..,x_n)$ with $x_{k+2} =....= x_n$. Once more by T.INV we assume $d_j = x_i$ $\forall j \in P$, therefore, $E^*(S,d,c) = (x_1,..,x_n) = x$. Let d' such that $d' \leq d$, and $d'_i = d'_k$ $\forall$ $i,k \in Q$, $d'_j = d_j$ $\forall j \in P$. Let c^j such that $c^j_i = 1$ $\forall i \in Q$, $c^j_j = 1$ for $j \in P$ and $c^j_k = c_k$ for $k \neq j$, $k \in P$. Finally, let $S' = CoCom\{ x, (a_1,d'_{N/(1)}), (d'_1, a_2, d'_{N/(1,2)}),...,(d'_1,..,d'_k, a_{k+1}, d'_Q)\}$. Thus, by way of the induction hypothesis [(ii)-(b)], we can conclude that $F(S,d',c^j) = x$ $\forall j =1,..,k+1$. We now take the pairs (S,d',c^j) (S,d',c) $\forall j \in P$ and by applying C.MON and B.D.D we will have $F_j(S,d',c) = d_j = x_j$ $\forall j \in P$. By ST.R.MON on (S,d',c) and (S',d',c), $F(S',d',c) \leq F(S,d',c)$ and, again, by B.D.D, $F_j(S',d',c) = x_j$ $\forall j \in P$. Now, by AN and WPO on (S',d',c), $F_i(S',d',c) = x_i$ $\forall\ i \in Q \Rightarrow$ $F(S',d',c) = x$. By applying ST.R.MON twice to pairs $(S',d',c),(S,d',c)$ and $(S,d',c),(S,d,c)$ we conclude that $F(S,d,c) = x$.

Finally, for an arbitrary element of $\sum^n$, we apply CONT. $\blacksquare$

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