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Chae, Suchan; Heidhues, Paul

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Nash Bargaining Solution with Coalitions and The Joint Bargaining Paradox

Suchan Chae *
Paul Heidhues **

* Rice University
** WZB

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Wissenschaftszentrum Berlin für Sozialforschung gGmbH,
Reichpietschufer 50, 10785 Berlin, Tel. (030) 2 54 91 – 0
Internet: www.wz-berlin.de

ABSTRACT

Nash Bargaining Solution with Coalitions and the Joint-Bargaining Paradox

by Suchan Chae and Paul Heidhues

We propose a solution for bargaining problems where coalitions are bargainers. The solution generalizes the Nash solution and allows one to interpret a coalition as an institutional player whose preferences are obtained by aggregating the preferences of the individual members. One implication of our solution is that forming a coalition is unprofitable in pure-bargaining situations (the joint-bargaining paradox). We show, however, that forming a coalition can be profitable in a non-pure bargaining situation.

Keywords: Nash bargaining solution, coalition, joint-bargaining paradox

JEL Classification: C78

ZUSAMMENFASSUNG

Die Nash Verhandlungslösung mit Koalitionen und Harsanyi's Verhandlungsparadox

In der vorliegenden Arbeit schlagen wir ein Lösungskonzept für Verhandlungsspiele vor, bei denen die verhandelnden Parteien aus Koalitionen von Individuen bestehen können. Unser Lösungskonzept basiert auf einer Verallgemeinerung der Nash-Verhandlungslösung. Nach unserem Lösungskonzept kann eine Koalition als ein institutioneller Spieler aufgefasst werden, dessen Präferenzordnung auf einer Aggregierung der Präferenzen seiner Mitglieder basiert. Eine Implikation unserer Verhandlungslösung ist, dass Koalitionen in “reinen Verhandlungsspielen” nicht im Interesse der Individuen sind. In “nicht reinen Verhandlungsspielen” hingegen können Koalitionen durchaus vorteilhaft seien.

1. INTRODUCTION

In many economic, social, and political situations, bargaining takes place between organizations, such as firms, unions, research joint ventures, NGOs, political parties, and local governments, rather than between individuals. In modeling these situations, it is natural to view such organizations as coalitions of individuals. In this paper, we propose an axiomatic bargaining solution to bargaining problems with exogenously given coalitions.

In dealing with situations where a coalition is a bargaining party, the literature on bargaining often uses two methods. In one, payoffs are assumed to be linear in a physical good or monetary unit so that the payoff of the coalition is the sum of the payoffs of its members. (See, for example, Horn and Wolinsky (1988) and Jun (1989).) In the other, bargaining is delegated to one particular member of the coalition so that the representing member's preferences become the coalition's preferences. (See, for example, Perry and Samuelson (1994), Haller and Holden (1997), Segendorff (1998), and Cai (2000).)

For a coalition to be a bargainer, it has to be equipped with preferences relevant for bargaining. If the coalition's members have heterogeneous preferences, then a question arises as to how one should aggregate the preferences of the individual members to obtain the preferences of the coalition. In this regard, the delegation approach in the literature is unsatisfactory, for it biases bargaining in favor of a chosen representative. Consider, for example, a coalition consisting of two members that negotiates with an outsider. Suppose one of the coalition's members has strong bargaining characteristics (for example, he is not very risk averse) and the other has weak bargaining characteristics (he is very risk averse). The coalition would prefer to delegate bargaining to the strong member, while the coalition's opponent would prefer to bargain with the weak player.

Here, the choice of the representing member is bound to be *ad hoc*. This is the case even if there is some internal sharing mechanism among the members of a coalition.

In this paper, we model a coalition as an institutional player whose preferences are obtained by aggregating the preferences of its members. This is done by extending the Nash solution to a bargaining model where the players are partitioned into coalitions. We add a new axiom to Nash's (1950, 1953) four axioms to treat a coalition as one bargainer. The new axiom, which will be called representation of homogeneous coalition (RHC), states that a homogeneous coalition may be replaced by a representative agent without changing the solution. Hence, if all members of the coalition have identical preferences, our approach yields the same outcome as the delegation approach. If, in addition, individual players are equipped with transferable utilities, then the payoff of a coalition is simply the sum of the payoffs of its members. In fact, most papers in which a coalition bargains use the RHC property implicitly for a homogeneous coalition. What is interesting is that combining this axiom with other standard axioms yields a solution that aggregates the preferences of a (possibly heterogeneous) coalition.

In Section 2, we show that there exists a unique solution to a pure-bargaining problem satisfying five axioms: Pareto efficiency, invariance with respect to affine transformation, independence of irrelevant alternatives, anonymity, and representation of homogeneous coalition. It turns out that our solution maximizes the weighted product of net utilities, where the weight for each player is the reciprocal of the size of the coalition to which he belongs.

In Section 3.1, we compare our solution to asymmetric Nash solution à la Kalai (1977). He remarks that an asymmetric Nash solution to a bargaining problem is equivalent to a (symmetric) Nash solution to a replicated bargaining problem. This observation provides some intuition for our solution, for replication is the inverse of the reduction process we will use in order to reduce a homogeneous coalition to a single representative player in defining the RHC property.

In Section 3.2, we look at “the joint-bargaining paradox” of Harsanyi (1977) using our solution. The paradox is that it may be unprofitable to form a larger coalition by combining smaller coalitions. Even though this might seem paradoxical at first blush, it is quite natural in pure bargaining situations where all bargainers have to agree to reach a desirable solution, that is, in situations were the resources of players are perfect complements to each other. Intuitively, a coalition loses some bargaining power that individual members had because the coalition speaks with one voice in the inter-coalition bargaining. Why do coalitions form then? To provide an answer to this question, we show that in a non-pure bargaining situation forming a coalition can be profitable.

In Section 4, some concluding remarks are provided.

2. NASH SOLUTION WITH COALITIONS

Let $N = \{1, \ldots, n\}$ denote the set of players. Then a coalition structure on N is a partition of N, denoted $C(N) = \{C_1, \ldots, C_m\}$. Let R^N and R_+^N denote an n-dimensional Euclidean space indexed by N and its nonnegative orthant, respectively. Let $S \subset R^N$ be the feasible set and $b \in R^N$ the breakdown point. Then $(C(N), S, b)$ is a bargaining problem. This generalizes the usual bargaining problem (N, S, b), where the coalition structure can be taken to be the finest partition $C(N) = \{\{1\}, \ldots, \{n\}\}$. We will use $x \geq y$, $x > y$, and $x \gg y$ to denote “$x_i \geq y_i$ for all i”, “$x \geq y$ and $x_i > y_i$ for some i”, and “$x_i > y_i$ for all i”, respectively.

Normalize the feasible set S by the breakdown point b and denote it by[1]

$$S_b = \{u - b \in R_+^N; u \in S, u \geq b\},$$

and put

$$\log S_b = \{(\log v_1, \ldots, \log v_n); v \in S_b\}.$$

We require that any bargaining problem satisfy the following three assumptions:

A1. Either $S_b = \{0\}$ or there exists some $v \in S_b$ such that $v \gg 0$.[2]

A2. S_b is compact.

A3. In the case where $S_b \neq \{0\}$, $\log S_b$ is strictly convex.[3]

A solution is a function F that associates to each bargaining problem $(C(N), S, b)$ a payoff vector $F(C(N), S, b) \in S$. Consider the following four properties of a solution:

Pareto Efficiency (PE): *There exist no* $x \in S$ *with* $x > F(C(N), S, b)$.

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[1] Harsanyi (1977) calls S_b the “agreement space”.

[2] We need the $S_b = \{0\}$ part for some degenerate sub-problems.

[3] The strict convexity of $\log S_b$ is weaker than the convexity of S.

Invariance with respect to Affine Transformation (IAT): *If* λ *is an affine transformation on* R^N *(that is, there exist some real numbers* $\alpha_1, \ldots, \alpha_n, \beta_1, \ldots, \beta_n$*, where* $\beta_1, \ldots, \beta_n > 0$*, such that* $\lambda(u) = (\alpha_1 + \beta_1 u_1, \ldots, \alpha_n + \beta_n u_n)$ *for any* $u \in R^N$*), then one has*

$$F(C(N), \lambda(S), \lambda(b)) = \lambda(F(C(N), S, b)),$$

where $\lambda(S) = \{\lambda(u) \in R^n; u \in S\}$.

Independence of Irrelevant Alternatives (IIA): *If there exists another bargaining problem* $(C(N), \tilde{S}, b)$ *such that* $\tilde{S} \subset S$ *and* $F(C(N), S, b) \in \tilde{S}$*, then* $F(C(N), \tilde{S}, b) = F(C(N), S, b)$.

The next property, anonymity, uses permutations of players. For any permutation (or one-to-one function) $\phi: N \to N$, let

$$\phi(D) = \{\phi(i) \in N; i \in D\} \text{ for any } D \subset N,$$

$$\phi(C(N)) = (\phi(C_1), \ldots, \phi(C_m)) \text{ for any partition } C(N) = \{C_1, \ldots, C_m\},$$

$$\phi(u) = (u_{\phi(i)})_{i \in N} \text{ for any } u \in R^N,$$

$$\phi(T) = \{\phi(u) \in R^N; u \in T\} \text{ for any } T \subset R^N,$$

$$\phi(C(N), S, b) = (\phi(C(N)), \phi(S), \phi(b)).$$

Anonymity (AN): *If* ϕ *is a permutation of players in N, then*

$$F(\phi(C(N), S, b)) = \phi(F(C(N), S, b)).$$

For the usual bargaining problem (N, S, b), which constitutes a special case of the above model where $C(N) = \{\{1\}, \ldots, \{n\}\}$, it is well known that there exists a unique solution that satisfies the above four properties, called the Nash solution, and that it solves the maximization problem

$$Max_{u \in S, u \geq b} \prod_{i \in N} (u_i - b_i).$$

We will generalize this result to our model.

Since the above four properties are not sufficient to produce a unique solution for the general bargaining problem with a coalition structure, we will now introduce an additional property. For any two players $i, l \in N$, let $\phi^{i,l}: N \to N$ denote a permutation such that $\phi(i) = l$, $\phi(l) = i$, and $\phi(k) = k$ for any $k \neq i, l$.

DEFINITION 1. A coalition C_j is *homogeneous* in bargaining problem $(C(N), S, b)$ if the bargaining problem is symmetric within the coalition, i.e., for any $i, l \in C_j$, one has $\phi^{i,l}(S) = S$ and $b_i = b_l$.

Suppose that coalition C_j is homogeneous in bargaining problem $(C(N), S, b)$. We will construct a reduced bargaining problem where coalition C_j is replaced by a new coalition $C_j^* = \{j^*\}$ that consists of a single representative player $j^* \in C_j$. By symmetry, it does not matter which player in C_j becomes the representative player j^*. Let $N^j = (N - C_j) \cup \{j^*\}$ and let $C(N^j)$ be the partition of N^j that is obtained from $C(N)$ by replacing C_j with $\{j^*\}$. Denote $(u_i)_{i \notin C_j} \in R_+^{N - C_j}$ by u_{-C_j}. Define the new feasible set by

$$S^j = \left\{(u_i)_{i \in N^j} \in R^{N^j};\ \text{there exists } v \in S \text{ such that } v_{-C_j} = u_{-C_j} \text{ and } v_i = u_{j^*} \text{ for all } i \in C_j\right\}.$$

For the case where $N = \{1, 2, 3\}$, $C(N) = \{\{1\}, \{2, 3\}\}$, and $j^* = 2$, Figure 1 illustrates how one transforms the original feasible set S into the reduced feasible set S^2.

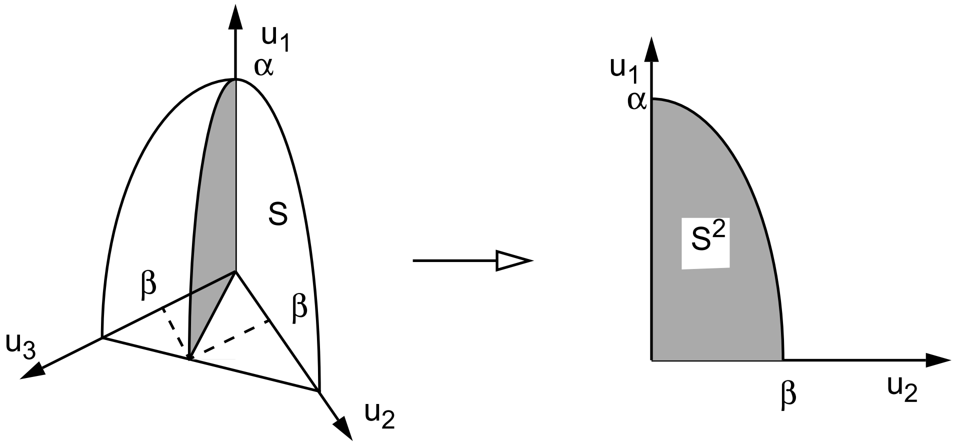

FIG. 1. Reducing feasible set

Also, define the new breakdown point $b^j \in R^{N^j}$ from $b \in R^N$ by replacing $(b_i)_{i \in C_j} \in R^{C_j}$ with $b_{j*} \in R$. Now consider the following property of a solution:

Representation of Homogeneous Coalition (RHC): If a coalition C_j is homogeneous in bargaining problem $(C(N), S, b)$, then $F_i(C(N^j), S^j, b^j) = F_i(C(N), S, b)$ for any $i \in N^j$ (where, of course, F_i denotes the *i*-th component of F).

The RHC property says that if one replaces a homogeneous coalition by a representative member, the solution does not change. In particular, it requires that the coalition be treated as one player. We will show in the Appendix

THEOREM 1. *A solution F satisfies PE, IAT, IIA, AN, and RHC if and only if F solves the maximization problem*

$$Max_{u \in S, u \geq b} \prod_{j=1}^{m} \Big(\prod_{i \in C_j} (u_i - b_i)^{1/c_j} \Big),$$

where c_j *is the size (or the number of the members) of* C_j *for* $j = 1, \ldots, m$.

We have thus extended the usual Nash solution to a more general class of bargaining problems. Note that the solution is a Nash solution within each coalition as well as across coalitions.

We can actually regard bargaining as being done simultaneously at two levels, between the members of a coalition and between coalitions. Imagine a two-stage process. Coalitions first bargain to determine the feasible set for each coalition. Once the feasible set is determined for each coalition, its members bargain to determine their shares. When coalitions bargain in the first stage, they anticipate the final payoffs that the members of coalitions will receive in the end. A coalition can be regarded as an institutional player in the inter-coalition bargaining whose preferences are obtained by aggregating the preferences of its members using the intra-coalition solution.

For the above intuitive interpretation to be meaningful, both the inter-coalition and intra-coalition bargaining problems must be well defined, that is, satisfy assumptions A1-A3. We will first describe the inter-coalition bargaining problem. Define the utility of the institutional representative, denoted *j*, of coalition C_j as the geometric average of the net utilities of its members

$$U_j(u_{C_j} - b_{C_j}) = \prod_{i \in C_j} (u_i - b_i)^{1/c_j}.$$

We can construct a bargaining game between these representatives, $j = 1, \ldots, m$. Denote $M = \{1, \ldots, m\}$. The feasible set for this inter-coalition bargaining problem can be defined as

$$S^M = \left\{ (U_j(u_{C_j} - b_{C_j}))_{j \in M} \in R^M;\ u \in S, u \geq b \right\},$$

and the breakdown point as 0. Let $C(M) = \{\{1\}, \ldots, \{m\}\}$. Then $(C(M), S^M, 0)$ is a well-defined bargaining problem satisfying A1-A3. In particular, $\log S^M$ is strictly convex as will be shown in the Appendix.

We will now describe intra-coalition bargaining problems. Denote $(u_i)_{i \in C_j} \in R_+^{C_j}$ simply by u_{C_j} and recall that $(u_i)_{i \notin C_j} \in R_+^{N - C_j}$ is denoted by u_{-C_j}. For any $u \in S$, define the projection of the cross-section of the feasible set $S \subset R^N$ on $R_+^{C_j}$ at $u_{-C_j} \in R_+^{N - C_j}$ by

$$S_{C_j}(u_{-C_j}) = \{w_{C_j} \in R_+^{C_j}; \text{there exists some } v \in S \text{ such that } v_{-C_j} = u_{-C_j} \text{ and } v_{C_j} = w_{C_j}\}.$$

Then $S_{C_j}(u_{-C_j})$ is the feasible set for coalition C_j given the payoffs u_{-C_j} of players outside the coalition. The feasible set can be normalized by the breakdown point and denoted

$$(S_{C_j}(u_{-C_j}))_{b_{C_j}} = \left\{w_{C_j} - b_{C_j} \in R_+^{C_j}; w_{C_j} \in S_{C_j}(u_{-C_j}), w_{C_j} \geq b_{C_j}\right\}.$$

It is obvious that $S_{C_j}(u_{-C_j})_{b_{C_j}}$ satisfies A2 and A3, for S_b does. Furthermore, $S_{C_j}(u_{-C_j})_{b_{C_j}}$ also satisfies A1 if u is our solution. Thus $(\{C_j\}, S_{C_j}(u_{-C_j}), b_{C_j})$ constitutes a well-defined bargaining problem at $u = F(C(N), S, b)$. It will be also shown in the Appendix that

THEOREM 2. *Let* $u = F(C(N), S, b)$. *Then*

(i) $F(C(M), S^M, 0) = (U_j(u_{C_j} - b_{C_j}))_{j \in M}$,

(ii) $F(\{C_j\}, S_{C_j}(u_{-C_j}), b_{C_j}) = u_{C_j}$.

The theorem may be called “the reduction theorem”. It says that (i) the solution of the inter-coalition bargaining is the same as the vector of “utilities” of the coalitions at our solution, and (ii) the solution of an intra-coalition bargaining, given the payoffs of outsiders at our solution, is the same as our solution. Together, (i) and (ii) show that the bargaining problem can be conceptually decomposed into two levels of bargaining.

Note that (ii) is similar to the reduction property of the Nash solution, often called “consistency” or “stability” in the literature. (See Harsanyi (1959, 1977) and Lensberg (1988) who use different versions of the reduction property as an axiom to characterize the Nash solution.[4]) In our solution, however, reduction is allowed not for any coalition but only for coalitions that belong to the given coalition structure $C(N) = \{C_1, \dots, C_m\}$.

We emphasize here that even though the RHC property only prescribes how a solution should treat homogeneous coalitions, the combination of the RHC property with the other four properties allows our solution to cover heterogeneous coalitions. For the heterogeneous case, our solution calls for aggregating the preferences of the members of a coalition.

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[4] Aumann and Maschler (1985) use consistency in the context of bankruptcy problems, and Moulin (1985) and Young (1987) in the context of cost-allocation problems. See Thomson (1990) for a survey on the use of consistency in the literature.

3. DISCUSSIONS ON THE SOLUTION

3.1. *Asymmetric Solution à la Kalai*

In order to gain some insights into the nature of our solution, let us now compare it with an "asymmetric Nash solution" that solves the maximization problem

$$Max_{u \in S, u \geq b} \prod_{i \in N} (u_i - b_i)^{\alpha_i}$$

for some $\alpha_i > 0 \, (i = 1, \ldots, n)$. Nash would have rejected a solution of this form on the ground that symmetry is required of a solution if players are rational, as the following paragraph from Nash (1953), quoted verbatim, shows:

> 'The symmetry axiom, Axiom IV, says that the only significant (in determining the value of the game) differences between the players are those which are included in the mathematical description of the game, which includes their different sets of strategies and utility functions. One may think of Axiom IV as requiring the players to be intelligent and rational beings. But we think it is a mistake to regard this as expressing "equal bargaining ability" of the players, in spite of a statement to this effect in "The Bargaining Problem" [2]. With people who are sufficiently intelligent and rational there should not be any question of "bargaining ability," a term which suggests something like skill in duping the other fellow. The usual haggling process is based on imperfect information, the hagglers trying to propagandize each other into misconceptions of the utilities involved. Our assumption of complete information makes such an attempt meaningless.'

Observe that there is nothing asymmetric in our solution. The solution actually satisfies anonymity, which captures Nash's idea of symmetry, but allows for coalitions to play a role. The difference between our solution and Nash's solution only reflects the coalition structure that has been included as an additional element in the mathematical description of the game.

Kalai (1977), however, makes an interesting observation on asymmetric Nash solution that could provide some intuition for our solution. He remarks that an asymmetric Nash solution to a bargaining problem is equivalent to a (symmetric) Nash solution to a replicated bargaining problem. Replication is the inverse of the reduction process we used in order to reduce a homogeneous coalition to a single representative player in defining the RHC property. We will now compare the asymmetric Nash solution *à la* Kalai to our solution.

For simplicity, consider two bargaining problems, $(\{\{1\},\{2\}\}, S, (0,0))$ and $(\{\{1\},\{2,3\}\}, \tilde{S}, (0,0,0))$, where $S \subset R^2$ and $\tilde{S} = \{(x,y,y) \in R^3; (x,y) \in S\}$. The three-person bargaining problem is obtained from the two-person bargaining problem by replicating player 2 into a homogeneous coalition {2,3}. Putting it in another way, the two-person problem is obtained from the three-person problem by reducing the homogeneous coalition {2, 3} to a single representative player, that is, player 2. Intuitively, players 2 and 3 are “twin brothers” who support each other.

In characterizing a two-person asymmetric Nash solution, Kalai remarks that (x, y) is a solution to

$$Max_{(u_1, u_2) \in S}\ u_1 \cdot (u_2)^2$$

if and only if (x, y, y) is a solution to

$$Max_{(u_1, u_2, u_3) \in \tilde{S}}\ u_1 \cdot u_2 \cdot u_3\ .$$

On the other hand, in characterizing our three-person solution, we remark that (x, y, y) is a solution to

$$Max_{(u_1,\, u_2,\, u_3) \in \tilde{S}}\ u_1 \cdot (u_2)^{1/2} \cdot (u_3)^{1/2}$$

if and only if (x, y) is a solution to

$$Max_{(u_1,\, u_2) \in S}\ u_1 \cdot u_2\ .$$

Suppose $S = \{(x, y) \in R_+^2;\ x + y \le 1\}$ so that $\tilde{S} = \{(x, y, y) \in R_+^3;\ x + y \le 1\}$. Then the asymmetric Nash solution to the two-person problem and the (symmetric) Nash solution to the three-person problem are $(1/3, 2/3)$ and $(1/3, 2/3, 2/3)$, respectively, while our solutions to these problems are $(1/2, 1/2)$ and $(1/2, 1/2, 1/2)$, respectively. The crucial difference is that in Kalai's framework, twin brothers maintain their separate rights to talk, while in our framework, they really become one bargainer.

3.2. *Joint-Bargaining Paradox*

One interesting implication of our bargaining solution is that it may be unprofitable to form a coalition in pure bargaining problems as can be seen easily from the following example:

EXAMPLE 1. Consider a pure-bargaining situation where $N = \{1, 2, 3\}$, $S = \{(x, y, z) \in R_+^3;\ x + y + z \le 1\}$, and $b = 0$ with two alternative coalition structures on *N*: $C(N) = \{\{1\}, \{2\}, \{3\}\}$ and $C^*(N) = \{\{1, 2\}, \{3\}\}$. One has

$$F(C(N), S, b) = \left(\frac{1}{3}, \frac{1}{3}, \frac{1}{3}\right),$$

$$F(C^*(N), S, b) = \left(\frac{1}{4}, \frac{1}{4}, \frac{1}{2}\right).$$

In this example, if all three players bargain independently, they split the joint payoff equally so that each player obtains 1/3. But if players 1 and 2 act as one player, the game becomes a two-person game between the coalition {1, 2} and player 3 so that each bargaining party obtains 1/2. Within the coalition, players 1 and 2 further split the joint payoff 1/2. Regarding (essentially) this example, Harsanyi (1977) says

> ‘Clearly we will obtain a similar result in *all n*-person simple bargaining games if two or more players decide to act as one player (except in the trivial case in which *all n* players participate in this agreement). We call this the joint-bargaining paradox. This paradox is not attributable to some peculiarity of our solution concept, because *any* possible solution concept will show this behavior if it satisfies the symmetry and the joint-efficiency postulates (which are obviously necessary ingredients of any acceptable solution for simple bargaining games).’

Harsanyi gives two alternative interpretations for the paradox presuming that actual bargaining is carried out by a representative on behalf of a coalition: (i) the representative of a coalition may be more cautious because she has to represent others; (ii) the representative’s incentive is affected because she has to hand over part of any gain to other members. Our interpretation for the paradox is that forming a larger coalition reduces multiple “rights to talk” to a single right and thereby benefits the outsiders. (See, for example, Horn and Wolinsky (1988) for a similar interpretation.) In pure bargaining situations, where all bargainers have to agree to reach a settlement, fewer rights to talk means reduced bargaining power.

One might ask if joining a larger coalition makes *all* participants worse off under our solution. The answer is no as the following example shows:

EXAMPLE 2. Consider a pure-bargaining situation where $N = \{1, \dots, 5\}$, $S = \{(x_1, \dots, x_5) \in R^5_+; x_1 + \dots + x_5 \le 1\}$, and $b = 0$ with two alternative coalition structures on N: $C(N) = \{\{1\}, \{2, 3, 4\}, \{5\}\}$ and $C^*(N) = \{\{1, 2, 3, 4\}, \{5\}\}$. One has

$$F(C(N), S, b) = \left(\frac{1}{3}, \frac{1}{9}, \frac{1}{9}, \frac{1}{9}, \frac{1}{3}\right),$$

$$F(C^*(N), S, b) = \left(\frac{1}{8}, \frac{1}{8}, \frac{1}{8}, \frac{1}{8}, \frac{1}{2}\right).$$

In this example, if player 1 joins the coalition {2, 3, 4}, then the coalition {2, 3, 4} benefits from the merger. Player 1, however, gets worse off. In general, there is always someone who will get worse off and thus has no incentive to join the coalition as the next theorem shows. Thus a coalition will not form voluntarily in a pure-bargaining situation. We will show in the Appendix

THEOREM 3. *Consider a pair of bargaining problems $(C(N), S, b)$, $(C^*(N), S, b)$, where the partition $C(N)$ has at least three coalitions and $(C^*(N), S, b)$ is obtained from $(C(N), S, b)$ by merging coalitions C_1 and C_2 into $C_{1,2}$. Suppose $F(C(N), S, b) \ne F(C^*(N), S, b)$. Then there exists some player $i \in C_{1,2}$, for whom $F_i(C(N), S, b) > F_i(C^*(N), S, b)$.*

That acting as one unit is not necessarily profitable is also well known in a non-bargaining context. In a market context, for example, Salant, Switzer, and Reynolds (1983) observe that a merger in a Cournot model can decrease the profits of the merging firms while increasing the profits of the outsiders.[5] This “merger paradox” occurs because acting as one unit decreases merging firms’ market share.

In some other market models, such as the Bertrand model of Deneckere and Davidson (1985), forming a coalition is profitable. In a market context, not only the division but also the size of the pie (that is, industry profits) changes due to a merger. Thus if the increase in overall industry profits is sufficiently large, a merger can be profitable. In our pure-bargaining problem, however, the size of the pie is not affected by coalition formation, and thus forming a coalition is always unprofitable.

According to Theorem 3, forming a coalition is not profitable in pure-bargaining situations. Why would a coalition form then? One answer may be that many real-life bargaining situations are not pure-bargaining situations. In a non-pure bargaining situation, it can be profitable to form a coalition. The reason is that forming a coalition can improve the fall-back positions of the coalition members.

EXAMPLE 3. Consider a pure-bargaining situation where $N = \{1, 2, 3\}$, $S = \{(x, y, z) \in R_+^3;\ x + y + z \le 1\}$, and $b = (0, 0, 0)$. Now, suppose that if players 1 and 2 form a coalition, they can select, without involving player 3, a point in

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[5] See also Farrell and Shapiro (1990).

$S_{\{1,2\}} = \{(x, y) \in R_+^2;\ x + y \leq r\}$, where $r \in [0, 1]$. The solution to this bargaining problem between 1 and 2 is $F(\{\{1\}, \{2\}\}, S_{\{1,2\}}, (0, 0)) = (r/2, r/2)$, which can be taken as the fall-back positions of the members of the coalition in the overall bargaining problem. Now consider two alternative coalition structures on *N*: $C(N) = \{\{1\}, \{2\}, \{3\}\}$ and $C^*(N) = \{\{1, 2\}, \{3\}\}$. One has

$$F(C(N), S, (0, 0, 0)) = \left(\frac{1}{3}, \frac{1}{3}, \frac{1}{3}\right),$$

$$F(C^*(N), S, (r/2, r/2, 0)) = \left(\frac{r}{2} + \frac{1-r}{4}, \frac{r}{2} + \frac{1-r}{4}, \frac{1-r}{2}\right).$$

Thus, if $r > 1/3$, one has

$$F_i(C(N), S, (0, 0, 0)) < F_i(C^*(N), S, (r/2, r/2, 0)) \text{ for } i \in \{1, 2\}.$$

In this example, it is profitable for players 1 and 2 to form a coalition if $r > 1/3$. When players 1 and 2 decide whether or not to form a coalition, they face a trade-off. On the one hand, as in the pure-bargaining case, forming a coalition reduces the rights to talk of the two players to a single right. On the other hand, the incremental pie over which the coalition bargains with the outsider (player 3) is reduced because the coalition members can secure part of the benefit of cooperation without the outsider's participation. This tends to put the coalition's members in a stronger bargaining position.

4. CONCLUDING REMARKS

In this paper, we introduced an axiomatic solution to pure bargaining problems with exogenous coalitions. The crucial axiom was *representation of homogeneous coalition*, which states that a homogeneous coalition can be replaced by one of its members without changing the solution. The combination of this axiom, which most papers in the literature where coalitions are bargainers have been implicitly using, with other standard axioms led to a solution that allowed us to interpret a (possibly heterogeneous) coalition as an institutional player whose preferences are obtained by aggregating the preferences of its members.

We compared our solution with Kalai's asymmetric Nash solution. We also examined Harsanyi's joint-bargaining paradox under our solution. Specifically, we showed that forming a coalition is unprofitable in pure-bargaining situations but that it can be profitable in non-pure bargaining situations.

Our solution is an ideal solution where the coalition's preferences fully reflect the members' preferences. This points to both the strength and weakness of the solution. In the real world, forming a negotiating entity, perhaps supported by appropriate contractual arrangements, that can negotiate faithfully on behalf of all of its members is a tall order. On the other hand, an institution that does not reflect the preferences of its constituency to some extent would not be politically viable.

From the modeling point of view, our solution can be used as a benchmark with which other solutions can be compared. In our solution, the members of a coalition act as one player consolidating their individual "rights to talk" into a single right to talk. In future research, one may think about some intermediate solutions where the members’ rights to talk are reduced but not necessarily into a single right. For instance, a simple majority of the members may be able to veto a deal.[6]

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[6] In a recent working paper, Manzini and Mariotti (2001) analyze the effect of various collective decision mechanisms on bargaining behavior in an alternating-offer game between a player and an “alliance”.

APPENDIX: PROOFS

Proof of Theorem 1. Denote the solution to the maximization problem by $F^N(C(N), S, b)$. It is obvious that this solution satisfies PE, IAT, AN, IIA, and RHC. Thus we only need show that if a solution F satisfies PE, IAT, AN, IIA, and RHC, then $F = F^N$. We do this in two steps. First, we show that $F = F^N$ holds for a class of bargaining problems using PE, AN, and RHC. Then we generalize this to any bargaining problem using IAT and IIA.

Consider a class of bargaining problems that are not only symmetric within any coalition but also such that the reduced bargaining problem where each coalition is replaced by a representative player is also symmetric. Then by PE and AN, the solution to the reduced bargaining problem prescribed by F is the symmetric solution. By RHC, the solution to the original problem prescribed by F is also the symmetric solution. Since the symmetric solution is the only solution that satisfies PE, AN, and RHC and F^N also satisfies these axioms, F and F^N prescribe the same solution for the class of bargaining problems we are considering. Consider a subclass of such bargaining problems where $b = 0$ and the symmetric solution is $e = (1, \ldots, 1)$. These bargaining problems will be called simple bargaining problems.

Now consider any bargaining problem $(C(N), S, b)$ such that $S_b \neq \{0\}$. Then by A1, $F^N(C(N), S, b) \gg b$. Let λ be an affine transformation such that $\lambda(b) = 0$ and $\lambda(F^N(C(N), S, b)) = e$.[7] Note that $\lambda(S)_{\lambda(b)} = \lambda(S_b)$. It is easy to see that $\lambda(S_b)$ contains $e \gg 0$ and that $\lambda(S_b)$ is compact. Since $\log S_b = \{(\log y_1, \ldots, \log y_n); y \in S_b\}$ is strictly convex,

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[7] Note that λ is well defined since $F^N(C(N), S, b) \gg b$.

the set $\log(\lambda(S_b)) \equiv \{(\log y_1, \ldots, \log y_n) \in R^N; y \in \lambda(S_b)\}$ is also strictly convex. (An affine transformation of S_b amounts to adding a constant vector to $\log S_b$.) Thus $\lambda(S_b)$ satisfies A1-A3. Therefore, $(C(N), \lambda(S), 0)$ is a well-defined bargaining problem.

Since $e = \lambda(F^N(C(N), S, b)) = F^N(C(N), \lambda(S), 0)$ and $\log(\lambda(S_b))$ is strictly convex, there exists some simple bargaining problem $(C(N), T, 0)$ such that $\lambda(S) \subset T$. By IIA, $F(C(N), \lambda(S), 0) = F(C(N), T, 0) = e$. Thus, by IAT, $F(C(N), S, b) = F^N(C(N), S, b)$.

If $S_b = \{0\}$, then $F^N(C(N), S, b) = b$. It is easy to see that the axioms also imply $F(C(N), S, b) = b$. ▮

***Proof of the Strict Convexity of* $\log S^M$**. Let $V, W \in \log S^M$. Then

$$V = \left(\log \prod_{i \in C_j} v_i^{1/c_j}\right)_{j \in M} \text{ and } W = \left(\log \prod_{i \in C_j} w_i^{1/c_j}\right)_{j \in M}$$

for some $v, w \in S_b$. Let $\alpha \in (0, 1)$. Then

$$\alpha V + (1-\alpha)W = \left(\frac{1}{c_j}\sum_{i \in C_j}\{\alpha \log v_i + (1-\alpha)\log w_i\}\right)_{j \in M} = \left(\frac{1}{c_j}\sum_{i \in C_j}\log z_i\right)_{j \in M}$$

for some $z \in S_b$ by the convexity of $\log S_b$. Thus

$$\alpha V + (1-\alpha)W = \left(\log \prod_{i \in C_j} z_i^{1/c_j}\right)_{j \in M} \in \log S^M.$$

That is, $\log S^M$ is convex.

In order to show that $\log S^M$ is strictly convex, one needs to show that all boundary points of $\log S^M$ are extreme points. Suppose to the contrary that there exist points $V, W \in \log S^M$ such that $\frac{1}{2}V + \frac{1}{2}W$ is a boundary point. There exist $v, w \in S_b$ such that

$$V = \left(\log \prod_{i \in C_j} v_i^{1/c_j}\right)_{j \in M} \text{ and } W = \left(\log \prod_{i \in C_j} w_i^{1/c_j}\right)_{j \in M}.$$

One has

$$\frac{1}{2}V + \frac{1}{2}W = \left(\frac{1}{c_j}\sum_{i \in C_j}\left\{\frac{1}{2}\log v_i + \frac{1}{2}\log w_i\right\}\right)_{j \in M}.$$

Since $\log S_b$ is strictly convex, the vector $((1/2)\log v_i + (1/2)\log w_i)_{i \in N}$ is an interior point of $\log S_b$. Since the function $f(x) = ((1/c_j)\Sigma_{i \in C_j} x_i)_{j \in M}$ from R^N to R^M maps open sets onto open sets, $(1/2)V + (1/2)W$ is an interior point of $\log S^M$. This leads to a contradiction. ▮

Proof of Theorem 2. By Theorem 1, $F(C(M), S^M, 0)$ is the solution to the maximization problem

$$Max_{V \in S^M} \prod_{j \in C_j} V_j.$$

In other words,

$$F(C(M), S^M, 0) = (U_j(u_{C_j} - b_{C_j}))_{j \in M},$$

where $u \in S$ is the solution to the maximization problem

$$\begin{aligned} & Max_{u \in S, u \geq b} \prod_{j \in M} U_j(u_{C_j} - b_{C_j}) \\ & = Max_{u \in S, u \geq b} \prod_{j \in M} \left(\prod_{i \in C_j} (u_i - b_i)^{1/c_j} \right), \end{aligned}$$

that is, $u = F(C(M), S^M, 0)$. This proves (i).

We will now show that (ii) holds. Let $u = F(C(N), S, b)$ and $v_{C_j} = F(\{C_j\}, S_{C_j}(u_{-C_j}), b_{C_j})$. Then $u = (u_{C_j}, u_{-C_j})$ is the solution to

$$Max_{w \in S, w \geq b} \prod_{k \in M} \left(\prod_{i \in C_k} (w_i - b_i)^{1/c_k} \right),$$

and v_{C_j} is the solution to

$$Max_{w_{C_j} \in S_{C_j}(u_{-C_j}), w_{C_j} \geq b_{C_j}} \prod_{i \in C_j} (w_i - b_i)^{1/c_j},$$

which is equivalent to

$$Max_{w \in S, w \geq b, w_{-C_j} = u_{-C_j}} \prod_{k \in M} \left(\prod_{i \in C_k} (w_i - b_i)^{1/c_k} \right).$$

Therefore, $v_{C_j} = u_{C_j}$. ■

Proof of Theorem 3. For brevity, let $x_i \equiv \log F_i(C(N), S, b)$ and let $y_i \equiv \log F_i(C^*(N), S, b)$. Since $F(C(N), S, b) \neq F(C^*(N), S, b)$, it follows from the definition of our solution that

$$\begin{aligned} &\frac{1}{c_1}\sum_{i \in C_1} x_i + \frac{1}{c_2}\sum_{i \in C_2} x_l + \sum_{C_j \in C(N) - C_1 - C_2} \left(\frac{1}{c_j}\sum_{i \in C_j} x_i\right) \\ &> \frac{1}{c_1}\sum_{i \in C_1} y_i + \frac{1}{c_2}\sum_{i \in C_2} y_l + \sum_{C_j \in C(N) - C_1 - C_2} \left(\frac{1}{c_j}\sum_{i \in C_j} y_i\right), \end{aligned}$$

and that

$$\begin{aligned} &\frac{1}{c_{1,2}}\sum_{i \in C_{1,2}} x_i + \sum_{C_j \in C(N) - C_1 - C_2} \left(\frac{1}{c_j}\sum_{i \in C_j} x_i\right) \\ &< \frac{1}{c_{1,2}}\sum_{i \in C_{1,2}} y_i + \sum_{C_j \in C(N) - C_1 - C_2} \left(\frac{1}{c_j}\sum_{i \in C_j} y_i\right). \end{aligned}$$

Subtracting the second equation from the first and rewriting yields (using $c_{1,2} = c_1 + c_2$)

$$\left(\frac{1}{c_1} - \frac{1}{c_1 + c_2}\right)\sum_{i \in C_1} (x_i - y_i) + \left(\frac{1}{c_2} - \frac{1}{c_1 + c_2}\right)\sum_{i \in C_2} (x_i - y_i) > 0,$$

and hence either $\sum_{i \in C_1} (x_i - y_i) > 0$ or $\sum_{i \in C_2} (x_i - y_i) > 0$, which implies that there exists some player $i \in C_{1,2}$ for whom $x_i > y_i$. ▮

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