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ABSTRACT

Self-enforcing Norms and the Efficient Non-cooperative Organization of Clans

We study how norms can solve distributional conflict inside a clan and the efficient coordination of collective action in a conflict with an external enemy. We characterize a fully non-cooperative equilibrium in a finite game in which a self-enforcing norm coordinates the members on efficient collective action and on a peaceful distribution of the returns of collective action.

JEL Classification: D72, D74, H11 and H41
Keywords: collective action, defence, distributional conflict, free-riding, norms and war

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1 Introduction

The formation of the state is typically seen as the institutional answer that overcomes the free-rider problem associated with collective goods such as defence against external enemies. Individuals join in a 'social contract', delegate the task of the provision of collective goods to a government and endow the government with the coercive power to collect the resources necessary for these public goods. Some writers have discussed the role of agents who either as monopolists or as competitors, act as providers of protection. Olson (1993) shows that the monopoly outcome may be an improvement over an anarchic state, but this need not be the case, particularly if there is a contest for the position of the enforcer of property rights (Konrad and Skaperdas 1999, Skaperdas 2002, Moselle and Polak 2001).

We contrast these analyses with a framework that is also fully non-cooperative, but in which a group of players coordinates successfully to achieve efficient collective actions and an equitable distribution of the total group revenue among the group members. We show that this outcome is feasible even though the general conditions for such an outcome are not very favourable. There is no institution that could grant property rights or enforce contracts; players interact in a finite game with complete information in a fully non-cooperative context; each player has a technology at his disposal that can be used to engage in an appropriation contest, and efficient bargaining is ruled out.

The outcome we describe has several attractive features. First, a fully efficient first-best outcome for the collective goods problem is implemented in a purely non-cooperative framework. Second, all members of the group receive some –possibly the same– share in the group's income. This share can be seen as a compensation for the member's contribution to collective action, but is not part of a formal contract and is paid in a way that does not involve any promise or commitment by the recipient. Third, group size is meaningful. Larger groups are more effective in their defence activities. Increasing returns in group size emerges endogenously from the assumption that each individual player's cost of defence effort is convex in own effort. Fourth, despite these increasing returns, there is an optimal group size that maximizes the group members' returns per capita. Fifth, the framework offers an explanation for why some clans, groups, or states perform very well whereas others perform very badly. The analysis provides an example of the functioning, importance and implicit enforcement of norms: the implementation of the efficient collective action requires all players to have a common view about their appropriate contribution to the collective good and an appropriate or equitable distribution of rents. Deviation from these norms by a single player may induce a shift from one equlibrium to another, less attractive one.

In the economic literature, early contributions by Nitzan (1991) and Davis and Reilly (1999) consider the implications of different rules governing a peaceful distribution of resources inside the group for the willingness of group members to make voluntary contributions to group effort. These rules and the peacefulness of distribution inside the group are taken as given in these frameworks. Their work shows from a group perspective the importance of merit rules as incentive instruments. Work by Katz and Tokatlidu (1996), Wärneryd (1998) and Müller and Wärneryd (2001) highlights that peaceful allocation rules inside the group cannot be taken for granted. Their work focuses on the role of hierarchies of conflict, with a conflict between groups, followed by a conflict among the members of the victorious group for the amount of overall resources spent on appropriation effort in the equilibrium.[1] This literature takes as given that a peaceful settlement is not feasible, or that the cost of effort emerges in terms of building up threats for an upcoming conflict which may then be settled. Hence, players may have to spend and sacrifice resources, either by building up a threat, or in the actual conflict. Most recently, the aim of contributions by Falkinger (2006) and Sánchez-Pagés and Straub (2006) is to explain the endogenous emergence of norm enforcement institutions by agents' voluntary costly contributions to their formation. They assume an enforcement technology as given. While Falkinger (2006) does not perform a game-theoretic analysis, Sánchez-Pagés and Straub (2006) analyse subgame perfect equilibria of a repeated game with strong - exogenously given - commitment power of agents. In contrast, our analysis strictly applies non-cooperative game theory in order to explain the emergence of cooperative peaceful behavior within a group or clan. The absence of any coordinating devices (like enforcement institutions) results in a multiplicity of equilibria, all of which have in common that a "peace dividend" is distributed among clan members in a conflict-free way.

In political science there has been careful discussion of whether, and how,

[1] This structure has been studied further by Glazer (2002) who discusses the cost and benefit of group members who are highly efficient fighters. They benefit the group in the conflict with rival groups, but they also appropriate a larger share in whatever the group wins.

violent conflict can or cannot be avoided in the context of the theory of rational approaches to studying war. From this literature it turns out (see, e.g., Fearon 1995) that problems of asymmetric information and commitment problems are the keys to explaining why conflict may take place, despite its obvious inefficiency compared to a peaceful settlement. However, as explained by Slantchev (2003), multiplicity of equilibrium and differences in the desirability of reaching one or other equilibrium, together with expectations about which action triggers which equilibrium may lead to actual conflict. Conceptually, Slantchev's analysis is closest to ours. We use the fact that multiple equilibria may exist with respect to the internal order of a clan or state. Different histories, hence, may lead to different equilibria, and this may induce individuals to overcome the free-riding incentives. They may choose efficient collective action, both with respect to the formation of military force to defend the group against outside enemies and with respect to a consensual distribution of the group income in a fully non-cooperative way, because this history of choices may trigger a collectively more attractive equilibrium.

2 The analytic framework

Consider a group, or clan that consists of a set N of n members. They interact with an outside enemy in an external conflict, and they interact inside.

We first study interaction inside. The members need to solve the problem of how to share the clan's income between them. One may think of the prize as an amount of a homogenous and universal good, or simply an amount of money, whose size we normalize to $V = 1$. The clan members may fight about this amount or settle. However, as all clan members are endowed with the means to fight about resources, any contractual relationships or simple bargaining concepts that also require commitment to some bargaining rules[2]

[2]If violent means for appropriation are available, even 'non-cooperative' bargaining requires a considerable amount of commitment: the acceptance of certain rules, the commitment abstain from using other, more violent, means of appropriation during the negotiations, or ex post, once a mutually agreed deal is struck and the surplus is divided. Why rational agents use violence in a conflict instead of negotiating peacefully has ben analysed most carefully in international politics (see Fearon (1995) for an overview.) Slantchev (2003) highlights the views of Clausewitz and of Schelling on war. They consider war itself as a bargaining process.

are ruled out as a settlement outcome. The outcome is determined in a fully non-cooperative framework in which players can, and may, use effort in trying to appropriate the prize for themselves in a contest where the amount of appropriation effort chosen by the players determines the allocation of the prize.

The internal governance structure is anticipated when the clan has the opportunity to acquire, or faces the threat of losing, some amount of income in a contest with an external enemy. In this external conflict the clan members must decide about their contribution to the total military effort. We turn to this external conflict having solved the internal allocation problem to which we turn now.

3 Inside the clan

Consider a clan that owns some income $V = 1$, for instance, as a result of winning an external conflict with an enemy. The allocation of this prize among its members is governed as follows. A conflict technology determines who receives the income.[3] Each clan member i can choose effort x_i, and the income is awarded to the player who spends the highest effort. More formally, let M denote the set of clan members j for which $x_j \geq x_k$ for all $k \in N$, and let $\#M$ be the number of members in M. The probability that j wins the conflict is a function of all contestants' efforts, and is denoted as

$$p_i = p_i(x_1, x_2, ...x_n) = \frac{1}{\#M} \text{ if } i \in M \text{ and } p_i = 0 \text{ otherwise.} \tag{1}$$

The process that eventually leads to this allocation follows a game with several stages. In a first stage, G1, one designated player 1 is allowed to distribute non-negative payments $(a_2, a_3, ...a_n)$ to the other group members. We denote

$$\mathbf{a} \equiv (a_2, a_3, ...a_n) \text{ and } a \equiv \sum_{j=2}^{n} a_j. \tag{2}$$

This player owns sufficient resources to make these payments, where $a_j \in [0, V]$ can be assumed without restricting generality. We call player 1 the

[3] The all-pay auction describes the limiting case of a very broad class of allocation rules that describe the the outcome of a contest in which a given group of players fight about how to distribute a given rent among themselves. It has been used in many contexts and compared to other contest success functions, has nice properties that simplify the analysis.

clan leader. Payments take place at stage G1, and are fully unconditional: members who receive a payment do not, and cannot, promise anything in exchange for the payment, and simply follow their own narrow interests in subsequent decision making. These payments also do not alter the set of possible actions to be taken by any clan member in the future. For simplicity, we assume that these payments are public information; all payments are observed by all members.[4] Note, however, that payments can change the behavior of a player who is indifferent about his own future actions, or change players' expectations if there are multiple equilibria in the continuation game. The payments may therefore drive the selection between a peaceful equilibrium and violent fights inside the clan.

In stage G2, each member decides about the timing of his own effort choice, building on Baik and Shogren (1992), Baik (1994, 2005) and Leininger (1993). There are two different points in time, early (e) and late (l). Each clan member must decide whether to make his effort choice at one of these points of time; $e$arly or $l$ate. If he chooses e, he cannot reduce or increase his effort choice at a later point in time l. Hence, clan members who choose e give members who choose l the opportunity to react to their effort choices. Members who choose e are Stackelberg leaders with respect to all who choose l.[5]

In stage G3, the point in time e is reached. At this point all observe their own and others' choices of timing.[6] Anyone who decided to make his effort

[4]This is mainly to be able to continue with a game with complete information. For the sake of the argument, it would be sufficient if each clan member observed his own a_j.

[5]To illustrate, consider a clan which receives some amount of outside income which is contested among clan members, but in which each clan member also owns and tills his own piece of land. Let each clan member have two units of time, say, two months, before the winter season starts. He needs one month for tilling the ground, leaving him at most one month's time to spend on engaging in intra-group conflict (e.g., he may literally produce weapons or spend time to conspire with others, or to persuade others etc.). A clan member who does not till his ground in the first month will need to do this in the second month, as otherwise he sacrifices one year's return on his land, so he is commited not to spend his time on arming in the second month. A clan member who uses the first month for tilling the ground, commits to a late choice of contest effort, as he can choose how much of the second month to use to spend on contest effort. As will turn out, the contestants who choose e will not spend effort. Hence, in more general terms, the choice of e can be seen as a player's choice to delay unavoidable activities to the late period, preventing him from using this time in the late period for contest effort.

[6]Note that this assumption is not needed. For the results in Proposition 1 to hold it is necessary only that the choice of e or l becomes common knowledge among all clan

choice at e chooses his x_i simultaneously with all others who made this same timing decision. Effort cost is quadratic in effort, and we denote i's cost as

$$C_i(x_i) = c_i x_i^2. \tag{3}$$

Clan members can, but need not, be symmetric. Generally we will assume that they may differ with respect to their cost of generating contest effort, and consider them sorted and numbered such that $c_1 \leq c_2 \leq ... \leq c_n$. Note that this together with the description of stage G1 implies that the leader has the lowest cost of contest effort.

In stage G4, the point of time l is reached. All observe the effort choices made by clan members who made this choice at time e. All others now decide simultaneously about their own efforts. The cost of a given amount of effort is the same whether chosen at e or at l and is described by the quadratic cost function (3). Recall that members who chose time e cannot revise their effort choices at time l. Once all effort choices are made, the prize is allocated according to the contest success function (1), and this constitutes stage G5 and has already been outlined.

The following lemma describes the equilibrium of the subgame starting in stage G3.

Lemma 1 *The subgame starting at stage G3 has unique equilibrium payoffs for any given choices $t_j \in \{e, l\}$. Payoffs are characterized as follows:*

$$\pi_j = a_j \text{ for all } j = 2, ...n, \text{ and} \tag{4}$$

$$\pi_1 = \begin{cases} 1 - \sum_{j=2}^{n} a_j & \text{if } t_1 = l \quad \text{and } t_j = e \text{ for all } j = 2, ...n \\ 1 - \frac{c_1}{c_{j_{\min}}} - \sum_{j=2}^{n} a_j & \text{if } t_1 = l \text{ and} \quad \text{if } t_j = l \text{ for some } j = 2, ...n \\ & \quad \text{with } c_{j_{\min}} \equiv \min\{c_j \,| t_j = l, j \neq 1\} \\ 1 - \frac{c_1}{c_2} - \sum_{j=2}^{n} a_j & \text{if } t_1 = e \end{cases} \tag{5}$$

The result is proven in Konrad and Leininger (2005), who combine and extend results of Baye, Kovenock and de Vries (1996) and Kaplan, Luski and Wettstein (2003). Intuitively, if $t_1 = l$ and $t_j = e$ for all $j = 2, ...n$, then it makes no sense for j to spend positive effort, as any effort that costs j less than the value of the prize will be overbid by player 1 in the last round. Player

members prior to l, which is consistent with the idea that a choice of e essentially means that a player delays mandatory duties to the future, and hence, commits to not using this future time for producing contest effort.

1 wins without any significant effort and his payoff equals the value of the prize, minus his unconditional payments from stage G1. Moreover, players $2, ...n$ receive nothing but the unconditional payment a_j. This explains the first line in (5). A similar argument applies whenever player 1 chooses $t_1 = l$. All players who choose $t_j = e$ will not spend positive effort, because they cannot win a positive payoff by any positive effort choice. However, player 1 will be in a contest with other players who also chose $t_j = l$. Given $x_j = 0$ by all players who choose $t_j = e$, the contest essentially reduces to a simultaneous contest among the group of players k who chose $t_k = l$. The equilibrium outcome of this simultaneous contest is well known. Only the two players with the lowest cost parameter bid positive effort, which is player 1 and player $j_{\min}$. The equilibrium is in mixed strategies, and some of the prize will be dissipated. For quadratic cost, $\frac{c_1}{c_{j_{\min}}}$ is the share that is dissipated. Finally, if player 1 chooses $t_1 = e$, one can distinguish two cases. If $j = 2$ chooses $t_j = l$, then the player 1 with the lowest cost can pre-empt player 2 by a sufficiently high bid $x_1 = \frac{1}{\sqrt{c_2}}$, which just yields the payoff $(1 - \frac{c_1}{c_2})$. If, instead, $j = 2$ chooses $t_j = e$, then things are more complicated and the equilibrium strategies take into account that players with $t_k = l$ may overbid low effort levels, but the same intuition gets through: $j = 2$ is the main competitor for player 1 and induces a dissipation equal to $\frac{c_1}{c_2}$. In particular, $j = 1$ can always attain at least $(1 - \frac{c_1}{c_2})$ by a choice $x_1 = 1/\sqrt{c_2}$, as no other player will ever reasonably choose a higher effort. This limits his payoff from below, and, with some formal effort, one can also show that this also limits his effort from above (see Konrad and Leininger (2005)). Obviously, the bidding of players at the second stage l can be interpreted as an all-pay auction with a minimal bid requirement (namely, submit at least a bid as high as the highest bid from stage e). Perhaps surprisingly, bidding in the first stage l also reduces to an all-pay auction with a minimal bid requirement (namely, submit at least a bid as high as the highest individually rational bid of the player with the least cost, who moves at l).

Note that all players $j = 2, ...n$ are fully indifferent with respect to their choice of timing. Their overall payoff is equal to the unconditional payment a_j, and their payoff from participating in the contest is zero in expectation and independent of their timing. Their choices matter for player 1's payoff, and if he could influence their behavior, he would have a strictly positive willingness to pay for making them choose $t_j = e$. Of course, any such contractual relationship between the group members has been ruled out, as we study strictly non-cooperative outcomes in an environment without any contracts that require commitment, and without tacit collusion through repeated interaction.

Consider now stage G2.

Lemma 2 *For player 1 the choice of* $t_1 = l$ *is a weakly dominant decision in the following sense:*

i) *For any timing decicisions* $t_{-1} = (t_2, ..., t_n)$ *by players 2 to n there is a subgame perfect equilibrium of the full game with* $t^* = (l, t_2, ..., t_n)$

ii) *For any* $t_{-1} = (e, t_3, ..., t_n)$ *the decision* $t_1 = l$ *is the unique equilibrium choice of player 1.*

The proof of Lemma 2 follows from Proposition 2 in Konrad and Leininger (2005).

Lemma 1 and Lemma 2 together suggest that the continuation game consisting of stages G2-G4 has at least 2^{n-1} equilibria. In each of these equilibria player 1 chooses $t_1 = l$, but this choice can go along with any combination $(t_2, ..., t_n)$ by the other players. The payoff for player j, with $j \in \{2, ..., n\}$, is a_j for all equilibria. The payoff for player 1 is highest and equal to $1 - \sum_{j=2}^{n} a_j$, if $(t_2, ..., t_n) = (e, ..., e)$, and lowest and equal to $1 - \frac{c_1}{c_2} - \sum_{j=2}^{n} a_j$, if $(t_2, ..., t_n) = (l, t_3, ..., t_n)$. Note, that player 1 is indifferent between $t_1 = e$ and $t_1 = l$ if $t_2 = l$; hence there are also equilibria in which player 1 chooses e, but these do not lead to new equilibrium payoff vectors.

In contrast, each of the players $j = 2, ...n$ is fully indifferent with respect to his own choice of timing and the choice of timing by all other players. The choice of timing t_j can therefore depend on any event or action that is observable at the beginning of G2; for instance on the payments made to group members. We denote this relationship as

$$t_j = \tau_j(a_2, a_3, ...a_n). \tag{6}$$

Here, τ_j can be a trivial or non-trivial function of these payments. The particular function τ_j determines which of the continuation equilibria in $G2-G4$ is chosen.

Proposition 1 *Define* $\mathcal{A} \equiv \{\ (a_2, ...a_n) | a < \frac{c_1}{c_2}$ *and* $a_j \geq 0$ *for* $j = 2, ...n\}$. *Then, for any* $\mathbf{a} \in \mathcal{A}$, *there exists a subgame perfect equilibrium of the game, in which player 1 chooses* $\mathbf{a}$ *at the first stage.*

Proof. Let $t_1 \equiv l$, but

$$\tau_j(a) = \begin{cases} e & \text{if } \mathbf{a} = \mathbf{a}^* \\ l & \text{if } \mathbf{a} \neq \mathbf{a}^* \end{cases}$$

By Lemmas 1 and 2, this behavior yields $\pi_j = a_j$ for all $j = 2, ...n$ in the subgame perfect equilibrium, independent of $j's$ choice of timing, and payoff $\pi_1 = 1 - a^*$ if $\mathbf{a} = \mathbf{a}^*$ and $\pi_1 = 1 - \frac{c_1}{c_2} - a$ otherwise. Player 1 maximizes his payoff by $\mathbf{a} = \mathbf{a}^*$ if $a^* \leq \frac{c_1}{c_2}$, and by $\mathbf{a} = (0, 0, ...0)$ if $a^* > \frac{c_1}{c_2}$. ■

Groups may overcome the problem of wasteful internal fights about the distribution of the group income between its members in a fully non-cooperative game without repeated interaction, without reputation building, and without relying on the rules of a non-cooperative bargaining game. This peaceful equilibrium is compatible with a large number of distributions of the group income. The leader receives at least what he could obtain from fighting, and any division of the 'peace dividend' $\frac{c_1}{c_2}$ is compatible with Proposition 1.[7]

The discussion of the clan members' efforts to make the clan receive the rent in the external conflict that is allocated among the clan members subsequently, will yield some further constraints on the feasible allocation of the clan's income. These constraints will result from a strictly non-cooperative analysis, but will still resemble some regime in which clan members receive transfers that are related to their 'merit'.

Note that Proposition 1 implicitly assumed that the leadership role was assigned to the player who is the strongest fighter, as $c_1 = \min_{j \in N}\{c_j\}$. A player j with $c_j > c_1$ cannot perform the leadership role. If he were to make positive transfers $a > 0$, he could never retrieve them. His payoff from the intra-group contest in any equilibrium would be 0. Hence any sort of leadership contest would see player 1 prevail. The sequencing of timing decisions has two effects: it not only yields equilibria in pure strategies, but also an "efficiency gain" *if* players move in an appropriate order. The latter effect relies on the possibility that the strongest player can use his greater strength against weaker players through their *expectations* (i.e. without having to exert it) if he moves late (and the others early). If he moves early (or others join him in moving late), he actually has to exert his greater strength by

[7] This indeterminacy is not uncommon, of course, in other contexts, e.g., the cake-eating problem. The main difference is that we do not make any assumption about procedural rules that the players agree to, and explicitly allow for resource wasteful appropriation effort here.

making the largest effort bid. This seriously limits the leadership potential of any player other than the strongest.

4 Collective action

The formation of clans, groups or states has a purpose - the provision of collective goods. One of the quintessential public goods problems is the collective provision of effort to defend the clan's territory, or to expand this territory at the expense of rivals or enemies. Returns to scale, or the importance of country size for relative strength in international conflict, has been one of the key drivers of a process of consolidation and the formation of ever larger units. Riker (1966, pp. 2-3, 8-9) emphasizes military considerations as central for the formation of federations, and illustrates this using examples starting from the federation of city states in Ancient Greece. The theory of the optimal size of nations by Spolaore and Alesina (2002) attributes the recent breakup of larger nation states to the decline in the importance of international military conflict in most modern, post cold-war times.

In an environment with conflict between nations, larger units acquire smaller units and grow in strength, and there seems to be a natural tendency for a monopoly of force, unless there are counteracting forces, for instance the problem of internal cohesion and problems of internal coordination and communication. We will first consider the potential for collective action for a clan of given size. The optimal size of clans is discussed in a later section.

The 'external' conflict Consider the competition between the clan and an enemy for a prize that can again be seen as an amount of resources, e.g., money or some homogenous universal good that is valued at $V = 1$. The contest follows the rules of an all-pay auction similar to the rules of the possible intra-clan conflict. Let y_E be the total contest effort chosen by the enemy, and the enemy's cost of providing this effort

$$D_E(z) = c_E y_E^2. \tag{7}$$

Further, let each clan member decide on his own contribution y_j to the clan's effort, which causes a cost of effort to this member that is equal to

$$D_j(y_j) = c_j y_j^2. \tag{8}$$

The use of the same c_j in (3) and (8) is mainly for notational parsimony. Clan members may differ in their relative abilities for internal and external fights, but often these abilities should be expected to be positively correlated. Let the external conflict efforts sum up to the total effort:

$$y_C = \sum_{j=1}^{n} y_j. \tag{9}$$

The clan or the enemy wins the prize, depending on who spends higher effort. A fair coin decides who wins the prize if $y_C = y_E$.

From the perspective of member i, any contribution y_i to the aggregate level of y_C is a contribution to a clan-wide pure public good. We first determine what the combinations of effort $(y_1, ...y_n)$ are that are collectively optimal from the perspective of the clan. Then we show that this collectively optimal behavior can be implemented as a fully non-cooperative equilibrium, taking into consideration that the prize must be allocated among the clan members if the clan wins the prize, and that this involves some intra-clan conflict as studied in the previous section.

Optimal collective effort in the inter-group conflict Suppose that the clan manages to coordinate on a peaceful equilibrium once it wins the prize. In this case, the clan collectively values the prize by its nominal value, which we normalized to $V = 1$. The optimal choice of the clan's effort y_C will generally depend on the enemy's choice of effort. However, the following proposition determines how a given amount of aggregate effort can be generated in an effort cost minimizing way.

Proposition 2 *If the clan generates a given amount of aggregate effort y in a cost minimizing way, the clan's aggregate effort cost is equal to*

$$D_C(y) = cy^2 \text{ with } c \equiv \frac{1}{\sum_{j=1}^{n} \frac{1}{c_j}}. \tag{10}$$

Proof. The cost function $D_C(y)$ of the clan is obtained as the solution to the maximization problem $y_C = y_1 + y_2 + ...y_n \rightarrow$ max subject to $\sum_{j=1}^{n} c_j y_j^2 \leq D$. The solution requires

$$D'_C(y) = 2c_i y_i^*(y) \text{ for all } i = 1, ...n, \tag{11}$$

Accordingly, $y_i^*(y) = \frac{D_C'(y)}{2c_i}$, and $y = \sum_{j=1}^n \frac{D_C'(y)}{2c_j}$. This, in turn, implies

$$D_C'(y) = \frac{y}{\sum_{j=1}^n \frac{1}{2c_j}}.$$

Integrating and taking into consideration that $D_C(0) = 0$ yields (10). ■

Note that c as defined in (10) decreases if the clan grows by an additional member. This monotonicity holds whatever the current size of the clan and the combination of cost parameters is. The size and the distribution of cost determines the size of the change in c. Large clans have a lower cost of a given amount of effort in an external conflict if this amount of effort is efficiently provided: if there are more clan members, each member needs to contribute a smaller portion of the given clan effort, and, with increasing marginal cost, the aggregate cost is decreasing in the number of clan members.

Also note that the cost parameter c of the clan cost function $D_C(y)$ equals $\frac{1}{n}$ times the harmonic mean $h(c_1, ..., c_n)$ of the individual cost function parameters:

$$c = \frac{h(c_1, ..., c_n)}{n}$$

Since $h(c_1, ..., c_n) > \min\{c_1, ..., c_n\}$ we conclude that

$$\frac{1}{n} h(c_1, ..., c_n) < \min\{c_1, ..., c_n\}.$$

This is a technological source of feasible "efficiency gains" for the clan beyond the leader's strength. These gains increase in n and the strength of any new member of the clan. The fact that efficient 'cost sharing' among clan members with quadratic individual cost functions in the provision of clan effort leads to the "per capita harmonic mean" of these cost functions as the clan cost function is of independent interest.

Propostion 2 means that clan member j has to contribute effort $y_j^*(y) = \frac{c}{c_j} y$ at individual cost $\frac{c^2}{c_j} y$ in the efficient provision of clan effort y. I.e. *all* members have to contribute and stronger members have to contribute more than weaker members.

The lower cost translates into an advantage in the external conflict with an enemy if the clan can manage to mobilize each member to contribute the efficient amount of effort. Let the clan maximize

$$\pi_C(y) = F_E(y) - D_C(y) = Prob(y_E < y) - D_C(y) \tag{12}$$

and, similarly, the enemy maximize,

$$\pi_E(y) = F_C(y) - D_E(y) = Prob(y_C < y) - D_E(y). \tag{13}$$

Then the following holds:

Proposition 3 *Consider the all-pay auction between the clan and an enemy for a prize which they both value at 1. If the clan can choose its aggregate effort efficiently in order to maximize (12), this payoff is*

$$\pi_C^* = \max\{1 - \frac{c}{c_E}, 0\}.$$

A proof relies on the standard result of an all-pay auction between two contestants with the same valuations of winning and quadratic cost functions (7) and (10).

The proposition shows that the clan can win a positive payoff in the wasteful conflict with the enemy if

$$c_E > c. \tag{14}$$

This condition defines the *potential superiority* of the clan in the conflict with the enemy. As c depends on the number and cost distribution of clan members, this superiority is endogenous with respect to the composition of the clan.

Equilibrium collective action Can the clan members non-cooperatively coordinate on the efficient collective action? What are the conditions that must hold for such a coordination to be feasible or likely? How does this ability or possibility depend on the size of the clan, on the internal structure of the clan, the distribution of cost and on the clan's ability to distribute any clan income peacefully among its members? These are the questions we turn to now.

The external conflict takes place in a stage W(ar). As discussed above, if the clan and its enemy choose their efforts y_C and y_E in order to maximize their respective payoffs, the equilibrium is in mixed strategies in which the effort choices are drawn from random variables with cumulative density functions F_C and F_E, respectively. Efficient provision of a given effort level y_C by the clan requires a particular, unique allocation of efforts, $(y_1, ..., y_n)$, among its members. If y_C is a draw from a random distribution, it is therefore important for efficiency that the individual effort choices and the choice of y_C are perfectly correlated. In order to make this feasible, we allow for the following coordination device. Some number θ is chosen as the outcome of a random draw from a distribution with cumulative density

$$F_C(\theta) = \begin{cases} 0 & \text{for} \quad \theta \leq 0 \\ c_E\theta^2 & \text{for} \quad \theta \in (0, \frac{1}{\sqrt{c_E}}) \\ 1 & \text{for} \quad \theta \geq \frac{1}{\sqrt{c_E}}. \end{cases} \tag{15}$$

This θ is observed by all clan members (but not by the enemy) before they freely and simultaneously make their individual effort choices y_j. Once all clan members and the enemy have chosen their efforts, θ and all effort choices are observed by all players. The clan wins the prize if $y_C > y_E$, and the enemy wins if $y_C < y_E$. Each of them wins with probability 1/2 if $y_C = y_E$. If the enemy wins, the game is over, as the clan does not receive a rent to fight about internally .

If the clan wins, then the clan members enter into stages G1-G5 as discussed in the section on internal conflict.

Proposition 4 *Let the clan be potentially superior to the enemy in the sense of (14). If $c_1 - c_2$ is sufficiently close to zero, then a subgame perfect equilibrium exists in which the clan can implement the externally efficient efforts and a peaceful distribution of rents from war.*

Proof. Lemma 1 and Lemma 2 characterize the equilibria of the subgames consisting of stages G2-G5. Each clan member except the leader is indifferent whether to choose $t_j = e$ or $t_j = l$. The choices and the equilibrium of G2-G5 can therefore depend on the history of the game at the beginning of G2. At G2, a history consists of a θ, choices of efforts in the inter-group conflict by the clan members, $(y_1, ...y_n)$, an effort choice by the enemy, y_E, an outcome of the contest in which the clan wins the prize, and a vector of unconditional transfers $(a_2, ..., a_n)$ that was chosen and paid by the leader in stage G1. Hence,

$$t_i = \tau_i(\theta, y_1, ...y_n, y_E, a_2, ...a_n)$$

replaces (6).

Consider the following candidate choice of timing in the continuation equilibrium at G2 as a function of the history up to this point,

$$\mathbf{t} = \begin{cases} (l, e, e, ..., e) & \left\{ \begin{array}{c} \text{for the class of histories with} \\ y_j(\theta) = \frac{c}{c_j}\theta \equiv y_j^*(\theta) \text{ for all } j \\ \text{and } \mathbf{a} = \mathbf{a}^* \text{ with} \\ a_j^* \geq \frac{c^2}{c_j}\theta^2 \text{ for all } j = 2...n \\ \text{and } a^* < \frac{c_1}{c_2} \end{array} \right. \\ (l, l, l, ..., l) & \text{for any other history that reaches G2,} \end{cases} \tag{16}$$

and the equilibrium payoffs determined by these choices as characterized in Proposition 1. To confirm that (16) can induce an efficient subgame-perfect equilibrium of the overall game, consider first G1 which is reached if the clan was victorious in the external conflict.

If at least one clan member deviated from $y_j^*(\theta)$, then $\mathbf{t} = (l, l, ...l)$, independent of $\mathbf{a}$. Accordingly, the leader chooses $\mathbf{a} = (0, 0, ..., 0)$ in this case, and the equilibrium payoffs are

$$\begin{array}{c} 1 - \frac{c_1}{c_2} - c_1 y_1^2 \text{ for } j = 1 \text{ and} \\ -c_j y_j^2 \text{ for } j = 2, ...n. \end{array} \tag{17}$$

If all clan members have chosen $y_j^*(\theta)$, the leader's choice of $\mathbf{a}$ determines the equilibrium outcome of the subgame in stages G2-G5. For $\mathbf{a} \neq \mathbf{a}^*$, the payoffs are

$$\begin{array}{c} \pi_1 - c_1(y_1^*(\theta))^2 = 1 - \frac{c_1}{c_2} - a \; - c_1(y_1^*(\theta))^2 \text{and} \\ \pi_j - c_j(y_j^*(\theta))^2 = a_j - c_j(y_j^*(\theta))^2 \text{ for } j = 2, ...n, \end{array}$$

and, among these transfer payments, the clan leader's payoff is maximal for $\mathbf{a} = (0, 0, ..., 0)$. Alternatively, the leader can choose $\mathbf{a} = \mathbf{a}^*$. This yields payoffs

$$\begin{array}{c} 1 - a^* \; - c_1(y_1^*(\theta))^2 \text{ for } j = 1 \text{ and} \\ a_j^* - c_j(y_j^*(\theta))^2 \text{ for } j = 2, ...n. \end{array}$$

The leader chooses $\mathbf{a}^*$ if

$$\frac{c_1}{c_2} - a^* \geq 0. \tag{18}$$

Turn now to the stage W. The mixed strategy described by the cumulative density function

$$F_E^*(y_E) = (1 - \frac{c}{c_E}) + c y_E^2 \text{ for } y_E \in [0, \frac{1}{\sqrt{c_E}})$$

is the enemy's optimal reply to $F_C^*(y) = F(\theta)$ as any $y_E \in [0, \frac{1}{\sqrt{c_E}})$ yields the enemy an expected payoff of zero and higher effort y_E yields negative expected payoff.

Taking F_E^* and the equilibrium effort choices $y_k^*(\theta)$ of all other clan members $k \neq j$ as given, $j \neq 1$ chooses between $y_j^*(\theta)$ which yields payoff

$$-c_j(y_j^*(\theta))^2 + F_E(\theta)a_j^*,$$

and $\arg\max_{y_j \neq y_j^*(\theta)}\{-c_j(y_j)^2\} = 0$. The latter makes use of $a_j = 0$ if $y_j(\theta) \neq y_j^*(\theta)$, and of j's payoff from the actual intra-clan conflict being zero for $j \neq 1$. The two possible candidates for an optimum are $y_j = 0$ or $y_j = y_j^*(\theta)$. $y_j^*(\theta)$ is chosen if $-c_j(y_j^*(\theta))^2 + F_E(\theta)a_j^* > 0$. This is the case if $a_j^* > \frac{c_j(\frac{c}{c_j}\theta)^2}{(1-\frac{c}{c_E}+c\theta^2)}$. This is fulfilled for all $\theta \in (0, \frac{1}{\sqrt{c_E}})$ if

$$a_j^* > \frac{c^2}{c_E c_j}. \tag{19}$$

Taking F_E^* and the equilibrium effort choices $y_j^*(\theta)$ of all $j \neq 1$ as given, $j = 1$ chooses between $y_1^*(\theta)$, by which he attains a payoff

$$-c_1(y_1^*(\theta))^2 + F_E^*(\theta)(1 - a^*),$$

which is his payoff in the efficient equilibrium in the intra-clan contest which results from a choice of $\mathbf{a}^*$, and the payoff from $y_1 \neq y_1^*(\theta)$ that maximizes

$$-c_1 y_1^2 + F_E^*(\theta - (y_1^* - y_1))(1 - \frac{c_1}{c_2}) \tag{20}$$

The characterization of the payoff (20) uses the fact the deviation from $y_1^*(\theta)$ will induce $a = 0$ and the equilibrium with violent intra-clan conflict. The choice problem of the leader therefore reduces to the choice between $y_1^*(\theta) = \frac{c}{c_1}\theta$ and $\arg\max_{y_1 \neq y_1^*(\theta)}\{-c_1 y_1^2 + ((1 - \frac{c}{c_E}) + c(\theta - \frac{c}{c_1}\theta + y_1)^2)(1 - \frac{c_1}{c_2})\}$. For $c_2 - c_1 \to 0$, the argument that maximizes (20) is $y_1 = 0$ and yields zero payoff. Accordingly, the candidate equilibrium effort $y_1 = y_1^*(\theta)$ is chosen if $-c_1(y_1^*(\theta))^2 + F_E^*(\theta)(1 - a^*) > 0$. Inserting the equilibrium values $y_1^*(\theta) = \frac{c}{c_1}\theta$ and $F_E^*(\theta) = (1 - \frac{c}{c_E}) + c\theta^2$ yields the condition

$$1 - a^* > \frac{\frac{c^2}{c_1}\theta^2}{(1 - \frac{c}{c_E} + c\theta^2)}. \tag{21}$$

As $\frac{\frac{c^2}{c_1}\theta^2}{(1-\frac{c}{c_E}+c\theta^2)}$ is monotonically increasing in θ, the condition (21) is strongest for $\theta = \frac{1}{\sqrt{c_E}}$, for which it becomes

$$1 - a^* > \frac{c^2}{c_1 c_E}. \tag{22}$$

For the condition (22) to be compatible with the conditions (19), it must hold that

$$1 - \sum_{j=2}^{n} \frac{c^2}{c_E c_j} > \frac{c^2}{c_E c_1}$$

or $1 - \sum_{j=1}^{n} \frac{c^2}{c_E c_j} > 0$, or $1 - \frac{cc}{c_E} \sum_{j=1}^{n} \frac{1}{c_j} > 0$, or, equivalently, $1 - \frac{c}{c_E} > 0$, which is identical with the condition of potential superiority. ■

Potential superority of the clan is one prerequisite from the external conflict structure for sustainability of the efficient effort in equilibrium. Another prerequisite from the internal conflict structure is limited potential superiority of the leader inside the clan. A strong "deputy" player 2 of the leader 1 not only increases competitiveness in the external contest, but also poses a larger threat (see (20)) in the internal contest, which stabilizes the efficient equilibrium.

The case $c_1 = c_2$ is an interesting benchmark case. The incentives to coordinate on the peaceful outcome are largest here; coordination is feasible at, and in the neighborhood of this benchmark case. Intuitively, at $c_1 = c_2$, if coordination fails, the leader does not receive a positive payoff even if the clan wins the prize in the external conflict, and his incentives to pursue a "stand alone" strategy in which he cheats on effort in the external conflict, and then also does not make positive transfers, are minimal, because his payoff in the resulting fighting equilibrium is zero. The opposite benchmark case is obtained if $c_1 << c_2$, and $c \approx c_E$. In this case the leader does not gain much from coordinated action, as the overall prize the clan wins from coordinated action is negligible. It turns out that the efficient coordinated equilibrium cannot be supported for all cost parameter values. This is shown for a numerical example in Appendix A .

Proposition 4 characterizes rules for contributions to the collective action and transfers from the leader to the followers that serve as a *norm*. If all players obey the norm, the outcome is efficient from the perspective of the group. Moreover, all players have an incentive to obey the norm. The norm is also self-enforcing. If the norm is not obeyed by some player, this simply leads to a different subgame perfect equilibrium which is inferior to the equilibrium in the subgame chosen if the norm is obeyed.

Many other norms can also be sustained as an equilibrium by the fact that the players can reach the peaceful equilibrium only if they obey the norm. These norms may support an equilibrium in which the behavior of the clan members is suboptimal from the clan perspective. An example would be to replace $y_j^*(\theta) = \frac{c}{c_j}\theta$ by some $y_j^* = \frac{c}{c_j}\theta + \delta$ for sufficiently small δ. This choice makes the clan win the contest with probability 1 (and leads to a different optimal reply by the enemy). It also causes some excessive effort cost. But, if δ is small, and if this behavior is a necessary condition for coordinating on the peaceful equilibrium, this inefficient norm can be sustained. This reproduces an important property of norms. Norms are excessively stable in the sense that they may become obsolete or inferior to some alternative norm but may still continue to be obeyed.

We turn to the comparative static properties of the result in Proposition 4 now.

First, the clan cannot do better using a commitment on even higher effort. $F_C^*(\theta)$ is the optimal reply to F_E^* of a player who values winning the prize by $V = 1$ and has a cost parameter $c < c_E$.[8]

Second, there are further equilibria. Note, however, that this is not our key question. The key question was whether what is efficient for the clan can be implemented as the outcome of fully non-cooperative interaction.

Third, the distribution of cost functions inside the clan is important, but the number of clan members also matters. Consider, for instance, a given c_E and a set of players who all have the same cost parameter $c_0 >> c_E$. As

$$\lim_{n\to\infty} c(n) \equiv \lim_{n\to\infty} \frac{1}{\sum_{j=1}^{n} \frac{1}{c_0}} = 0,$$

a sufficiently large clan exists such that $c_E > c$, making the payoff of the clan in the peaceful non-cooperative equilibrium that is characterized in Proposition 4 strictly positive.

[8] The clan could improve upon the equilibrium outcome if it could make it credible that it values winning the prize by more than $V = 1$, as this induces a different, less aggressive, equilibrium response by the enemy.

5 Optimal clan size

Would clan members prefer an ever larger clan, or is there an optimal n for given c_E? An answer to this question depends on the cost structure of clans, and also on the norm about the equilibrium transfer payments $\mathbf{a}^*$. We focus on the particular case in which the cost parameter is the same for all clan members, i.e., $c_j = c_0$ for all $j = 1, 2, ...n$. If all clan members have the same parameter c_j in their cost of fighting effort, this constitutes the strongest clan with n members that a leader with individual cost parameter $c_1 = c_0$ can assemble. Its clan cost function is characterized by a cost parameter $c = \frac{c_0}{n}$. Any clan with the same number of members, but with $c_j < c_0$ for some clan members, has a higher cost of fighting. Moreover, for $c_j = c_0$ for all j, internal distributional fighting is easiest to contain, because the sacrifice from actual internal fighting is largest.

Egalitarian clans With identical cost structures for all members, each member contributes the same amount of effort to the external conflict. If the distribution is egalitarian, each member receives the same share in the payoff. We call this case egalitarian. Let $c_j = c_0 = const.$ for all $j = 1, 2, ...n$, and assume that the incentive compatibility constraints (18), (19) and (22) are fulfilled for symmetric payments $a_j = \frac{1}{n}$. This is the case if the clan is potentially superior to the enemy: (18) holds trivially, and (19) and (22) coincide and reduce to potential superiority of the clan. The size that maximizes per capita payoff then solves

$$\max_n \{\frac{1}{n}(1 - \frac{c}{c_E})\},$$

where, for homogenous clans, $c = c_0/n$. The first-order condition can be solved for n and this yields

$$n^* = 2\frac{c_0}{c_E}. \tag{23}$$

This result is stated as a proposition:

Proposition 5 *Consider a homogenous and egalitarian clan. The number of clan members that maximizes the individual member's payoff in the efficient equilibrium is described by (23).*

The condition (23) states that the size of n is chosen that reduces the cost parameter c to half the size of c_E: $c^* = \dfrac{c_0}{n^*} = \dfrac{c_E}{2}$.

6 Conclusions

Everyday life experience tells us that if individual members of a group do not do their "duty", this can easily upset the other members, and can upset the peaceful regime that may otherwise prevail inside the group. If the norms about social behavior within the group are violated by some group members not contributing what is considered their appropriate share of contributions to the common interest, this may induce other members of the group to reconsider given predispositions of intra-group distribution of resources and may cause quarrelling among the group members. Such quarrelling dissipates resources and is collectively disadvantageous. In turn, anticipation of quarrelling as an outcome of neglecting own duties may give the group members an incentive to behave. Hence, the fear of possible fighting and resource wasting conflict inside the group may stabilize an efficient outcome in which group members voluntarily contribute to group specific public goods.

In this paper we provide a microeconomic underpinning for this mechanism within a strictly non-cooperative framework and within a framework with a finite horizon. Multiple equilibria can exist with respect to the distribution of resources within the group, some of which are peaceful and others are characterized by resource wasting conflict. If the selection of equilibrium is driven by the group members' conduct with respect to their contributions to a group specific public good, this can induce fully efficient voluntary contributions to the public good. This is the key result of the paper.

The general mechanism analysed here works equally well for contributions to many group specific public goods. More specifically, we considered contributions to protecting the group against other rival groups, or contributions of effort in a resource wasting conflict between this and another group. It turned out that one group member may perform the role as leader. The leader distributes gifts among the group members. We identify a reason why the role as leader should be performed by the strongest group member. We also find that groups are stronger if they are homogenous, and we find that an interior group size is optimal.

One main difference between our framework and many other considerations and possible solutions that are offered for overcoming the collective action problem is the strictly non-cooperative nature of our framework. We do not rely on the folk theorem of infinitely repeated games. We do not assume that group members play cooperatively in the future only if they make the appropriate public good contributions now. We also do not assume that the group collectively manages to empower a government that punishes group members who do not contribute their share. Such an assumption leaves open the question of how the group members are protected from this government which may abuse its power and extort from the group members if it is made sufficiently powerful. Such an assumption would also leave open the question of how costly punishment can be enforced. Instead, we consider a framework for which each and every decision is made fully non-cooperatively, and in which any future individual action is sequentially rational. Punishment for norm disobedience is self-enforcing as disobedience triggers the selection of an equilibrium which involves lower payoffs, whereas obedience triggers the selection of a superior non-cooperative equilibrium.

7 Appendix A

We show that the efficient equilibrium need not be achievable for some cost parameters. Assume that $c_E = 1 + \epsilon$ and consider the limiting case with $\epsilon \to 0$. Assume further that $N = \{1, 2, 3\}$, with $c_1 = 2$, $c_2 = c_3 = 4$. Note that $c = 1$. Note further that the maximum effort by the enemy is $y_{E_{\max}} = 1$, as $D_E(1) = 1 = V$. If the members of N play efficiently, the maximum $\theta = 1$ is generated by effort levels $y_1^* = \frac{c}{c_1}\theta = \frac{1}{2}$ and $y_2^* = y_3^* = \frac{1}{4}$. Hence, the minimum that needs to be paid to 2 and 3 is $a_2^* = a_3^* = c_2(y_2^*(1))^2 = 4\frac{1}{16} = \frac{1}{4}$. The leader ends up with a rent that equals $1 - 2(\frac{1}{2})^2 - 2a_2^* = 1 - \frac{1}{2} - \frac{2}{4} = 0$. Now consider a leader who defaults, given $\theta = 1$, and chooses $y_1 = 0$. In this case, N wins with a probability $F_E(1/2) = c(\frac{1}{2})^2 = 1/4$, and, once the clan wins the prize, the leader receives an expected contest payoff in the intra-clan contest that equals $(1 - \frac{c_1}{c_2}) = 1/2$. Hence, the payoff is zero if the leader behaves according to the equilibrium candidate of Proposition 4, but receives 1/8 if he defaults. This counter example shows that the efficient equilibrium cannot always be implemented. □

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