Self-enforcing norms and efficient non-cooperative collective action in the provision of public goods*

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Abstract

Leadership by a 'big-man' has been observed as a successful governance structure in several historical contexts with small groups. We illustrate this by way of examples and analyse this framework in the context of non-cooperative games with narrowly selfish players. We show how norms solve the distributional conflict inside a group and yield efficient coordination of collective action in a conflict with an external competitor. In the equilibrium one of the players assumes a central role that resembles the role of the 'big-man' in the empirical examples. Also, the group members' contributions to collective output and the donations from the big-man to these members seemingly look like reciprocal behavior, even though they are driven by narrowly selfish preferences in a fully non-cooperative equilibrium of a finite game.

Key words: free-riding, defence, collective action, distributional conflict, war, norms, big-man

JEL classification numbers: D72, D74, H11, H41

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1 Introduction

Organizations such as business companies, clans or rudimentary states have to overcome two difficult collective goods problems. First, they have to induce their members to contribute to group specific public goods or group income. Depending on the type of organization, these can be contributions to defence, effort in acquiring the property of other groups, or productive effort that increases group output. Second, the group members need to be prevented from fighting internally when it comes to dividing the returns from the collective effort among themselves. In a perfect world, these problems can easily be overcome by suitable contracts that are perfectly and costlessly enforced. However, in an imperfect world such enforcement is often unavailable. The ultimate enforcement power is clearly absent in clans or primitive states. Modern business organizations can rely on courts, but it is often very difficult to write enforceable contracts which make their members contribute efficiently to the group output and prevent members from internal fighting in the allocation of output among group members.

We show that a fully efficient outcome for both collective goods problems can emerge in a non-cooperative (subgame perfect) equilibrium of a game with complete information in the absence of any enforcement power. In this solution, the two collective goods problems interact. The underlying mechanism exploits the presence of multiple equilibria with respect to intra-group behavior, and equilibrium selection: if individuals do their duty in the collective good provision, then one of the players makes uncontingent donations to each group member. While we do not assume that this player is in control of any enforcement technology, this player has a particular role: he controls a sufficient amount of wealth to be able to make considerable redistributions. Also he will typically be among the most able fighters in case of intra-group fighting. If players' contributions and the 'big-man's' donations are in accordance with the group members' expectations or what could be called the group's "norms", then all group members choose the peaceful equilibrium.[1] If single members' contributions to group output differ

[1] Our theory and in particular use of the term "norm" follows Hardin's influential view, that "an important fact about many norms is that behaviors they guide may be strongly reinforced by incentives of self-interest" (Hardin, 1995, p.22), which makes norms the subject of consequentialist analysis. This view is in stark contrast to e.g. Elster, who claims that norms are not oucome-oriented (Elster, 1989). In our non-cooperative game set-up behavior according to a norm gets reinforced by individual self-interest, while at the same

from these expectations, this upsets the other members. Donations will not be distributed and a less peaceful regime is chosen. Similarly, if all group members make adequate contributions to group output, but the big man's donations fall short of their expectations, they will also coordinate on the less peaceful regime. Resources will be wasted in these cases, and this is collectively disadvantageous. In turn, anticipation of this less peaceful regime as an outcome of neglecting own duties or inadequate donations may give the group members an incentive to behave in accordance with the expectations that lead to the peaceful regime. The fear of possible fighting and resource wasting conflict inside the group can stabilize an efficient outcome in which group members voluntarily contribute to group specific public goods.

These elements of efficient non-cooperative governance can be found in primitive societies who lack advanced technologies of coercion or enforcement technologies. They can also be found in modern organizations if efficient contributions to team production are not verifiable and internal distributional conflict cannot be ruled out. We outline three examples.

First, anthropologists like Sahlins (1963) describe the leadership regime of *big-man* for a variety of primitive states. Sahlins emphasizes the role of great public giveaways as a common means for a rising 'big-man' for a large number of societies, and for a number of Melanesian tribes in particular. Our game features a prominent figure who has formal control of substantial resources in the absence of internal fighting, and whose donations essentially replace an intra-group distribution mechanism for the group output. The 'big-man' represents this figure well. The 'big-man' is involved in extensive and unconditional gift giving, whereas his 'followers' provide productive services. Orenstein et al. (1980, 71) emphasizes the importance of material wealth as a key qualification for leadership in this society: "Leadership was determined by wealth." Moreover, the transfer from the 'big-man' to his followers in these societies is seen as fully unconditional:

> In this kind of ideology the leader is thought to give by right and receive by grace. The ordinary people, having elevated one of their members to the superordinate place, hold him in their debt

time it is in the self-interest of any individual to have a (group) norm. Hardin's further, more concrete observation that "many norms appear to have the strategic structure of coordination" (Hardin, 1995, p.73) also pertains to our model: the power of a group is greatly enhanced by the efficient coordination of individual efforts; which is achieved through the role of a clan leader, who also has (an incentive) to submit to the norm.

> for this honor and require him to supply their expressed needs. What the leader gives to his constituency is their due; what he gets from them – largely the honor of high office – is by their grace. (Orenstein et al., 1980, 71)

This mutual giving has often been interpreted as reciprocating behavior (Sahlins, 1963, 293). It is one of the major insights which can be gained from our analysis that mutual unconditional exchange need not be interpreted as reciprocity. Our non-cooperative approach reveals that what looks like mutual exchange or reciprocity from the outside may be a sequence of actions in a subgame perfect equilibrium among narrowly selfish players.

The efficient provision of group effort and the peaceful distribution of group output is only one possible equilibrium outcome in our framework. A group norm about adequate contributions to group output and adequate wealth distributions plays the role of coordination devices that allow players to choose this efficient equilibrium. However, such a framework with multiple equilibria is notoriously prone to disturbances. It is therefore not surprising and in line with our results that Sahlins (1963, 293) also reports that "... there are not merely instances of big-man chicanery and of material deprivation of the faction in the interests of renown, but some also of overloading of social relations with followers: the generation of antagonism, defections, and in extreme cases the violent liquidation of the center-man." Similarly, Orenstein et al. (1980, 72), referring to several other sources, reports:

> "Revolutions," usually bloodless, are frequent, for the people stand to gain from the installation of a new headman – that is, from the new man's as yet unconstrained resources.

Our second example considers an organization which established itself in a period in which more refined institutions of coercion and enforcement existed, but to which this organization could not resort to: the Palestine Liberation Organization (PLO). Its long-time leader Yasir Arafat was known for travelling with a little suitcase which contained the information on access codes to a large set of funds of the PLO (see, e.g., Rubinstein 1995). Livingstone and Halevy (1990) describe these financial aspects in greater detail. They report that the Chairman's Secret Fund (CSF) was estimated to be in the range of two billion US-dollars, and used for funding the PLO's operations and Arafat's own struggle inside the PLO. They consider the CSF as the main source of Arafat's leadership:

> Money is the source of Yasir Arafat's power. Without it Arafat would have been just another voice in the tumult, another salesman of broken dreams, a kind of Palestinian Willi Loman. Instead, he is a global mover and shaker, feted by kings and prime ministers, the leader of a revolution that threatens to change the map of the world. He is feared by his enemies, who know that his threats are not hollow, and loved by his followers, who know that he can be a generous patron. (pp. 184-185)

His leadership regime resembled the big-man regime in a number of respects. Livingstone and Halevy (1990) report that Arafat used the CSF and expended large sums to fund weddings, wedding anniversaries and ceremonies for high ranking members inside the PLO. Also, he funded the operations, including the terrorist operations of group members of the PLO. These operations were the PLO's members' contributions to the group output or group income, as these operations created the type of credible threats that were required to elicit the payments of protection money from airline companies, oil companies and governments which, according to Livingstone and Halevy (1990), replenished the PLO's bank accounts and the CSF.

A third example comes from the financial sector, well inside the 'official sector' of modern economy: investment banking. Knee (2007) recognizes the importance of the collective goods problem, the difficulties in installing merit based compensation, and the potential for internal conflict about the distribution of profit inside Morgan Stanley.[2] William D. Cohan (2007, p. 182n.) described the governance structure of Lazard when this investment banking company was de facto chaired by Michel David-Weill. The US branch of Lazard was a company with a large number of partners, and all partners contributed to the aggregate profit of the company. They received percentage shares in this aggregate profit. These shares, however, were freely chosen by Michel David-Weill, with himself as the residual claimant. Accordingly, Michel David-Weill was the de-facto owner of the firm's profits to which all partners contributed during the year, and he decided how much to give to each partner. As Cohan (2007, 184) describes it:[3]

[2] As Knee (2007, p. 120) explains: "The politics of which fees appear on which banker's "revenue sheet" in a given year and how this translates into actual compensation is more an art than science, and highly contested. Because any other alternative would have resulted in fistfights between bankers in the hallways, there was not even a theoretical limit to how many bankers could claim credit for the same deal."

[3] This is not to say that the mechanism which we describe in this paper is the only

> Michel was generally happy to reward his partners well, often better than they could possibly be paid by other firms. He was long-term greedy and knew that if the pie kept getting bigger, he stood to make more money himself, as he had the largest profit percentage by far. Mostly, though, Michel was interested in his partners' ability to generate fees - as he himself had little ability or desire to do so.

The governance structure which can be found in these examples and which we are going to describe more formally has several attractive features. Firstly, a first-best efficient outcome for the collective goods problem is implemented in a purely non-cooperative framework. Secondly, all members of the group receive some –not necessarily 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. Thirdly, group size is meaningful. Larger groups are more effective in generating group income. Increasing returns in group size emerges endogenously from the assumption that each individual player's cost of group effort is convex in own effort. Fourthly, despite these increasing returns, there is an optimal group size that maximizes the group members' returns per capita. Finally, the framework offers an explanation for why some organizations, clans, groups, or primitive 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 about what would be an appropriate or equitable distribution of rents. Compliance with this norm is reinforced by self-interest. Deviation from this norms by a single player would induce a shift from one equilibrium to another, less attractive one. Hence the alignment of the norm with individual self-interest works twofold: self-interest is instrumental in stabilizing the norm, and the norm is instrumental in asserting self-interest.

instrument of governance in Lazard at that time. David-Weill negotiated with partners, they lobbied him somwhat, and repetition may also have played a role. However, the key role of one player who is formally in charge of making uncontingent payments to the group members is noticeable.

2 Related literature

The question we address is most closely related to one of the most fundamental questions in the theory of the state: the enforcement of property rights. Seminal papers by Skaperdas (1992), Hirshleifer (1988, 1995) and Grossman (1994) have stimulated a major research program.[4] Their starting point is the absence of property rights: players need to allocate their resources between production of consumable output and appropriation effort, which may consist of stealing, arming or guarding. A general message that emerges from this literature is: the absence of property rights induces multiple inefficiencies, because players use some of their resources trying to protect their income or wealth, or to steal from others, instead of using it for producing more consumer goods, and the fact that own production of consumer goods needs to be guarded and can be stolen further reduces the incentives to engage in productive activities. Contracts and the enforcement of contracts by courts would be desirable in such situations, but in numerous contexts contract enforcement is simply not feasible. This is true not only for early primitive societies, but also the most modern world, as has been highlighted by the study of incomplete contracts.

Researchers who study economics under anarchy are interested in how anarchy can be overcome, how existing rules of enforcement came into place, and about the welfare implications of such regimes. Olson (1993) and McGuire and Olson (1996) analyzed the welfare outcome if a king or sovereign ruler has access to a power monopoly and can enforce property rights. A power monopoly may improve upon the situation with anarchy, provided that the ruler can commit himself to abstain from ex-post opportunistic behavior. Long-term considerations and the forces of infinitely repeated play may, but need not overcome what several writers identified as the fundamental problem with an agent who has the power to enforce property rights: his ability to abuse this very power and to extort his subjects even more severely than in a state of anarchy.[5] Moreover, a competition for the position of enforcer of property rights may become an additional source of inefficiency and worsen the outcome compared to anarchy (Skaperdas 2002).

Several authors analyze technologies for overcoming appropriation conflict. Falkinger (2006) considers the non-cooperative investment in a pun-

[4]See, for instance, Garfinkel and Skaperdas (2007) for an overview.

[5]See, for instance, Acemoglu, Robinson and Verdier (2004) and Shen (2007), who also reviews this literature.

ishment mechanism that enforces contracts. Similarly, Sánchez-Pagés and Straub (2006) explain the endogenous emergence of norm enforcement institutions by agents' voluntary costly contributions to their formation. An enforcement technology is given, but players must still agree to adapt and use it. Once this decision is made and the enforcer of property rights is appointed, he uses this power benevolently and does not opportunistically abuse this power. The question whether and how individuals would like to resort to an enforcement technology- when it exists- is interesting. It does not address the problem of what restrains the agent who is empowered with this technology from abusing his power. Gradstein (2007) analyses the relationship between income distribution, democratic choice of property rights regimes and growth performance. A majority decision enforces the property rights regime in his framework. Unanimous or majoritarian adoption of institutions has strong intuitive appeal. However, we would like to go one step further and provide an explanation for collectively efficient behavior which is self-enforcing in a fully non-cooperative equilibrium. We do not resort to an ultimate provider of enforcement nor to a formal enforcement technology or collective decision which provides this enforcement. Given the absence of a single player's enforcement power, no assumption is needed about what prevents the enforcer from abusing this power. Collectively efficient and peaceful behavior within a group, organization or clan nevertheless can emerge. Conflict itself becomes the key driver in this process as the absence of enforcement institutions leads to a multiplicity of equilibria, some of which involve costly conflict and some of which do not. The norm allows the distribution of a "peace dividend" in an equilibrium without conflict, which emerges from efficient collective action and from abstention from fighting. A "bad" equilibrium is selected if players do not behave according to the norms.

Our framework induces efficient provision of a pure public good and points to an important motivation for voluntary contributions. Research on the private provision of public goods identified four possible motivations for making own contributions. A contributor may benefit from an increase in the amount of the public good that is provided.[6] Also, a contributor may like the feeling of doing something good; Andreoni (1990) referred to this motivation as the warm glow of giving. Further, contributions to the public good may be instrumental for reaching other goals. Bagwell and Bernheim (1996) and

[6] See, e.g., McGuire (1974), Hirshleifer (1983), Cornes (1993) and Bergstrom, Blume and Varian (1986) for seminal contributions in this formal context.

Glazer and Konrad (1996) suggested that observably contributing to a public good may convey information to others and this may generate other benefits. Finally, Bénabou and Tirole (2006) introduced the role of self-image as a possible motivation for charitable giving. In our framework another motivation dominates these motives for giving: if individual contributions do conform with social norms, the non-cooperative outcome is peaceful. Otherwise societal conflict is induced and makes all players worse off. Hence individual contributions to group effort occur "in the shadow of conflict" (Hirshleifer 1994). Hirshleifer advances the much more general and provocative proposition that "cooperation, with a few obvious exceptions, occurs only in the shadow of conflict".

From a structural point of view, our analysis is related to research on the relationship between inter-group conflict and rules that govern the behavior of members of the same group vis-a-vis each other. 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 peaceful distribution inside the group are taken as given in these frameworks. Their work shows that merit rules, if they can be enforced, can be an important incentive instrument for groups for overcoming free-rider incentives. Katz and Tokatlidu (1996), Wärneryd (1998) and Müller and Wärneryd (2001) highlight that peaceful allocation rules inside the group cannot be taken for granted. A peaceful merit rule may be a desirable incentive system from the group's perspective, but in many contexts such rules cannot be enforced. In this case hierarchies of conflict may emerge, with a conflict between groups being followed by a conflict among the members of the victorious group for the prize.[7] We as well consider an inter-group contest with possible free-riding of group members, that is followed by a strong intra-group contest about the allocation of the winner prize. However, we show that these two activities may "incentivize" players mutually; efficient contributions to group effort and peaceful settlement of internal conflict may then be complementary equilibrium outcomes.

In political science there has been careful discussion about whether, and how, violent conflict can or cannot be avoided in the context of the theory of

[7] 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.

rational approaches to studying war. From this literature it turns out (see, e.g., Fearon 1995) that 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, Slantchev (2003) explains how the occurrence of multiple equilibria and differences in the desirability of reaching a particular equilibrium, together with expectations about which action triggers which equilibrium may lead to actual conflict. Conceptually, Slantchev's analysis is close to ours. Slantchev uses the framework of multiple equilibria to explain why wasteful conflict may emerge in a complete information world with non-cooperative bargaining. We use it to explain how (by using the conflict equilibria as credible threats) efficient cooperation and distributional harmony inside a group a group may emerge.

3 The analytic framework

Our formal analysis is framed in the context of primitive states, with contributions to military effort as the contributions to the group's collective good. We consider a 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[8] 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

[8] If violent means for appropriation are available, even 'non-cooperative' bargaining requires 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 been 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.

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.

4 Inside the clan

Consider a clan that has n members who constitute the set N. This clan 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 by an appropriation game in which contest efforts decide about the allocation of the prize, and in which the timing of the choices of contest efforts is endogenous. Prior to this appropriation game, 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

$$\mathbf{a} \equiv (a_2, a_3, ...a_n) \text{ and } a \equiv \sum_{j=2}^{n} a_j. \tag{1}$$

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 *clan leader*. This player is the 'big-man' in our motivating examples in section 1. 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.[9] 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

[9] 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.

payments may therefore drive the selection between a peaceful equilibrium and violent fights inside the clan.

Stages G2-G4 describe the allocation of the prize in an all-pay auction with endogenous timing, building on Baik and Shogren (1992), Baik (1994, 2005) and Leininger (1993). The cornerstone of this allocation rule is a contest success function that maps clan members' effort choices into win probabilities. Let clan member i choose effort x_i. The probability p_i that i wins the conflict is a function of all contestants' efforts,

$$p_i = p_i(x_1, x_2, ...x_n). \tag{2}$$

Denote $\bar{x} \equiv \max_{k \in N}\{x_k\}$. If $x_i = \bar{x} > x_j$ for all $j \in N - \{i\}$, then $p_i = 1$ and $p_j = 0$ for all $j \neq i$. If there are several players who have chosen the same, highest effort, $\bar{x}$, we assume a tie-breaking rule that is outlined later and avoids discontinuity problems.[10] The three stages of this appropriation conflict game are as follows.

First, in stage G2, each member decides about the timing of his own choice of contest effort. 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. 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.[11]

[10] 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.

[11] 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

In stage G3, the point in time e is reached. At this point all observe their own and others' choices of timing.[12] Anyone who decided to make his effort 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.[13]

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 (2).

For situations in which several clan members expend the same effort we adopt the tie-breaking rules in Konrad und Leininger (2007) that are also discussed there and which are made in order to avoid equilibrium outcomes in which some player would like to expend the smallest possible positive amount of effort: Let M be the set of players who choose $\bar{x}$. Let E be the set of clan members who choose e, and $L = N - E$ the set of clan members who choose L. If $M \subset E$, or $M \subset L$, then each $i \in M$ wins the prize with the same probability equal to $1/\#M$, where $\#M$ is the cardinality of M. This is the standard tie-breaking rule for the simultaneous all-pay auction. If $M \cap E \neq \varnothing$ and $M \cap L \neq \varnothing$ then the allocation of the prize among the

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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.

[12] 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 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.

[13] Our results can be generalized to other cost functions than (3), but we constrain the analysis to this parametric case because it yields simple closed form solutions and allows for a simple ordering in terms of group members' effort costs.

players in M depends on their cost of effort. If $C_i(\bar{x}) \geq 1$ for all $i \in M \cap L$, then $p_i = 1/\#(M \cap E)$ for $i \in M \cap E$ and zero for all other players. In this case the bids of the early moving players are regarded to be preemptive (as they exhaust the maximal individually rational bids of the later moving players). However, if there are players at $\boldsymbol{l}$ for whom this is not the case, then the early bids can obviously not be preemtive for these players and hence they win: Denote by $(M \cap L)^+(\bar{x})$ the subset of $(M \cap L)$ with players for which $C_i(\bar{x}) < 1$ holds. If $(M \cap L)^+(\bar{x}) \neq \varnothing$, then $p_i = 1/\#(M \cap L)^+(\bar{x})$ for $i \in (M \cap L)^+(\bar{x})$ and $p_i = 0$ for all other players. 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:*

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

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

The result is proven in Konrad and Leininger (2007), 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 expend 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 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 (2007)). 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 decisions $t_{-1} = (t_2, ..., t_n)$ 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 (2007).

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.[14]

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

Note also that the leader behaves similarly to a 'big-man', making donations to the other group members. In order to make such donations, he needs access to funds which can be used for making the required distributions $\mathbf{a}^*$. This fund can be external, private wealth, wealth that belongs to the clan, but is controlled independently by the clan leader, much like in the examples in section 1.

5 Collective action

The formation of clans, groups or states has a purpose - the provision of collective goods. One of the quintessential public goods problems in the con-

[14]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.

text of primitive states is the collective provision of effort to defend the clan's territory, or to expand this territory at the expense of rivals or enemies.[15] 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.

[15] In other contexts the contributions to the public good can be seen as the effort in attracting customers or clients from competing firms in law firms and other companies that share revenue among partners, or other individually costly activities that increase the group income.

In particular, it is not required for our results that the clan leader is a player with a superior fighting ability in the external conflict.

Let the external conflict efforts sum up to the total effort:

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

This is a special case of more general technology determining the public good as a function of individual contributions, $y_C = y_C(y_1, ...y_n)$. However, free riding incentives are particularly strong in this the case of perfect substitutability as in (9), this case dominates in the literature on private provision of public goods[16], and our mechanism for implementing efficient contributions can easily be adapted to a whole class of other functions.[17]

The contest between the clan and the enemy is again governed by the same type of contest success function: the clan or the enemy wins the prize, depending on who expends 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

[16]McGuire (1974) introduced this setup when studying collective action. The seminal paper using this technology is Bergstrom, Blume and Varian (1986). For the case with contribution substitutability but convex individual contribution cost see Esteban and Ray (2001). For further discussion and a survey see Batina and Ihori (2005).

[17]Other technologies are Hirshleifer's (1983) "weakest link" model with $y_C = \min(y_1, ..., y_n)$, or the "best shot" model with $y_C = \max(y_1, ..., y_n)$, or the case of a discontinuous public good such that the public good is provided if and only if the sum of contributions exceeds a given threshold as in Bagnoli and Lipman (1989). In some of these cases an efficient non-cooperative outcome exists already if there is no threat of an intra-group conflict.

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 $y_C = y_1 + y_2 + ...y_n \to \max$ 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-G4 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-G4. 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-G4 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,

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

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-G4. 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

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

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 superiority 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 the Appendix.

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 $c < c_E$.[18]

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

[18] 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.

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.

6 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: $c^* = \frac{c_0}{n^*} = \frac{c_E}{2}$.

7 Conclusions

Experience from everyday life 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 everyday life experience within the strictly non-cooperative framework of a game with a finite horizon. Multiple equilibria can exist with respect to the distribution of resources within the group, some of which are peaceful and some of which 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 a key result of the paper.

The general mechanism analyzed 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 there is a natural role for one group member to perform the role as leader. The leader has no enforcement power. On the contrary, he is expected to make gifts to the group members and the only source of enforcement is equilibrium selection that is governed by social norms. The leader makes gifts once the other group members contributed their efficient share to group output. For an outside observer, these contributions and gifts seemingly look like reciprocity. However, they are not the outcome of preferences for reciprocity or altruism. They emerge from narrowly selfish preferences in non-cooperative equilibrium.

The leadership regime that emerges as an equilibrium outcome is in line with observed leadership structures in some primitive states, gangs, and other organizations that cannot rely on courts and other external enforcement mechanisms, either because they operate outside the formal sector, or because contributions to collective output and internal fighting effort are non-verifiable, making a contractual arrangement very difficult.

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 a limited 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 also do not rely on the folk theorem of infinitely repeated games. We also do not assume that the group collectively manages to empower a government that punishes group members who do not contribute their share. Instead, we consider a framework for which each and every decision is made independently, and in which any sequence of individual actions is sequentially rational. Punishment for norm disobedience is self-enforcing as disobedience triggers the selection of an equilibrium in the continuation game which involves lower payoffs, whereas obedience triggers the selection of a superior non-cooperative equilibrium.

8 Appendix

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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