Explaining Social Order and Norms Of Cooperation: Nested Hierarchies

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Abstract: Existing formal models of social order have difficulty providing convincing accounts of stable cooperation within societies because they do not analyze the full range of institutional forms that are available for large collectivities. This paper presents a new model of cooperation within societies, based upon a nested hierarchies of groups. The problem of maintaining cooperation is viewed as isomorphic at each level, with successful enforcement of cooperation at one level allowing a group to be treated as unitary entity at the next. This allows for comparison of the efficiency of a wide range of institutional structures within a fairly simple model. Finally, the effect of particularistic factors (in the form of member dependence) on the costs of maintaining cooperation within groups is analyzed, as are its effects on optimal institutional structure.

A recent revival of interest in the problem of order has been enriched by rational choice models that focus on management of cooperation within groups, societies and the international arena. The literature on decentralized ("anarchic") cooperation, in which all members of society are responsible for enforcing prescribed actions upon one another, has now become a genre unto itself, and hence needs little introduction.[1] This literature, however, has been

complemented but a smaller and growing body of work that discusses centralized monitoring and/or enforcement, in which a specialized agent is responsible for enforcement, as an alternative institution for cooperation. (Bendor and Mookherjee 1987, Bianco and Bates 1988, Hardin 1991, Milgrom, North and Weingast 1990, Mookherjee and Png 1992, Calvert 1994). It towards this latter literature that this paper is addressed.

Unlike most preceeding work, however, this paper will be less concerned with comparing the dynamics of centralized vs. decentralized cooperation than with modeling the costs and conditions for sustainability associated with different types of centralized and semi-centralized (i.e. federalized) institutions. The reason for this is that, given reasonable assumptions about the problem of monitoring, decentralized cooperation can be shown to be unsustainable in groups of sufficiently large size (Hechter 1987, 1993; Bendor and Mookherjee 1987, Hardin 1982, Taylor 1982, Olson 1971). This makes decentralized cooperation an implausible option for entire societies, as is clear from examining reality. Hence centralized or semi-centralized enforcement can be seen as as the only plausible institutions for cooperation within large-scale social entities. Understanding how such mechanisms work is a key to analyzing the problem of social order, as well as the role of the state and civil society in maintaining it.[2]

One major portion of the paper will be devoted to examining the costs of different institutions of hierarchical, federalized nested control within a large collectivity. Such institutions will be made up of a central authority (such as a state) that maintains cooperation among a number of subgroups, each of which has its own (possibly nested) control structure to maintain cooperation among its members. The model presented here will be used to demonstrate how enforcing cooperation entails costs that affect the original calculus of cooperation vs. shirking, which in turn, in a recursive manner, increases the amount of enforcement required. Because this paper is particularly concerned with the complex control mechanisms that can be found in large societies and organizations, the model will analyze federalized structures of control with arbitrarily levels of nesting. As a side-effect, this analysis will provide one method for spanning the levels-of-analysis problem by specifying conditions under which groups at one level of analysis can be treated as virtual unitary actors at a higher level of analysis. Finally, it will allow us to examine how changes, due to technological and other factors, in the relationship

between group size and the difficulty of monitoring can affect the optimal organization of control in a society.

The other major portion of this paper will be used to introduce into the analysis a crucial but often ignored factor in group dynamics: member dependence. Dependence, defined here as the difference between the expected utility that a member can gain within its group and the maximum that which he/she/it can gain in other, alternative, groups, will be seen as a crucial factor in cutting down the costs of maintaining cooperation within a group, hence in promoting group solidarity and the group's ability to contribute to higher-order cooperation. Dependence will help us to explain the frequent significance of communal factors in determining the boundaries of corporate groups within federal systems of societal control, but will also show how other types of non-communal "asset specificity" within a group can also contribute to solidarity.

Finally, the paper will address a number of additional topics briefly: the initial creation of authority, the possibility of exploitation within groups, and the autonomy of the state.

The point of this model will be to provide a fairly general, albeit highly simplified, way of thinking about a wide range types of centralized and semi-centralized control mechanisms, one which can be used at arbitrary levels of analysis: small and large groups, an entire society, or even the international system. Furthermore, it will provide a way of introducing important social variables, in the form of dependence, to the heretofor impersonal analysis of institutions for collective action. In examining how variations in the depth and breadth of nested hierarchy literature affect the costs of ensuring cooperation, it will provide implications for both the literature on organizational span-of-control and the evolution of state systems. In examining the role of dependence in groups and it impact on the cost and sustainability of authority within nested hierarchies, it will have implications for the literatures on ethnic and corporate groups and their effect on the stability of the state.

Because of this attempt at generality, the model will leave several important aspects of the problem of order unexamined; some attempt will be made to discuss them in the closing sections of the paper.

Centralized enforcement in a group

As implied in the introduction, the model is designed to apply to arbitrary units of analysis. Furthermore, with the exception of the

atomic (individual) level, each unit will be divisible into further, possibly nested, units. Analysis at each level will hence focus on a unit and the subunits that constitute it. The generic terminology used will be "group" for the unit and "members" for the subunits. Despite this, it should be emphasized again that "groups" can stand for a variety of things, from the international system to small communal collectivites, while "members" can range from entire societies to individuals.

Initially, I will a present a model of centralized monitoring within a group. Borrowing elements from numerous earlier models, the model's structure is based on a generic N-person prisoner's dilemma, in which a group of actors seek to gain some collective benefit, but where production of the benefit is conditioned upon costly action by themselves. For simplicity, we will only consider the single-period interaction. Each member has the option of either contributing towards the collective benefit of the group or shirking, and its (we will use an inanimate pronoun to refer to members, whether or not they are individuals) contribution will add a fixed amount, uniform across all members, to the amount of the collective benefit provided. All members will have the same cost and benefit structure, and the benefit will be non-joint in the sense that the amount of benefit that each member receives will be equal to the total amount of the benefit produced divided by the number of members in the group. The benefit will not be excludable from group members. The cost of contribution will be c, the amount of collective benefit generated by each member will be b, hence the marginal benefit to a member for contribution in a group of size n where all other members cooperate will be $b/n - c$. Members' cost and benefit structures will be common knowledge within the group. Since this is a prisoner's dilemma, $b > c > b/n$, hence all members will fail to contribute in a one-shot game, absent possible sanctions.

The problem of order, as portrayed here, is getting members to contribute to the group rather than to free ride on the contributions of others. Monitoring and sanctioning will be under the control of an enforcer, which will monitor group members and carry out sanctions against detected violators. For each period of interaction, it will be assumed that the probability that a shirking member will be monitored in a particular period will be equal to an exogenous factor $0 < \pi(n) < 1$, divided by the number of shirkers. $\pi(n)$ will represent the intrinsic ease of monitoring in a society of population n, such that $\pi'(n) < 0$. This exogenous factor reflects the fact that

the anonymity of large groups makes monitoring more difficult, even given proportionate resources devoted to monitoring (Bendor and Mookherjee 1987, 141; Taylor 1982, 53).

It is assumed that enforcer does not have direct control over the distribution of benefits. In other words, there is no way for it to prevent a member from receiving benefits from the contributions of all members, regardless of whether the member is detected shirking. Hence there will be no disincentrive to cooperate in a centralized enforcement system unless the enforcer has the means to impose after-the-fact sanctions on members that shirk.

Sanctions will be carried out by the enforcer by expending coercive power. Each unit of coercive power is capable of reducing the payoff of one member by one unit. We will use r to represent the amount of coercive power that the enforcer holds at any given time, and assume that the magnitude of r is observable by all members of the group. In order to hold coercive power r for a single period, the enforcer must pay a supply cost of $k\pi(n)r$ for that period, $1 > k > 0$. This assumption reflects the notion that the cost of maintaining a given level of coercive power is generally less than the amount of damage this coercive power can inflict on others, but also that the cost of maintenance has to be paid whether or not the coercive force is expended during that period. The presence of the exogenous probability factor π in the formula indicates that, although group size increases the difficulty of monitoring members, it also creates certain scale efficiencies in creating and maintaining force.

For the enforcer to rationally seek to maintain coercive power, however, the cost of maintenance must be compensated for by a reward that is at least equivalent to that cost. In this model, it is assumed that this compensation will take the form of additional contributions (taxes, if you will) that the enforcer levies upon the members themselves. However, the need to provide these additional contributions has effect of creating additional incentives for shirking by members, which must then be suppressed by yet more coercive power, which requires additional contributions, and so on. Whether or not centralized order is sustainable at all in a group depends on whether this type of recursion leads to a finite level of total contribution.

We can examine the conditions for single-period Nash equilibrium:

Proposition 1: In a centralized enforcement group environment, there is a Nash equilibrium where the enforcer maintains coercive

resources $r = (nc - b)/(\pi(n)(n - k))$ and each member cooperates by contributing c for generation of the collective benefit and r/kn for the generation of authority.

This equilibrium can be analyzed by examining a member's calculus for contributing or free-riding within a group. The probability of a shirking member being detected, as noted earlier, will be the exogenous probability factor $\pi(n)$. The marginal benefits from shirking from contributing toward the collective benefit are $c - b/n$. For a Nash equilibrium, we need be concerned only with unilateral shirking by one member. As noted, however, an expected sanction level of equal amount based on coercive resources of $(c - b/n)/\pi(n)$ will not be sufficient to prevent a member from shirking, since the costs for maintaining the enforcer's coercive resources must ultimately be borne by the group members themselves. This in turn requires another sort of cooperation: cooperation to provide the coercive resources.

In every period, members will need not only contribute cost c towards producing the collective benefit but also an additional amount towards producing the means to enforce their own contribution. The latter contribution may be referred to as "second-order contribution" to distinguish it from the former, "first-order" contribution. The dynamics of enforcing second-order contribution are isomorphic to those involved in enforcing first-order contribution. This brings up an obvious issue - third and higher-order contributions. Clearly, this recursion goes on indefinitely, and members must pay the sum of all these contributions in order for the enforcer to be effective in policing themselves. Likewise, the enforcer must have sufficient coercive power to collect these contributions. Hence, the calculus of whether or not to cooperate within a group will depend not only on the gap between costs (first-order contributions) and marginal benefits but on the sum of second to infinitieth-order costs as well. If this sum fails to converge, then clearly cooperation will not be possible.

The idea of first and higher-order contributions might be made clearer by examining what it means more concretely. First-order contributions correspond to organizational or statuatory laws that, despite requiring personal sacrifice, contribute to the economic success of one's group or locality. Second-order contributions involve additional costs, themselves embodied in laws, that are necessary for providing the means to enforce the original laws. However, the added burden of second-order contributions increases members'

incentive to violate laws, and additional enforcement power is needed to compensate for this additional incentive, and so forth. This is not to say that these contributions are made in separate installments; there is no reason they cannot be combined together into lump sums. Nonetheless, these sums can theoretically be decomposed into the portion that corresponds to each order of contribution.

Let r_i stand for the amount of resources required to enforce first-to-ith order contributions from the group members. $r_1 = (c - b/n)/\pi(n)$ and $r_2 = (c - b/n + k\pi(n)(c - b/n)/n)/\pi(n)$, the $k\pi(n)(c-b/n)/n$ portion being the amount of each member's second-order contributions.

In general, for $i > 1$,

$$r_i = (c - b/n + k\pi(n)r_{i-1}/n)/\pi(n).$$

If r_i converges,

$$\lim_{i\to\infty} r_i - (c - b/n + k\pi(n)r_i/n)/\pi(n) = 0.$$

If we simply use r to refer to the asymptotic value of r_i and solve for r, this then leaves us with

$$\pi(n)r + k\pi(n)r/n = c - b/n,$$

or

$$r = \frac{c - b/n}{\pi(n)(1 - k/n)} = \frac{nc - b}{\pi(n)(n - k)},$$

as indicated in Proposition 1.

In some ways, however, the Nash equilibrium seems an unsatisfactory concept for this kind of model, since the equilibria are vulnerable to coordinated shirking by more than one member. Given a fixed amount of enforcement resources, the expected punishment for any shirker will be inversely related to the number of shirkers. Hence, the enforcement resources that are adequate to dissuade a single member from shirking may be not provide sufficent disincentive for several coordinating shirkers. Hence it makes sense to consider equilibria that are resistant to coordinated exit by all m-member subsets of the group.

Proposition 1a: In a centralized enforcement group environment, ignoring indivisiblities, there is a set of equilibria resistant to coordinated simultaneous shirking where the enforcer maintains coercive resources $r = (nc^2)/(2\pi(n)(2b - ck))$ and each members cooperates by contributing c for generation of the collective benefit and r/kn for the generation of authority.

To analyze this, consider each possible scenario of m members simultaneously shirking. In each case, the amount of first-order benefit that the members will gain from collectively shirking will be $c - mb/n$, which will be positive as long as $m < nc/b$. Note that, if this is the case, the incentive for one member of the subgroup to shirk given the assumption that the others will is $c - b/(n - m + 1)$, which is positive if $m < (c(n + 1) - b)/c$. Since $b > c$, it is clear that $(c(n+1)-b)/c > nc/b$, hence it will be in the interest of each member of the shirking subgroup to shirk if it believes the others are.[3]

The amount of coercive resources that will have to be maintained for the expected sanctions to be equal to the incentive for the subgroup members to coordinate in shirking is $m(c - mb/n)/\pi(n)$. Consider the "worst case" m that maximizes this amount. Taking the first order condition, $c - 2mb/n = 0$, we get $m_{worst} = nc/2b$.[4] In that case, the amount of total enforcement resources that are required are $nc/2b(c/2) = nc^2/4b$.

Using a similar logic as the proof for Proposition 1,

$$r_1 = (nc^2/4b)/\pi(n).$$

$$r_i = (nc^2/4b + (c/2b)k\pi(n)r(i-1)/\pi(n)).$$

This gives us

$$r = \frac{nc^2/4b}{\pi(n)(1 - ck/2b)} = \frac{nc^2}{2\pi(n)(2b - ck)}.$$

One thing that the above analyses allow us to do is to specify the conditions under which centralized enforcement is possible in groups, taking into account group size, costs and benefits, and the costliness of maintaining force. In this case, where members have equivalent exit opportunities and where coordinated simultaneous exit is possible,

effective sustainable enforcement is clearly possible only if r converges, i.e. $ck/2b < 1$, or $k < 2b/c$.

However, if participation in groups is voluntary, there is another, more binding, condition, which is that the sum of the cost of 1st to infinitieth- order contributions net be low enough so that cooperation is worthwhile given the benefits provided. If this is not the case, even if an enforcement system can be set up, members will have no reason to create one, since they will gain nothing from it. This requires that $b - kr/n - c$, or $k < n(b-c)/r$. kr/n, of course, is the sum of 2nd+ order contributions from each member.

Proposition 1b: In centralized enforcement groups where exit is voluntary, ignoring indivisibilities, cooperation in a group will be sustainable if and only if $k < (4b(b-c)\pi(n))/(c^2 + 2c\pi(n)(b-c))$.

Since $r = (nc^2)/(2\pi(n)(2b - ck))$,

$$k < \frac{n(b-c)2\pi(n)(2b-ck)}{nc^2} = \frac{(b-c)2\pi(n)(2b-ck)}{c^2}$$

or

$$k < \frac{4b\pi(n)(b-c)}{c^2 + 2c\pi(n)(b-c)}$$

If k is above this amount, then the cost of centrally enforcing cooperation will exceed the gains to the group from that cooperation, making a cooperative equilibrium unsustainable. Rather intuitively, a higher cost of contribution of c or a higher enforcement maintenance coefficient k for maintaining enforcement resources will lower the possibility of sustainable cooperation. Also, note that $(4b(b - c)\pi(n))/(c^2+2c\pi(n)(b-c)) < (4b(b-c)\pi(n))/(2c\pi(n)(b-c)) = 2b/c$.

One thing this model allows us to do, then, is to endogenize the costs for maintaining a group's control system by specifying their relationship to the original costs and benefits for supplying the group's collective good. Hence, unlike previous models in the literature on centralized enforcement, which focus on the ability of exogenously limited amounts of punishment to provide sufficient disincentives for shirking, this model allows for theoretically unlimited amounts of punishment, but recognizes the effect of increasing punishment amounts on the costliness of maintaining the authority system and hence its stability.

Designing hierarchically nested, federalized systems of enforcement

In addition to providing a basis for analyzing the dynamics of cooperation in groups, this model provides a natural way of analyzing federalized institutions of authority in which a group is divided up into subgroups, with a enforcer within each subgroup responsible for ensuring the contribution of its members. Such institutions may be effective in enforcing cooperation even under circumstances where single-level centralized or decentralized institutions may not (Bendor and Mookherjee 1987, 140-4; Hardin 1982, 184; Olson 1971, 143). Like Bendor and Mookherjee's pioneering work (1987), this model examines the dynamics of different federalized systems of enforcement. However, it also analyzes the effects of different levels of nesting in hierarchical structures, as well as different possible sizes for subgroups at each layer of nesting.

Because the model presented here is designed to apply to arbitrary units of analysis, it can quite readily be used to examine multiple levels of nesting. In a multilevel hierarchy, a group at a higher level of analysis will have members that themselves function as groups at a lower level of analysis. In this situation, we can conditionally treat a group of size n whose members contribute amount c apiece and receive benefits b apiece as a unitary actor at the next level of analysis with contribution nc and benefits nb to its own group.

This type of analysis allows us to formalize the idea of a "corporate actor" (Coleman 1993) that can be treated as a unitary entity at one level of analysis, yet divided into its component parts at another. It is one way to span the levels of analysis problem that confronts all actor theories. At the same time, it avoids some of the fallacies associated with arbitrarily transfering assumptions at one level of analysis to another (Hannan 1993; Wrong 1994, chapter 6) by specifying a set of conditions under which this can occur.

Using this model, then, we can compare various nested institutions for cooperation among a population of N individuals, where cooperation requires contribution c from each of them will yield benefits b in return. k and $\pi(n)$ will be assumed to be the same for all possible groups of these individuals at all levels of nesting.

It follows from the above assumptions that the optimal design of a nested institution, one that minimizes total enforcement costs at all levels, will be based upon groups of uniform size at each level of nesting, as well as between levels. This is true because, if there

is any change in size that reduces enforcement costs per member encompassed within one group, it will also reduce costs per member encompassed in all other groups.[5] The uniform size will in turn determine the number of levels: the larger the size, the fewer the levels of nesting.

Proposition 2: Given a hierarchically nested federal structure of enforcement encompassing a population of N individuals, with exogenous probability factor $\pi(n) = n^{-1/z}$ for $z \geq 1$, with groups of uniform size at each level, then, ignoring indivisibilities, the optimal size of groups for the efficient enforcement of sustainable cooperation will be $n^* = e^z$, and the optimal number of levels of nesting in the hierarchy will be $ln(N)/z$.

We can begin by examining the total costs of enforcement for a hierarchy with groups of size n. In such a case, the lowest level (that made up of individuals) will contain groups of n individuals each, hence there will be N/n groups. These groups will be joined into supergroups, each containing n groups. Hence, there will be N/n^2 groups at the next level. At the jth level, we can expect N/n^j groups, each encompassing n member subgroups and n^j individuals total within those subgroups. At the very top level, there will be one group encompassing N individuals. Hence, the number of levels J will be such that $N/n^J = 1$, i.e. $J = log_n(N)$.

Given this, we can examine the total costs of enforcement at each level. At level j, each group will contain n members. The contribution of each member will be cn^{j-1}, while the benefits generated from the contribution will be bn^{j-1}. Given this, the total coercive resources required for enforcement for each group at this level will be

$$\frac{nc^2n^{2j-2}/4bn^{j-1}}{\pi(n)(1-ck/2b)} = \frac{c^2n^j/4b}{\pi(n)(1-ck/2b)}.$$

However, because there will be N/n^j groups at each level, the total cost of enforcement for all groups at one level will simply be

$$\frac{N(c^2/4b)}{\pi(n)(1-ck/2b)}.$$

Note that the j factors out, hence total resources required for enforcement at each level will be the same as at other levels.

The total required for enforcement at all levels will hence be

$$\frac{log_n(N)(Nc^2/4b)}{\pi(n)(1-ck/2b)} = \frac{ln(N)(Nc^2/4b)}{ln(n)\pi(n)(1-ck/2b)}.$$

Eliminating constant factors, the first order condition over n for this can be simplified to $d(1/ln(n)\pi(n))/dn = 0$, or $1/n - ln(n)p'(n)/\pi(n) = 0$. This implies that

$$n^* ln(n^*) = \frac{p(n^*)}{p'(n^*)}.$$

This is a rather abstract result, but it can be clarified by examining the values which n^* takes under more specific values of $\pi(n)$. In particular, let $\pi(n) = n^{-1/z}$ for $z \geq 1$. The value of z will reflect the degree to which increases in group size increase the difficulty of monitoring. The higher the value of z, the less the factor will be decreased by a change in size.

If $\pi(n) = n^{-1/z}$, $p'(n) = -1/zn^{-1-1/z}$. Hence, the first order condition becomes

$$n\, ln(n) = \frac{n^{-1/z}}{(-1/z)n^{-1-1/z}} = zn,$$

or $ln(n) = z$.

Hence

$$n^* = e^z.$$

The above analysis has implications for two separate, very different, groups of theories: First of all, most obviously, it has implications for span-of-control analysis in the study of organizations (Perrow 1982, chapter 7), a theoretical subfield that has remained more or less dormant despite the recent popularity of re-engineering within firms (Champy and Hammer 1993). In particular, it identifies how optimal span-of-control can be related in a reasonably precise manner to the rate of change in monitoring difficulty as a function of size, as well as a deductive justification for doing so.

Also, however, it allows us a way of analyzing in a new way the Hobbesian problem of order, particularly the ways states can maintain order among large populations of individuals. As Bendor and Mookherjee (1987) have pointed out, federal institutions are one way in which the monitoring problems of large societies can be reduced through compartmentalizing authority within federal units of manageable size. This frees us from either showing how very large numbers of unattached individuals can coordinate in maintaining institutions of cooperation or ignoring individuals as the units of analysis. What this paper shows is how the optimal configuration of such compartmentalized units is related to technological factors that affect the relationship of size to monitoring difficulty. This in turn provides a deductive underpinning for the transformation of institutions of state authority from narrow, feudal hierarchies in which layers of authority intermediated between the state and the individual and where collective responsibility was the norm; to modern, "mass" societies in hierarchies are flatter and state authority penetrates down to much lower levels.

The fact that this model is based upon a generic model of authority that can apply to arbitrary units allows the analysis to highlight out parallels between the analysis of organizations and the analysis of states. The basic logic of authority remains similar from level to level, despite the fact that these levels may be nested within each other.

Member dependence and the reduction of enforcement costs

So far, I have not considered conditions under which group members can move their participation from one group to another and be expelled from a group if they fail to cooperate. We can start by defining the concept *dependence* as the difference between the net utility a member obtains from cooperative membership within its group and the highest possible utility it could gain from membership within an alternative group. Hence, one-period dependence $d = b-c-(b_0-c_0)$, where b_0-c_0 can be seen as the member's "reservation wage" that it can gain outside the group. Again, for simplicity, we will consider only the single-period interaction, and assume that individuals are capable of immediately moving their participating to an althernative group.[6]

Dependence has been seen as a key factor in maintaining group solidarity (Hechter 1987), and its effects can be examined formally by

considering the effect of dependence on the calculus of contribution vs. shirking. In particular, we can examine the effects of the threat of expulsion on the amount of coercive resources required to maintain cooperation within a group, and its effect in turn on the highest level of first and higher-order costs that can be sustained in equilibrium.

Proposition 3: In centralized enforcement groups where members have dependence d, ignoring indivisibilities, there will be a cooperative equilibrium where the enforcer maintains coercive resources $r = n((c-d)^2)/(2\pi(n)(2b-(c-d)k))$ if $c > d$ or $r = 0$ otherwise, and all members cooperate.

This follows from the fact that the prospective expulsion penalty lowers the amount of coercive force that has to be maintained in order to make shirking irrational. If m members simultaneously shirk, the coercive resources that are needed in order to match the incentives to shirk will be $max(m(c-mb/n-d),0)/\pi(n)$.

In the case where $c \leq d$, it is clear that this can be set to zero by simply setting x to $n/\pi(n)$, in which case, $\forall m$ s.t. $n \geq m > 0$, and $m(c-mb/n-d) \leq 0$.

Where $c > d$ the first-order condition is $c - 2mb/n - d = 0$, and $m^* = n(c-d)/2b$. Hence x set to $nc/2b\pi(n)$ will make detection certain. Using a similar logic to the proof of Proposition 1a, $r = m(c-mb/n-d+kr/n) =$

$$\frac{n(c-d)^2}{2\pi(n)(2b-(c-d)k)}.$$

Since $c-d < c$, this is clearly less than r for a similar group where members have equivalent exit opportunities.

Proposition 3.1: In centralized enforcement groups where members have equivalent exit opportunities, ignoring indivisibilities, and where exit is voluntary, cooperation in a group will be sustainable if and only if $k < (4b\pi(n)(b-c)\pi(n))/((c-d)^2+2(c-d)\pi(n)(b-c))$.

The proof for this is similar to that for Proposition 1a.1. Furthermore, it is clear that this bound is larger than for the case where equivalent exit opportunities exist.

Among other things, the analysis of dependence shows why communal groups might have an easier time maintaining internal solidarity than other groups (Taylor 1982, Taylor and Singleton 1993). As interactions continue for a long period of time, members of

communal groups develop various sorts of "asset specificity" which create distance between the amount of utility that they can gain within the group and that which they can gain outside. The sources of asset specificity might include complementary specializations in productive activities, common preferences developed through shared experiences (including mutual altruism), and shared modes of communication. Given these sorts of complementaries, it will be difficult for members to leave without significantly lowering the level of benefits they enjoy. This in turn allows communal groups to maintain cooperation without as much resort to costly coercion.

However, the analysis can also be extended to non-communal groups. It suggests that interest groups such as unions or industrial associations can lower the costs of enforcing cooperation by the extent to which their members cannot easily move to another organization and enjoy equivalent benefits. Furthermore, it shows that selective incentives within such groups will be effective in eliciting cooperation only to the extent that there exists no alternative groups into which members can move and be offered the same incentives. This shows, somewhat counterintuitively, that the difficultly of exit can actually increase the incentives for cooperation, reduce the cost of enforcement, and hence the increase level of benefits that members can enjoy within a group, a point related to one made by Hirschman years ago (1970).

Dependence slack and higher-level cooperation

One rather straightforward corollary of the analysis in the previous section and the analysis of hierarchically nested groups is the implication that member dependence gained through cooperation at one level of analysis can be used to lower the cost of enforcing cooperation at a higher level of analysis, possibly for activity that is unrelated to the activity at the lower level. In essence, dependence can be passed from one level to another.

Consider an interaction within a group in which $d - c/\pi(n) > 0$. Then, according to Proposition 3, the cost of enforcing cooperation will be nil. However, there will some "slack" dependence remaining in the sense that the group could support higher levels of contributions without increasing enforcement costs. We can refer to $\hat{d} = d - c/\pi(n)$ as the dependence slack of a group, and it is clear that the amount of additional contributions that can be supported without enforcement

costs is such that $(\Delta c - b/n)/\pi(n) \leq \hat{d}$, where Δc represent the increase in contributions.

Suppose, then, that a number of such hypothetical groups are participating in interactions at a higher level. If so, and if c_h and b_h refer to the costs and benefits for each group from cooperation within the supergroup, then it is clear that such cooperation can be sustained without cost as long as $(c_h - b_h/n)/\pi(n) \leq \hat{d}$ for each group. This means a "savings" of $(nc_h^2/4b_h)/\pi(n)(1 - c_h k/2b_h)$ from the enforcement costs that would have to be borne if these groups had no dependence among their members. Even if $(c_h - b_h/n)/\pi(n) > \hat{d}$,

$$R = \frac{n(c_h - \hat{d})^2}{2\pi(n)(2(b + b_h) - (c_h - \hat{d})k)}.$$

Note not only that r is reduced by the presence of $\hat{d}$ in the numerator, but also by the presence of b in the denominator. This latter reduction occurs because the effects of benefits on incentives are not affected by dependence, while the effect of costs are.

Hence, dependence "borrowed" from a lower level can reduce the enforcement cost of cooperation at a higher level, or may even make cooperation possible where it would otherwise be impossible. This can be compared to Olson's "by- product" theory of collective action by interest groups, which discusses how collective action may succeed as a result of unrelated actions which provide groups with selective incentives to offer their member (Olson, 1971, chapter 6). While the above analysis is in large part constistent with such an implication, it shows not only how the provision of selective incentives may be costly, but also how their effectiveness in promoting further cooperation is contingent on their being unavailable or more costly in other groups. It also shows how selective incentives from interactions at a one level of analysis can, through dependence slack, promote cooperation at a higher level of analysis.

This in turn can explain why high-dependence groups, whether they be ethnic groups (Lijphart 1972, 1977) or corporate economic entities (Schmitter 1974), are often used as intermediaries to maintain order in large societies. Such groups can often deliver the cooperation of their members at less cost than the state could through attempts at coercive control (Hechter 1993). Dependence slack can be seen as a kind of "social capital" (Coleman 1988) that allows both communal

groups (Murakami et al 1981, Tu 1984, Hechter and Kanazawa 1993) and high-dependence civic ones (Putnam 1994) to bypass the need for costly coercive enforcement and hence provide order more efficiently.

This analysis, however, also points out limits to consociational or corporate solutions to the problem of order. In particular, it suggests such solutions will be of use only to extent that the members of intermediary groups depend on the the group for important benefits and cannot gain the benefits outside the group. Furthermore, the groups must be large enough that the state's job of maintaining cooperation among them is not itself problematic. Only then will the central authorities of such group be able to ensure the cooperation of their members at the state level more efficiently than the state itself.

Various topics connected to this model

In this section, I will attempt to discuss a variety of additional topics connected with the model. I will not have the space to examine any in detail, but hope to provide hints on how development of the model might proceed in these directions.

The initial formation of authority : The discussion above has focused on equilibrium, i.e. the types of authority institutions that can remain stable over time. However, it does not discuss how such institutions are created in the first place. There are a number of ways in which this may be accomplished, but each requires that initial cooperation take place without the help of an established enforcer.

The "primordial" method for cooperation will be where groups are small enough for members to appropriate enough of their contributions to make contributing worthwhile, regardless of sanctions. Over time, dependence may develop, which allows groups to increase the level of contributions collected rom members, including contributions which allow them to cooperate as a group with other groups within encompassing supergroups.

Building up coercive enforcement resources, on the other hand, will require a gradual ratcheting up in the amount of contributions required from group members, even if this increase is not immediately reflected in returns. This can take place in either of the two cases mentioned above, and if discounting rates are low enough. Then it may be rational for members to contribute to the creation of a enforcer structure which will later enforce higher levels of first-order contribution.

One additional way in which coercive authority may be formed is through the actions of a political entrepreneur, who may offer to disproportionately provide the resources for coercive authority in return for a disproportionate share of the benefits of the resulting cooperation.[7]

Exploitation within groups : The fact that member dependence can help lower the costs of enforcing cooperation in a group brings up a related question: what if members have negative dependence, i.e. they can actually gain more benefits outside their group than within it? Of course, if members can freely exit their groups, then they will, and the question is moot. But voluntary exit is not essential to model, and it may be possible that a group's enforcer may try to keep members within the group through coercion.

In such a case, calculations of the cost of enforcement are the analogous to that in the previous sections with $D < 0$. Hence enforcement costs will actually be higher than in groups where equivalent exit opportunities exist. There are two reasons why groups may persist despite negative dependence. One, which I will discuss further, is when the enforcer is self- interested and attempts to confiscate member assets to the fullest extent possible. Another is when it benefits a subset of members to contribute to an enforcement structure which exploits another subset of members.

Here, it can be pointed out that positive dependence among some subset of members can actually aid in making them contribute to a coercive enforcer that maintains the contribution of other members by force, by reducing the cost of enforcing their own 2nd and higher-order contributions. Hence, the flip side of dependence's contributory role to the maintenance of cooperation is its role in sustaining exploitation by one subset of a group over another. Moreover, dependence slack within a group can be used by that group and its allies at a higher level to contribute to exploitation of other groups within the same supergroup.

Central autonomy and exploitation : As I noted, the creation and maintenance of enforcer depends on contributions by group members. However, once it is created, and if we abandon the assumption that it acts in the members' interests, it may choose to use its coercive force to elicit higher contributions (including further resource maintenance costs) than is warranted by the benefits that

they receive back. However, the enforcer will be constrained in the extent to which it can do this by the increasing costs to maintaining coercive resources in light of increased incentives for members to resist. The greater the inequities between contributions and benefits, the higher the enforcement costs and the higher the possibility that such "cooperative" equilibria cannot be sustained.[8]

Conclusion

What all this suggests, then, is that there are plenty of opportunities for further formal analysis based upon a model similar to the one suggested above. Other changes that may be considered include noisy monitoring of whether or not member cooperates. Complications may also include economies or diseconomies of scale in groups, differences within the productivity of group members, both of which may create a dependence of a group upon certain of its members, which may create costs to expelling them which in turn offset the effects of dependence of the members on the group. Finally, the model be changed to accomodate overlapping membership in several groups or "mixed" systems with decentralized cooperation at some levels and centralized cooperation at others.

Nonetheless, I believe that more realistic modeling of human processes on a large scale requires the analysis of the dynamics of arbitrarily nested hierarchies as well as of the social factors involved in group membership. As we have seen, such modeling has implications for a wide variety of substantive work in the social sciences. I hope that this is a constructive step in developing models along those lines.

NOTES

1. Olson 1971, Ullman-Margalit 1977, Axelrod 1986, Taylor 1982 and 1987 to give only a few prominent examples.

2. Some theories of social or international order overcome the size problem by using large units such as social groups or states as their units of analysis. While this is a legitimate simplification, it brings up the question: How do these units maintain their internal solidarity? What internal conditions allow them to be treated as unitary actors?

3. An equilibrium which in which no subgroup of members can gain by collectively shirking is referred to as a "strong equilibrium" (Aumann 1959). That which is resistant to shirking by a subgroup of members such that no further sub-subgroup of has of the subgroup has any incentive to "efect" from shirking by cooperating is called "coalition-proof." (Bernheim, Peleg and Whinston 1987) In this case, the prospect of collective shirking by an m-member subgroup always makes it rational for each member of the subgroup to shirk, so conditions for each type of equilibria are equivalent.

4. Adjustments may have to be made for indivisibilities, including when $nc^2/4b < 1$, but they will be ignored here for reasons of simplicity.

5. Again, I will ignore indivisibilities, i.e. the fact that the size of groups must be integers, in the following analysis, although the appropriate optimum values given these can by examining integer values on each side of the optimum, and allowing groups to arbitrarily differ in size by one to accomodate spare members.

6. It can be assumed that the reservation wage consists of the benefits of participating in a cooperative equilibrium in the other groups, since groups that allow free entry and shirking among all those who enter will in the long run disappear because the benefits to even productive members will disappear.

7. For a model which begins work along these lines, see Bianco and Bates 1988.

8. One further possibility is that central authorities may collude with one another by limiting the exit opportunities of the members of their respective groups. This, for instance, is quite typical of state behavior.

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