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IN PUBLIC GOODS PROVISION

by

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INTRODUCTION

This paper considers the problem of public goods as an example of non-Nash behavior, in which contributions to a public good are a function expectations concerning the contributing behavior of others in a well-defined group. It argues (a) that non-Nash behavior is an empirically plausible foundation for the analysis of public goods problems; (b) that the influence of expectations affecting this behavior may be described in terms of the theory of "conjectural variations;" (c) that the principal difficulty in achieving an adequate level of public goods is due to the "assurance problem" in cases in which conjectures are positive, that is, when agents are uncertain whether a sufficient number of others will contribute if they do. This framework is consistent with recent work by Cornes and Sandler (1984a, 1984b) and encompasses recent arguments by Sugden (1984) and the author (Runge, 1981, 1984a,b).

The paper is divided into five sections. The first discusses recent literature on public goods provision, and the importance of expectations and non-Nash behavior as a central argument in the analysis of underprovision. The second section describes a useful model of conjectural variation allowing analysis of expectations at a formal level. The third section argues that the assurance problem emerges as central to the understanding of both successful and unsuccessful public goods provision. The fourth extends the argument developed in section two to consider issues of group homogeneity and provides a definition of "institutional failure." The last section briefly considers an important instance of these problems: common property.

1. Public Goods and Economic Theory

Models of public goods and collective action make extensive use of the Prisoner's Dilemma (PD), in which "free riding" dominates regardless of the expected decisions of others. These models predict a Pareto-inferior Nash equilibrium in which contributions are less than the level that would be Pareto-optimal. These models are increasingly unpersuasive to many economists, primarily because they fail the empirical test ordinarily required of positive scientific inquiry. A wide and increasing body of experimental results fails to support the free rider hypothesis and the impossibility of voluntary public goods provision, casting "serious doubt upon the importance - and, in some cases, even upon the existence - of the free rider problem" (Kim and Walker, 1984, p. 3). These experimental results include those in which free riding is less than predicted, or what Brubaker (1975, 1984) terms "weak" free riding (Smith, 1980; Alfano and Marwell, 1981; Marwell and Ames, 1979, 1980, 1981). They also include results in which no free riding occurs at all (Bohm, 1972). Responding in part to some design problems with these experiments, more recent experiments have given stronger support to the free rider hypothesis (Isaac, McCue and Plott, 1982; Plott, 1982; Kim and Walker, 1984). Because of the wide variation in these results, it would appear that additional information is necessary to understand when and why public goods are provided. Neither strict free riding nor complete provision of public goods are universally observed phenomena.

One important source of information concerns the expectations held by agents about the likely behavior of others. Where these expectations affect the outcome, the conjectures held by individuals about others are important parameters. These conjectures may be either positive (if I expect you to contribute, I will too) or negative (if I expect you to contribute, I won't). Positive and negative conjectural variations represent non-Nash behavior. Nash behavior is a special case in which conjectural variations are zero (I'll contribute or I won't, regardless of what I expect you to do).

The importance of non-Nash conjectures has received recent experimental support. In a series of experiments testing the assumption of Nash behavior in a generalized bargaining situation, Roth and Schoumaker (1983) report the failure of models based on such behavior to predict equilibrium outcomes.[1] These experiments support the hypothesis that bargaining is based on expectations about the contributing behavior of others, implying non-zero conjectures. The conclusion of the experiments is that "it may be necessary to

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[1]These may be understood in terms of the following thought experiment. A randomly selected individual plays a large number of bargaining games over how to divide a certain sum of money with an opposing player. Although he is unaware of it, all of his opponents are confederates of the experimenter, and consistently allow his actions to yield him, say, 80 percent of the available money. After he has gone through this experience, <u>you</u> have an opportunity to bargain with him on your own behalf (not as a confederate). Since his past experiences lead him to expect to gain 80 percent of the money, he has every reason to expect that you will concede this amount to him. The rules of the game are that after completing a set of negotiations, the players separately write down their demands, which they receive if their demands are compatible (i.e., if their conjectures are consistent). Otherwise they receive nothing. The fact that the randomly selected individual tends to expect to receive 80 percent makes it risky for you to write down a demand of more than 20 percent.

incorporate the expectations of bargainers into any description of equilibrium outcomes, and that there may in general be multiple equilibria supported by different sets of mutually consistent expectations" (Roth and Schoumaker, 1983, p. 371). This result is consistent with more specific tests of the free rider hypothesis. Isaac, Walker and Thomas (1984), for example, determine that unique equilibria do not exist in public goods situations because there is no generally dominant strategy, so that the very concept of free riding is poorly defined. They therefore conclude (p. 141) that "Definitions and predictions must explicitly state what assumptions about expectations and what solution concepts are being employed." In yet another experiment testing the significance of expectations in public goods provision, Marwell and Ames found a statistically significant relationship between the level of contributions to public goods expected of others, and the amount contributed by individual subjects (1979, p. 1356). Fleishman, in experiments similar to those of Marwell and Ames, found that "forming expectations of others' behavior does influence decisions to cooperate" (1981, p. 11).

These findings are remarkable primarily because they are explicitly rejected in models based on Nash conjectures, of which the most well known is the Prisoners' Dilemma. In a number of earlier papers (Runge, 1981, 1982, 1984a), I have argued that the concept of Nash conjectures and the Prisoners' Dilemma are therefore inappropriate in most public goods situations, and argued in favor of the comparative plausibility of non-Nash conjectures, multiple equilibria, and the absence of dominant strategies.

One consequence of non-Nash behavior is to emphasize the distinction between expectations and actions. For example, if I expect my neighbors to contribute to public radio or television, does this lead me to do so too, or does it lead me not to? Is there some critical mass of others who must contribute for me to consider doing so too? (see Runge, 1985).

These issues can be considered in terms of three types of relations between expectations and actions. The first of these is Nash behavior, captured by the dominant free rider strategies of the single-period PD game. The second type is represented by the assurance problem, one in a variety of coordination games (Schelling, 1960). The assurance problem (AP) does not predict that public goods will always be provided (Runge, 1981, 1982). It simply states that they <u>can</u> be if expectations are appropriately structured. Specifically, the AP holds (1) that expectations affect actions, or that conjectures are non-Nash; and (2) that these conjectures are positive, so that expectations are positively correlated with actions. Hence, if I expect others to contribute to a public good, I will contribute too; but if I expect others to free ride, I will free ride too. The single period PD, in contrast, holds that it does not matter what I expect of others; I will always free ride. The "iterated" PD introduces expectations by repeating the PD game. As Axelrod and Hamilton (1981) and various others have shown, the iterated PD leads to equilibrium strategies which, while unstable, are most robust when agents pursue a "tit-for-tat" strategy. This strategy reflects positive conjectural variations, since expectations of next-period contribution lead to contribution, while expectations of next-period defec-

Table 1

CONJECTURES

STRATEGIES		NEGATIVE CONJECTURES	ZERO CONJECTURES	POSITIVE CONJECTURES
	Defection	If I expect contribution, I will defect (conjectural free riding)	I will defect, regardless of what I expect of others (dominant free riding)	If I expect defection, I will defect
			SINGLE PERIOD PRISONERS DILEMMA	ASSURANCE PROBLEM ITERATED PRISONERS' DILEMMA
	Contribution	If I expect defection, I will contribute (conjectural altruism)	I will contribute, regardless of what I expect of others (dominant contribution)	If I expect contribution, I will contribute
		CONFLICTING STRATEGIES	INDEPENDENT STRATEGIES	COORDINATED STRATEGIES

tion lead to defection. A third category of game involves negative conjectures, which are often erroneously associated with the Nash conjectures of the single period PD. Negative conjectures imply a negative correlation between expectations and actions. If I expect others to contribute, then I will free ride, if I expect others to free ride, then I will contribute.

We can think of expectations determining actions in terms of conflict and coordination: negative conjectures imply actions that purposively conflict; positive conjectures imply actions that purposively are coordinated. Zero conjectures imply that expectations simply do not influence actions; they are independent (see Table 1). Whether the structure of expectations in a given situation is that of positive, negative, or zero conjectures is an empirical question. In order to develop adequate tests, a more precise analytical framework is necessary. This framework has recently been developed in a series of important papers.

2. Models of Conjectural Variation

Nash behavior, or zero conjectural variations, assume that contributions to the public good are independent of the expected contributions of others. Non-Nash behavior may take the form of either positive or negative conjectural variations, in which expectations determine individual contributions. A relatively simple graphical technique following Cornes and Sandler (1984a) may be used to describe non-Nash behavior, thus illustrating a number of important issues discussed above.

Cornes and Sandler's description is as follows. Suppose that n individuals constitute a well-defined group consuming a pure public good and a private good. The ith consumer has a continuous, strictly increasing and strictly quasiconcave utility function

(1) $U = U(y, \tilde{Q} + q)$

where y is consumption of the private good, q is the quantity of the pure public good purchased and $\tilde{Q}$ is the purchase of the public good by the rest of the group. The individual consumes both his own purchases of the public good and those of others so that $\tilde{Q} + q = Q$. This "total" consumption results from nonrivalry and nonexcludability due to the good's pure public nature (Samuelson, 1954). Where the public good is not pure, the level of consumption of $\tilde{Q}$ will decrease for the consumer to the extent that rivalry or excludability exist. The ith consumer maximizes utility subject to a budget constraint:

(2) $y + pq = I$

where the price of the numeraire private good is 1, the public good's price is p, and the individual's income is I. Equations (1) and (2) imply

(3) $U = U(I - pq, \tilde{Q} + q)$.

If I and p are fixed, this function in turn implies the existence of indifference curves for various levels of q and $\tilde{Q}$. Expressed in $(q, \tilde{Q})$ space, these curves are a two dimensional representation of the three-dimensional indifference surface expressed by levels of y, q, and $\tilde{Q}$. If this two-dimensional plane cuts this space in the yq orthant, where $y + pq = I$, and is parallel to the $\tilde{Q}$ axis at a height of I in the $y\tilde{Q}$ orthant and a height of $\frac{I}{p}$ in the $q\tilde{Q}$ orthant, the procedure eliminates the numeraire from consideration and the trade-off between q and $\tilde{Q}$ can be displayed in two-dimensional $(q, \tilde{Q})$ space.

In the figure below, three such indifference curves are pictured. Their shape reflects the well-behaved nature of the utility functions. Monotonicity, for example, insures that I_2 lies above I_1, and I_3 above I_2. Hence, for a given level of q, added measures of the public good $\tilde{Q}$ due to the decisions of others increases utility overall. The slope of an indifference curve is

$$(4) \quad \frac{p}{MRS_{Qy}} - 1$$

where MRS_{Qy} is the marginal rate of substitution between total public good consumption $(\tilde{Q} + q) = Q$ and the private good. This is because

$$(5) \quad U = U(I - pq, \tilde{Q} + q)$$

$$(6) \quad \frac{\partial U}{\partial q} = -p \frac{\partial U}{\partial y} + \frac{\partial U}{\partial Q}$$

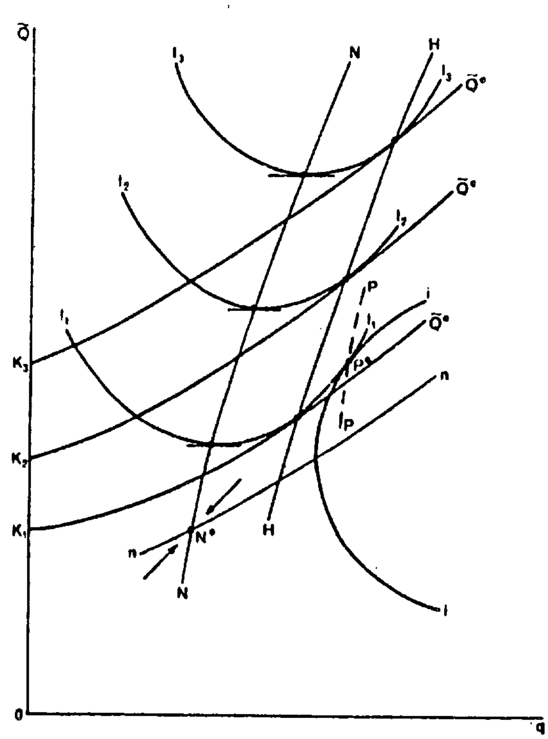
and

$$(7) \quad \frac{\partial U}{\partial \tilde{Q}} = \frac{\partial U}{\partial Q}$$

Dividing (6) by (7) and simplifying yields (4).

Where P/MRS_{Qy} is equal to 1, and the slope is therefore zero, the curve reaches an interior minimum. The utility-maximization problem leading to the minimizing choice is subject to both the budget constraint and the constancy of $\tilde{Q}$. This implies Nash conjectures, or zero conjectural variation, in the sense that the individual views the public goods contributions of others as independent of how much he contributes himself (q) or the consumption of private good (y). Hence, with Nash conjectures,

Figure 1



$\tilde{Q}$
I_3
N
H
I_3
$\tilde{Q}^*$
I_2
$\tilde{Q}^*$
I_2
P
i
I_1
$\tilde{Q}^*$
I_1
K_3
P^*
n
P
K_2
K_1
N^*
H
n
N
i
0
q

(8) $\frac{d\tilde{Q}}{dq} = 0.$

A reaction path consistent with Nash conjectures is traced out along the minima of these indifference curves, where MRS_{Qy} = p, or NN (which may be either positively or negatively sloped). If the "rest of the group" is only one person, then we can describe another indifference curve in the same space, such as ii, which yields a locus of minima such as nn, which intersects at point N*, the Nash equilibrium. Stability requires that the absolute value of the product of the two paths be less than 1 in the neighborhood of equilibrium (see Cornes and Sandler, 1984b). The tangencies of the two agent's indifference curves, such as point P*, trace out the Pareto optimal path PP. Along this path, the sum of MRS's is equal to the price ratio or marginal rate of transformation. In cases of more than two individuals, a "representative individual" may be described by assuming that individuals hold the same tastes and endowments and that the Nash symmetric equilibrium results where each is behaving identically.

Non-Nash behavior in the public goods model occurs when

(9) $\frac{d\tilde{Q}^e}{dq} \neq 0$

where $\tilde{Q}^e$ is the value of $\tilde{Q}$ that is expected to occur. As noted above, an agent may expect that his own contribution will have either a positive or negative influence on the expectations of the group. In general, the larger the group, the smaller the individual share $\frac{q}{(q + \tilde{Q})}$ would be. In those cases where n is large, an argument can be made for small effects of conjectural variations expressed by (9). This is Olson's (1965) classic argument. The conjectural variation captured by (9) expresses the effect of changes in an individual's contribution on the expected contributions of others. Equally important may be the effect of the expected contributions of others on the individual, or $\frac{dq}{d\tilde{Q}^e}$. Even in large groups, the expectation that contributions will be made by others may lead to increased individual contributions if conjectures are positive, and decreased contributions if conjectures are negative.

In general, individual contributions will thus depend not only on the conjectures of agents, but on parameters that affect these conjectures, such as group size, the costs of monitoring individual contributions, enforcement capacity, reputation, and other arguments. Below, I shall argue that these parameters are determined largely by social institutions, which are innovated so as to affect the conjectures of individual agents. Cornes and Sandler propose the general specification

$$(10)\ \frac{d\tilde{Q}^e}{dq} = F(\theta\, ,\ q),$$

where θ is a vector of parameters including influences on the responsiveness of individuals to the expected behavior of others. Following the argument above, we will also be interested in the impact of the group on individual behavior, expressable as

$$(11)\ \frac{dq}{d\tilde{Q}^e} = G(\theta\, ,\ \tilde{Q}^e)$$

In general, we can express $\tilde{Q}^e$ as endogenous, so that

$$(12)\ \tilde{Q}^e = F(\theta\, ,\ q,\ K)$$

where K is a constant of integration (see Cornes and Sandler, 1984a, equation (4) and (5)). Similarly,

(13) $q = G(\theta, \tilde{Q}^e, K)$.

In both cases, K is dependent on initial conditions. In (12), these are given by the initial value of $\tilde{Q}$, and in (13) by the initial value of q.

This ingenious representation can accommodate any function, allowing description of conjectural variations using "expectations contours" in $(q,\tilde{Q})$ space. This assumes that the current level of expectations is given exogenously, expressed in current values of $\tilde{Q}$ and q, and does not depend on any other endogenous variables. One way to interpret this is as a short-run condition. In the short run, expectations of the behavior of others are "given" by the rules in force. In the long run, these rules, and therefore the vector parameters θ, may change as new institutional arrangements are innovated.

Derivation of equilibrium in a non-Nash setting proceeds by substituting $\tilde{Q}^e$ for $\tilde{Q}$ in the individual's utility function, because the agent's contributions depend on his expectations. Substituting (12) for $\tilde{Q}$ in (3) results in the problem of the effects of individual contributions on the group's expected contributions.

$$\max_{y,q} U(y, F(\theta, q, K) + q)$$

$$\text{st. } I = y + pq$$

In this case first order conditions simplify to

(14) $[(\partial F/\partial q) + 1]MRS_{Qy} = p$

The solution to this problem takes the form of q^*, which is a function of $\tilde{Q}^e$. Hence, not only do individual contributions affect expectations of the group, these expectations affect individual contributions. This result reduces to that of Nash when $d\tilde{Q}^e/dq = 0$ which will also imply that $dq/d\tilde{Q}^e = 0$. Otherwise, the conjectural variation serves as an additive weighting factor that affects optimal behavior. Expectations, in other words, determine optimal actions.[2]

In the figure, curves $K_1\tilde{Q}^e$, $K_2\tilde{Q}^e$ and $K_3\tilde{Q}^e$ represent different expectations paths, each different by a constant. These correspond to (12) but with different initial conditions established by the level of public goods contributions $\tilde{Q}$ provided by others in the group. The slopes of these functions are conjectural variations dQ^e/dq. Where the slope of expectations paths is positive, positive conjectures are described, and an increase in q is expected to increase $\tilde{Q}$. Where the slope is negative, negative conjectures are described. These conjectures provide a constraint binding the contribution of the individual for the public good.

Positive conjectures lead to a hybrid reaction path, HH, which is the locus of tangencies of the indifference curves and the expectations paths. This can be seen by rearranging (14) so that

(15) $\partial F/\partial q = p/MRS_{Qy} - 1$

The left hand side is the slope of the expectations path of $\tilde{Q}$ and the right hand side is the slope of the indifference curve, so HH is the path charac-

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[2]Second order conditions, of course, must also be satisfied. Cornes and Sandler (1984a, p. 375) note that second order conditions require that expectations contours have less curvature than the indifference contours in the neighborhood of the point of frequence.

terized by the optimality conditions in (14).

It is important to note that the hybrid reaction path resulting from positive conjectures characterizes a situation in which increased individual contributions are matched by increased contributions by others (though not necessarily in the same proportion). Wherever this is the case, the hybrid path shows that a dollar's worth of contributions return more than a dollar's worth of public goods. Hence, it is not surprising that with positive conjectures, HH always lies to the right of NN, and closer to the Pareto path PP. It is also clear that with negative conjectures, expectations contours are negative, and the locus of tangencies with the indifference curves will fall to the left of the Nash path, and therefore even further from the Pareto path then either NN or HH. The implication of this model is that individuals have an incentive to supply more of the public good if they expect the rest of the group to do so too. This incentive for coordinated behavior is fundamental to the appeal of the assurance problem as an analytical description of the problem of public goods provision.

3. The Assurance Problem

The incentive for coordinated action, reflected by the Pareto superiority of positive conjectural variations in the Cornes and Sandler framework, is also central to other recent work on voluntary public goods provision. Sugden (1982, 1984) has argued explicitly that a desire for coordination may explain such behavior. Individuals pursue self-interest subject to rules which it is in everyone's interest that everyone should follow (see also, Liebenstein, 1984). If an individual expects others to contribute at least $\tilde{Q}$, for example, then he might feel obliged to contribute some minimal amount, say $\frac{\tilde{Q}}{n}$. This type of rule is often called "Kantian" (Collard, 1983), implying a moral foundation for public goods contributions. Harsanyi (1980) has given it the more revealing title of "rational commitment." This is appropriate, because it is unclear that there is any moral content to the decision except that it is constrained by expectations of others' behavior. Sugden (1984) refers to this simple rule as the "principle of reciprocity," in which individuals commit themselves to a certain level of public goods contribution, conditional on the expectations that others will do the same. In Sudgen's model, reciprocity appears to be simply a manifestation of positive non-Nash conjectures, since decisions to contribute are conditional on the expectation that others will do so too.

Consistent with the framework above, Sugden finds that in a simple model based on reciprocity, an equilibrium level of public goods contribution exists, but is not generally unigue, because the particular equilibrium depends on expectations of reciprocation. Moreover, the set of attainable equilibria includes the Pareto efficient one, but other equilibria involve under-provision of the public good. As Sugden notes (1984, p. 788), "These inefficient equilibrium states are ones in which everyone would contribute more if only he know that the others would too, but in which no one will make the first move. They are instances of the 'assurance problem' (Sen, 1967) as opposed to the n-person prisoner's dilemma problem."

It is worth emphasizing that the assurance problem reflects a set of preferences in which agents prefer to coordinate their behavior. If they expect free riding by others, they prefer to free ride, but if they expect contribution by others, they prefer to contribute (Runge, 1984a). Nothing is implied concerning the optimality of actions, which depends on the structure of expectations at the point at which the choice is made. As Sugden's language suggests, everyone would contribute more "if only he knew that the other would too."

This implies that the particular structure of expectations reflected by $\tilde{Q}^e$ in the model above is in general uncertain. A probability distribution of conjectures faces the agent, so that he is uncertain what level of contribution to expect from others. Hence, any information concerning this likelihood has value. This information set determines the predictability of others' contributions. It is relatively easy to see that rules or institutions which can increase this predictability and inform expectations will coordinate individual choice. If the coordination of these expectations leads to a Pareto-superior allocation, as in the Cornes and Sandler framework, then the incentive to innovate institutions to accomplish this coordination is clear. The demand for rules and institutions is thus a demand for assurance respecting the likely behavior of others (Runge, 1984b) or what Heiner (1983) has called simply "predictable behavior."

I believe that the incentive for coordinated choice lends a strong plausibility to the assurance problem as a model of public goods provision, because it is capable of explaining both undersupply and increasing increments of voluntarily provided public goods, based on alternative specifications of expectations determined by the institutional rules in force. In this sense, it is consistent with the wide range of experimental findings reported above. Institutional rules in force set parameters on individual expectations, resulting in alternative levels of public goods provision. In a dynamic setting, they inform the prior distribution of a Bayesian sequence of decisions (Runge, 1984a). In the short run, the institutional setup is fixed. In the longer run, incentives will exist to further coordinate expectations (subject to transactions costs), leading to Pareto-superior allocations.

In the Cornes and Sandler framework, the particular manner in which expectations are formed is outside of the model. However, if expectations are modeled as probability distributions defined over the contributing behavior of others, so that the institutions enter as variables affecting the parameters of these distributions (Runge, 1984a), the choice of institutions can be modeled as an endogenous response to the assurance problem. Reductions in the variance of a distribution of conjectured public goods provided by others can then be used as a measure of assurance.

Where expectations are rational, in the sense of Muth (1961), agents hold the relevant and correct theory allowing predictions of others agents' actions, and the uncertainty giving rise to the assurance problem is not a problem. We may therefore equate "perfect" institutions with the relevant, correct theory allowing "rational" expectations leading to a Pareto-optimal outcome. These institutions provide forecasts of the behavior of others that are, on average, both accurate and conducive to Pareto optimality. However, because individuals are in general unable to rely on the relevant correct theory, norms, conventions and institutions are innovated that can provide information concerning the average opinion, or what Frydman has called a "consensus condition" (Frydman, 1982). This condition provides the assurance necessary for coordinated choice, and may be described as arising from institutional innovations emerging endogenously from the problem of public goods.

4. Group Homogeneity and "Institutional Failure"

An important issue arising from the analytical framework developed above concerns the issue of group homogeneity. In the Cornes and Sandler framework, a "representative" individual is achieved by treating tastes and endowments as identical. In Sugden's (1984) model, identical individuals are a special case. In Sugden's more general case, underprovision of the public good will generally be an equilibrium where heterogeneous tastes and endowments are present, but will converge on Pareto-optimality as tastes and endowments become more homogeneous. Sugden therefore argues that the more homogeneous a group's tastes and endowments, the more likely the coordination of positive conjectures becomes. The more heterogeneous a group, the more likely is underprovision. Of course, heterogeneity of tastes and endowments also generally increases with group size, although it need not. Group size per se may be a misleading indicator of the capacity for voluntary public goods provision if the group is relatively homogeneous (see Runge, 1981; Frohlich and Oppenheimer, 1970).

Regardless of group homogeneity, the assurance problem remains an issue as long as the particular contribution of agents is conditional on expectations, and these expectations are uncertain. As Sugden (1984, p. 781) observes:

> Even for a society of identical individuals, the theory of reciprocity does not predict that the free-rider problem <u>will</u> be solved. Because of the assurance problem, a society of moral citizens can get locked into an equilibrium in which no one contributes anything towards a public good - even though everyone would prefer that everyone contributed. The theory says only that the free ride problem <u>can</u> be solved.

Hence a framework based on positive conjectures and the assurance problem is consistent with a variety of levels of public goods contributions, depending on whether coordination or "consensus" has been achieved. The assurance problem is thus more fundamental than the issue of group homogeneity, and concerns the capacity of any group, even a set of agents with identical tastes and endowments, to coordinate expectations and actions.

The inability of any group to solve the assurance problem represents a form of "institutional failure." This inability will be exacerbated by heterogeneous tastes and endowments, but the potential for underprovision even in a group of identical agents will remain. The absence of institutions capable of providing consensus may be considered analogous to a "missing market" in the analysis of market failure. Indeed, since markets are simply a subset of the set of rules that coordinate individual choice, I would argue that market failure is in actuality a subset of institutional failure, and that both are manifestations of a lack of information allowing for coordinated individual choice (see Dahlman, 1979). The concept of "missing institutions," united with a theory of "missing markets," is an important line of theoretical inquiry that can provide a new basis for institutional economics.

5. The Case of Common Property

A representative issue in the public goods literature is the commons problem (see Dasgupta, 1982). While a full model of the commons along the lines developed above is beyond the scope of this paper, it may be useful to draw together the implications of this line of inquiry for commons problems. Cornes and Sandler (1983) have applied an earlier version of their model to the commons, but their conclusions depend on assumptions of zero fixed costs and no barriers to entry, making the analysis more pertinent to problems of open access than common property (Ciriacy-Wantrup and Bishop, 1975). In such a situation of open access, they show that consistent conjectural equilibrium loads to overexploitation of the resource regardless of the number of agents using it. This overexploitative behavior is made worse by positive conjectures, which reinforce each agent's expectations that others are extracting rents, so that profits are eventually driven to zero. This result is consistent with what we know of open access, but not necessarily with what we know of common property.

In situations of common property, as distinct from open access, it is the function of institutional agreements to impose both fixed costs and barriers to entry to those outside the group. A variety of forms of monitoring, enforcement or other costs and controls affect expectations where common property exists, represented by θ in the framework developed above. In these situations, the particular impact of institutional rules, and the set of incentives they provide, will determine the structure of expectations held by individual members of the group. If institutions fail to coordinate these expectations, this institutional failure will be manifest in increased overexploitation of the resource, and the situation will approach that of open access. Where property institutions are not failing, the assurance problem is being confronted, individual uncertainty is reduced, and consensus allows coordination of individual use of the common resource.

The ability to coordinate this behavior, solving the assurance problem, may be more difficult where tastes and endowments are less homogeneous, especially where the group is large. Hence, traditional or highly homogeneous societies may require fewer forms of monitoring or enforcement to achieve Pareto-improvements in common use of resources, even if the group involved is large, as long as the existing structure of institutions allows for consensus. Where this consensus is absent, an assurance problem arises that must be confronted either by the endogenous innovation of institutions capable of solving it, or by the imposition of exogenous rules, monitored and enforced so as to reduce the level of uncertainty and stabilize expectations of others' behavior. The relative cost of the former and latter strategy, especially in the context of Third World resource management, is an important focus for future research in the new institutional economics of public goods provision.

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