

Sharing, Gift-Giving, and Optimal Resource Use Incentives in Hunter-Gatherer Society[†]

By

Matthew J. Baker^{*}

And

Kurtis Swope^{**}

Department of Economics
United States Naval Academy
Annapolis, MD 21402

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Abstract:

In the typical hunter-gatherer society, decision-making is collective, yet decentralized, access to resources is shared, goods are distributed via reciprocal exchange, sharing, and gift-giving, and the distribution of both income is egalitarian. We argue these features are interrelated. We adopt an incentive-based view of sharing and gift-giving: sharing rules and customary gifts obligations implement socially desirable production decisions in decentralized fashion, and elicit information about agents' willingness and ability to produce in the face of a common resource use/congestion problem. The system may result in a relatively equal distribution of income, and the theory is also able to account for some features of the ethnographic record that do not jibe well with existing theories of sharing.

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^{*} Corresponding author. Email: mbaker@usna.edu.

^{**} Email: swope@usna.edu

I. Introduction

The economic organization of hunter-gatherer societies is a subject that has attracted increasing attention in recent years.¹ One might attribute some of this interest to the fact that the hunter-gatherer economy features a host of what seem to be singular social practices and institutions. To give some examples, in the typical hunter-gatherer society decision-making is collective, yet decentralized, access to resources is shared, goods are typically distributed via reciprocal exchange, sharing, and gift-giving, and the distribution of both income and decision-making power is egalitarian.

In this paper we argue that these features of the hunter-gatherer economy are interrelated. We adopt an incentive-based view of sharing and gift-giving, in which the fundamental role of sharing and gift-giving is to implement socially desirable production decisions, given that agents share access to resources. We show how this system decentralizes socially desirable decision-making. We also show how this system can solve a related problem – extraction of information about individual productive abilities. The sharing and gift system has some interesting properties; for example, it may result in a relatively equal distribution of income, even though the productive capabilities of agents and effort provision decisions of agents differ. Our theory is also able to account for some features of the ethnographic record that do not jibe well with existing theories of sharing; for example, why the rather extensive free-riding on the efforts of the most productive agents is typically tolerated in hunter-gatherer society.

In our model the output sharing mitigates overexploitation of the commons, a potential role for sharing originally hinted at by Alchian and Demsetz (1973), more formally developed by Cauley, Cornes, and Sandler (1999) and Ellis (2001), and explored in an experimental

setting by Schott, Buckley, Mestelman, and Muller (2004). In contrast to this work, however, we explore the consequences of rules when agents vary in their productive capabilities, and we direct attention to the informational properties of the rules. For example, we argue that a sharing-rule based system of CPR management may have advantages over alternatives such as observing effort directly and punishing deviations from established norms, as in, for example, Sethi and Somanathan (1996).² Given the social organization of hunter-gatherer societies, this organizational form places a minimal informational burden on the members of the group.

Also common among hunter-gatherers is a relatively equal distribution of output, even though individuals vary greatly in ability.³ This implies that some agents share more with others and give more to others than they receive in return. While our model does not produce a perfectly egalitarian distribution of output, we show that the sharing and gift giving regime may result in a relatively egalitarian distribution of output in spite of stark differences in ability level.

The rest of this paper is organized as follows. In section II, we discuss the literature on output sharing in hunter-gatherer societies, prominent theories of sharing, and some of the difficulties with these theories. In section III, we append the discussion in Section II with more detailed information on production and sharing among Kalahari Desert hunter-gatherers. In section IV, we develop a simple model that shows how sharing rules among users can feasibly mitigate a commons problem without relying upon observation of effort, illustrate a potential adverse selection problem created by the sharing scheme, and then show how this adverse selection problem might be mitigated through the introduction of gift-giving obligations. Section V concludes.

¹ See, for example, Baker (2003), Marceau and Myers (2004), and Kaplan and Robson (2003).

² Schott, Buckley, Mestleman, and Muller (2004) also make this point.

II. Literature on Sharing and Gift-Giving in Hunter-Gatherer Societies

A wide variety of theories have been used to describe sharing and gift-giving practices in hunter gatherer societies.⁴ Most prominent among theories of sharing and gift-giving are those based on exchange and insurance. Posner (1980) argues that sharing and obligatory gift giving in hunter-gatherer societies, in concert with other institutions, functions as a comprehensive insurance system when a formal insurance market is unfeasible. Common hunter-gatherer institutions support the insurance plan and mitigate potential free riding. Communal living conditions allow easy policing of hoarding and effort, and ease transmission of other important information. While anthropologists have stopped short of full consideration of the supporting institutions necessary for sharing and gift-giving to function as an insurance system, the idea that sharing can reduce variance in individual consumption has been part of the conventional wisdom of anthropology at least since the famous "Man the Hunter" conference in 1966.⁵ (Kelly, 1995 p. 167) Generally speaking, so-called variance reduction models are successful in explaining many sharing and gift-giving events, in that sharing behavior does seem both in simulated models and in practice to greatly reduce variance in consumption.

Sahlins (1972) is prominent among those who argue that sharing and gift-giving are a form of exchange, though this idea also has earlier antecedents - for example, Mauss (1924).⁶ Givers accumulate a reserve of debts through sharing with and giving gifts to others, and

³ See Woodburn (1982).

⁴ See Chapter 5 in Kelly (1995).

⁵ See Lee and Devore (1968). Cashdan (1990) is a good review of the anthropological literature on variance reduction and sharing. Some applications of variance reduction models to specific societies include Winterhalder (1981), Stephens (1990) and Hames (1990). Winterhalder (1981, 1986) in particular has shown that sharing and gift-giving among even a small number of foragers can result in significant decreases in day-to-day variations in output.

⁶ A recent model of the relative merits of reciprocal exchange is Kranton (1996), who contrasts the benefits of engaging in reciprocal versus market exchange.

debtors are obligated to return the favor in the future. Sharing and gift-giving has also been cast as trade, in which sharers receive a complementary stream of different goods such as prestige (Hawkes, 1993b) or sex (Siskind, 1973). Like insurance theories of sharing, exchange theories are apparently successful in explaining many sharing events.

Both insurance and exchange theories share one difficulty: the rather stark differences in individual provision rates that become clear in studies of production and sharing among hunter-gatherer groups. Hawkes (1990, 1992, 1993a, 1993b), Kent (1996) and Kaplan and Hill (1985a, b), for example, have found consistent and stark differences in the provision rates of different hunters/gatherers. Better hunters contribute significantly more to the sharing network and others contribute significantly less, even over time periods long enough to permit reciprocation of sharing acts. In many instances better hunters go uncompensated for their efforts, and strangely, care is often exercised in ensuring that compensation of more productive agents is avoided. There also appears to be little pressure for those who consistently produce less to increase their output or effort; see, for example Lee (1979), Hawkes (1993a), Kent (1996), and Woodburn (1982). Considering the observed differences in provision rates, exchange theories do not tell the whole story, as the productive do not receive a complimentary stream of goods. Indeed, the social pressure directed towards prevention of moral hazard one would expect to coexist with both insurance and exchange-based sharing is absent in the typical hunter-gatherer society. Alternative theories of sharing, while capable of explaining some other aspects of sharing, do not address this basic point. For example, *cooperative acquisition* posits that sharing occurs because output is produced cooperatively. *Kin selection* posits that agents share with kin relations to increase biological fitness. *Tolerated theft* posits that sharing occurs

because excluding outsiders from consumption is costly.⁷ Cooperative acquisition and kin selection appear to have limited explanatory power in hunter-gatherer societies where extensive fieldwork (generally, South America and Africa) on sharing has been done. In these locations, hunters spend the bulk of their time hunting independently and dispersed over the landscape, yet game is still shared extensively.⁸ In many cases, no significant bias towards sharing more with closer relations emerges, as kin selection predicts.⁹

To summarize, the biggest problem with theories of sharing is that they do not explain why some agents apparently do so little, without any sort of pressure from other group members. If exchange or insurance were the sole reason for sharing, one would expect that control of moral hazard would be a priority. To make this point a bit more concrete, we now discuss in detail some evidence on the nature of sharing among Kalahari hunting and gathering peoples.

III. Sharing in the Kalahari

Anthropologists have extensively studied Kalahari societies and have produced detailed data on individual production decisions and sharing rates among Kalahari peoples. Among these peoples, most explanations for sharing perform rather poorly.¹⁰ The most interesting feature of sharing which emerges in this data is the pronounced disparity in individual production and hunting efforts, in spite of the fact that hunting effort or productivity is

⁷ See Blurton Jones (1983) and Kelly (1995, Chapter 5) on tolerated theft. Anderson and Swimmer (1997) discuss, in a property rights context, what is essentially a tolerated theft model. They find some supporting evidence in a cross-cultural analysis of 40 North American peoples.

⁸ Among many people, such as the Mbuti, much hunting is cooperative. Cooperative acquisition may thus be a sufficient, but not necessary, condition for sharing, as Kaplan and Hill (1985a, 1985b) note.

⁹ Kelly (1995, Chapter 5). See also Kaplan and Hill (1985a, 1985b).

¹⁰ Among South American hunter-foragers such as the *Yanomamo* [Hames (1990)] and the *Ache* [Kaplan, Hill, and Hurtado (1990)] there is similar evidence. However, among South American hunter-gatherers, there is limited

apparently undirected or rewarded and much output must be shared. Also interesting is the lack of concern over the apparently low effort levels exerted by some agents.

The *!Kung San* (also referred to as *Jo'Huansi*) of the northwest Kalahari are one of the most intensively studied hunter-gatherer peoples.¹¹ The *!Kung* live in groups of approximately 20 people that collectively maintain loose association with a specific tract of land, usually centered around a watering hole. Everyone in the group maintains free access to resources in the area, and while outsiders may use the group's resources, it is expected that they receive permission, or actively observe group rules during their stay.¹²

The *!Kung* subsist on a variety of plant and foodstuffs found in the region. Giraffe, warthog, gemsbok, kudu, wildebeest, eland, roan antelope and hartebeest count among the most frequently taken large game resources, though the warthog is the most regularly taken game animal. Individuals equipped with digging sticks obtain gathered resources. While cooperative hunting occurs, solitary individuals do most hunting. Hunting is done most commonly with poisoned arrows, and sometimes using traps. Individuals are free to choose when and where they would like to hunt. There are considerable differences in hunter skill and production effort in the camp. The best hunters are not awarded with prestige or in other ways, and members of the camp in fact devote significant energy to ensuring that successful producers are not compensated. Hunters boastful of their success are subject to ridicule and scorn, and modesty is expected (see Woodburn (1982, p. 440) or Lee (1979, p. 243-246)). Both income and power are distributed relatively equally among members of the group – *!Kung* society is egalitarian.

evidence that suggests better hunters are compensated by sex [e.g. Hawkes (1993 (b)), Hames (1990)]. Also, more hunting is done cooperatively among these peoples. See Kelly (1995).

¹¹ A detailed description of the *!Kung* is Lee (1979), and where not otherwise noted, the exposition relies heavily on parts of his book, especially chapters 4, 7, 8, and 12.

¹² See Woodburn (1982), Marshall (1976), or Lee (1979). See Baker (2003) for a detailed discussion of land ownership among the *!Kung* and other hunter-gatherers.

Lee (1979) reports information on the nature of the sharing and work habits of a group of 12 able-bodied *!Kung* hunters over a one-month period. The most skilled hunter hunted 16 days over the period and provided 65% of the community's meat by killing four warthog; only two other hunters produced in excess of their own caloric needs. One of these hunters, named *≠Toma*, was approximately 60 years old. Three other hunters produced some meat over the period of observation, but not enough to support themselves and their families. One hunter was completely unsuccessful over four hunting days, and four of the twelve able-bodied men in the camp did no hunting at all over the period. In spite of the rather stark differences in effort and the resulting differences in acquired game, no individual was excluded from consumption of the take, and consumption appeared to bear no relation to the amount an individual provided. In fact, distribution and sharing of game is serious business; Lee (1982) writes that "...the most serious accusations that one *!Kung* can level against another are the charge of stinginess and the charge of arrogance." (Lee 1982, p. 45)

One might wonder if these patterns persist over longer time periods, or if the hunters are simply rotating vacation time. Evidence from a nearby people suggests that these patterns emerge even over extended periods of time. Kent (1996) observed production and sharing differences amongst the *Kutse Basarwa*, a people of the central Kalahari similar in custom and material culture to the *!Kung*. Kent's data spans a much longer time period than Lee's; she studied hunting variation and sharing amongst the *Kutse* over a five-year period in which 175 hunting trips were observed over 290 days between 1987 and 1991. She also finds consistent disparities in contributions to the needs of the group, though some hunters often take extended periods of time off from hunting. For example, "Hunter 1...a relatively poor hunter, brings in more meat through sharing than he loses, while Hunter 5 loses more meat through sharing than

he gains" and "Hunter 5 consistently shared more meat with friends and kin than he received" (Kent (1996, p. 148)). Kent investigates the fitness rates of some of the hunters, and concludes that better hunters are offered no additional social prestige, and no special advantage in terms of mating preference, but continue to provide most of the food for the group.

While there is apparently no attempt to police or monitor the activities of others, the nature of hunting in the Kalahari suggests that directly monitoring effort or even attempting to infer effort from output would be exceedingly difficult. In the Kalahari, hunters often travel substantial distances away from camp while hunting, and a hunter is never certain if his arrow has hit the mark or if enough poison has entered the target animal's bloodstream. Animals take anywhere from six to twenty-four hours to die after being hit by a poison arrow, and in the interim the game may be lost or eaten by lions. Lee reports Yellen's estimate that about %50 of all animals wounded by the *!Kung* escape. (Lee (1979, p. 221)) Thus, there is a rather tedious link between effort and output given the nature of *!Kung* production.

While it is difficult to infer the effort levels of others, individuals are certainly cognizant of differences in skill. Kent writes of the *Kutse* that "Although on one level people know that some hunters are more skillful than others, they usually do not discuss it or analyze why." (Kent, 1996, p. 145-6) Kent also writes: "During an interview when [a poorer hunter] was absent, others within his sharing network were unwilling to speculate about his consistently poor success, beyond suggestions that maybe his traps or their locations were not good." (Kent, 1996, p. 146).

We may draw the following points from this evidence: 1) some hunters are more skilled than others, 2) skilled hunters provide a disproportionate amount of the game, while some hunters engage in significantly lower levels of activity, 3) it appears that better hunters are not

compensated for their exemplary efforts, 4) hunters are typically free to decide where, how, and when they would like to hunt, but share their output according to well-specified, customary rules, 5) given the high variability of production, it is difficult to infer hunting effort directly from output, 6) it is difficult to hide game from others once it actually has been obtained, and 7) society is egalitarian, in the sense that the distribution of income is roughly equal.

Given these stylized facts about the nature of sharing, we now turn to describing how a system of gifts and sharing rules, rectifies an overuse problem, and how the implied nature of the income distribution and effort decisions coincide with the 7 stylized facts described in the previous paragraph.

IV. The Model

This section proceeds by first solving for a sharing rule that internalizes the common property use externality when agents differ in productive abilities and face a common production problem. We then show how a system of gift-giving can be superimposed upon the sharing regime to elicit correct information about hunter productivities

Some literature has discussed the possibility that sharing according to customary rules may have some desirable properties when resources are commonly owned. Alchian and Demsetz (1973, p.25) speculate that output sharing and shared access to resources coexists because "sharing may cure the overhunting problem by creating an underhunting problem," but do not investigate the possibility formally and dismiss the idea.¹³ Cornes and Sandler (1996, pg. 284-9) discuss sharing rules that trade off overuse and underuse effects to social benefit.

¹³This argument has also been hinted at by Harris (1983). Alchian and Demsetz center their argument against sharing as a resource management tool centers on the idea that it implies excessive control over the production process, whereas our argument, to some degree, implies the opposite.

They describe the crucial effect output sharing has in altering resource use incentives: output sharing introduces a free riding incentive that may counteract the commons problem. Cauley, Cornes, and Sandler (1999) also discuss of sharing rules and the countervailing effects of such rules. They present a rule that is a combination of effort-proportional sharing and equal sharing, and show that this rule can provide first-best use incentives. Ellis (2003) contains a discussion of sharing rules which mitigate overuse resources, and Schott, Buckley, Mestleman, and Muller (2003) provide experimental support for the idea that sharing might mitigate overuse of common property resources. Our model is distinct from other work in the literature in that it does not rely directly on the observation of the effort levels of agents and takes into account differences in agents' productive capabilities.

The basic framework is the standard CPR model (see Dasgupta and Heal 1979 and Cornes and Sandler 1996). A group of N risk-neutral agents shares access to a productive resource. We consider the group size to be exogenously determined, though the group size could be understood as the result of a welfare-maximizing decision.¹⁴ Let x_i denote the effort level of agent i , $X = \sum x_i$, and let q_i denote the output of agent i . The production function for each agent is given by:

$$\tilde{q}_i = x_i A(X) \varepsilon_i,$$

Where A represents average product and $A' < 0, A'' < 0$. The important thing about the production function is that it captures the idea that the effort of one hunter imposes a negative externality on other hunters. This could be either due to the familiar commons effect, or it could be understood as due to a congestion effect, where one hunter's efforts "get in the way" of the activities of others. ε_i is an agent-specific random variable with a mean of unity, which we

include merely as a way of reminding the reader that effort is not directly inferable from output.

Expected output for agent i is:

$$q_i = E[\tilde{q}_i] = E[x_i A(X) \varepsilon_i] = x_i A(X).$$

Effort costs for each agent are given by $c_i(x_i), c' > 0, c'' \geq 0$. We capture differences in the capabilities of agents through differences in the costs-of-effort function.. Expected group payoffs are:

$$\Pi = \sum_i x_i A(X) - \sum_i c_i(x_i), \quad (1)$$

Differentiation of (1) with respect to each of the N effort levels results in the following first-order conditions describing socially optimal effort levels:

$$\frac{\partial \Pi}{\partial x_i} = A + \sum_{j=1}^N x_j A' - c'_i = 0; i = 1, 2, 3, \dots, N. \quad (2)$$

Let x_i^* denote the solutions to (2), and let $X^* = \sum x_i^*$. Note that an implication of (2) is that at the optimum $c'_i = c'_j$, which implies that if $c_i(x) < c_j(x)$ and $c'_i(x) < c'_j(x)$ for a given x , then $x_i^* > x_j^*$. Thus, it is socially desirable that those agents who are better hunters provide more effort (and thus, on average, more output) at the social optimum. Agents do not choose their effort levels according to (2), and instead choose effort to maximize own expected returns:

$$\pi_i = x_i A(X) - c_i(x_i), \quad (3)$$

Differentiation of (3) with respect to x_i results in the following first order conditions describing Nash equilibrium effort levels:

$$A + x_i A' - c'_i = 0. \quad (4)$$

¹⁴ For a model of such a decision, see Lueck (1994) or Anderson and Swimmer (1997). See also Wagner (1995).

Comparing (2) and (4) illustrates the commons problem. It is straightforward to see that all agents exert too much effort in hunting at the Nash equilibrium. Output sharing rules allow unregulated resource access and use to the local community of agents, but require that agents share the output obtained from using the common resource with others according to specific rules. To parameterize sharing, let $t_{i,k}$ denote the percentage of agent i 's output that must be shared with agent k . The rules can be thought of as customary in the sense that they are not set by any particular agent.¹⁵ The rules are fixed in that they require each agent to make a percentage payment of his output to each other agent, and this percentage does not change with the level of effort an agent actually chooses.¹⁶ For the sharing rules to be feasible, we require that for every agent, the sum of shares paid out to other agents be strictly less than one:

$$0 < \sum_{k=1, k \neq i}^N t_{i,k} < 1 \forall i \in N.$$

Under the sharing scheme, the expected payoffs of agent i can be written as:

$$\pi_i = x_i A(X) \left(1 - \sum_{k \neq i} t_{i,k}\right) + \sum_{k \neq i} t_{k,i} x_k A(X) - c_i(x_i) \quad (5)$$

The first-order conditions associated with maximization of (5) are:

$$(A + x_i A'(X)) \left(1 - \sum_{k \neq i} t_{i,k}\right) + \sum_{k \neq i} t_{k,i} x_k A'(X) - c'_i \quad (6).$$

Equation (4) reveals the same effects introduced by the sharing rules discussed in Cornes and Sandler (1996). Agents reduce effort for two reasons: because they must share with others, and because others must share with them. The latter effect is less familiar than the first, and occurs because agents do not wish to reduce the amount that they receive from other agents

¹⁵ A benevolent elder(s) concerned with group welfare could have set the rules in the past, or gradually evolved towards efficiency through a process of trial and error. The rules then persisted to the present because they are efficient.

¹⁶ Contrast this with Cauley, Cornes, and Sandler (1999), in which sharing rules depend on the effort levels that agents choose, or Schott, Mestleman, Buckley, and Muller (2004), in which equal sharing rules are imposed.

by increasing effort and therefore reducing the average product of other agents. Consider the sharing rules:

$$t_{i,k} = \frac{-x_k^* A'(X^*)}{A(X^*)}, \quad (7)$$

In the appendix, we demonstrate that the rules in (7) provide first best use incentives for all agents, and are also feasible. We also outline the method by which we obtained these sharing rules in the appendix. The sharing rules in (7) have a peculiar feature: they require that agent i pay a share of his output to agent k based on *agent k 's optimal level of effort*. Thus, if k is relatively more productive than other agents, and should in equilibrium exert higher hunting effort, *he should receive a larger share of the output of other agents*. A little algebra reveals that if this sharing system was in place, the resulting distribution of output is exactly the distribution that would emerge if agents collectively agreed to exert first-best effort levels without sharing. That is, each agent earns $x_i^* A(\sum_{j=i}^N x_j^*) - c_i(x_i^*)$ under the sharing system.

While (7) demonstrates that a budget-balancing sharing rule can always be found, the problems with the sharing system described by (7) are twofold. A first, practical problem is with implementing the sharing rule; agents have incentives to misrepresent their abilities. Given that better hunters must receive larger shares of the output of others under the sharing scheme, agents have incentives to claim to be better hunters than they in fact are. From our discussion of the evidence in section II, it seems that hunters are generally knowledgeable about the skills of others in spite of the fact that they spend no time or effort observing the skills of others or trying to mislead others about their skills. It therefore seems reasonable to suppose that information on ability is offered voluntarily. But the sharing system described by (7) indicates that this shouldn't be the case. A second problem with the sharing system in (7) is

that it may produce a widely disparate distribution of output among the agents, particularly if productivity differences among agents are large. This is also inconsistent with the features of the empirical record highlighted in section II.

We now turn to showing, for a simple and specialized example, how requiring hunters who claim to be high productivity to also pay a gift obligation to low productivity hunters can, under some conditions, elicit information from agents about their type. A by-product of the sharing-gift obligation system is that it tends to produce a roughly egalitarian distribution of output among the members of the tribe. The intuition is that the sharing/gift obligation system can be viewed as a mechanism which, under some conditions, can elicit information about hunter type and also provide incentives for socially optimal production decisions.

Along these lines, consider a tribe composed of two hunters, each of whom has imperfect information about the type of the other, who may be either a high or a low productivity hunter with the (publicly known) probability of p . Let x_i denote the effort level of agent i , and let $\phi_i \in \{h, l\}$ denote agent i 's type. As before, hunters are distinguished by their costs of exerting hunting effort: the costs of effort for a high productivity hunter are zero, while the costs of effort for low productivity hunters are given by cx_l , with $c > 0$. The expected output of any given agent is given by the function:

$$q_i = x_i A(X), \quad A(X) = A - \alpha X, \quad X = x_1 + x_2. \quad (8)$$

First-best effort levels depend upon tribe composition. Given (8) and the nature of the costs-of-effort function, optimal effort levels are symmetric when the tribe is composed of two like agents (two high types or two low types – we use $\phi = h, l$ to denote agent type):

$$\phi_i = \phi_j = l \rightarrow x_i^* = \frac{A - c}{4\alpha}; \quad \phi_i = \phi_j = h \rightarrow x_h^* = \frac{A}{4\alpha} \quad (9)$$

However, when one agent is a high type and the other is a low type, we have:

$$\phi_i = h, \phi_j = l \rightarrow x_i^* = \frac{A}{2\alpha}, x_j^* = 0 \quad (10).$$

The solutions in (10) result because effort is costly for low types but not for high types; therefore, at the social optimum only the high type should exert effort. Making note of (10) and applying (7) reveals that the following sharing system institutes first best effort levels, given the distribution of types among members of the tribe:

$$\phi_i = \phi_j = l \rightarrow t_{ll} = \frac{1}{2} \frac{A - c}{A + c}; \quad (11.a)$$

$$\phi_i = \phi_j = h \rightarrow t_{hh} = \frac{1}{2}; \quad (11.b)$$

$$\phi_i = l, \phi_j = h \rightarrow t_{hl} = 0, t_{lh} = 1. \quad (11.c)$$

The sharing system in (11) indicates that the average volume of sharing is larger when the tribe is composed of high productivity hunters (compare (11.a) with (11.c)). The rules in (11.b), when the agents are of different types, are a result of the “corner solution” characteristics of optimal effort levels described in (10). In this case, optimal effort levels are implemented by requiring that a high productivity hunter not share at all with a low productivity hunter, while at the same time a low productivity hunter should share all of his output with the high productivity hunter. This reduces the effort levels of low productivity hunters to zero in accordance with the social optimum. This also illustrates the low productivity hunter’s incentive to overstate his abilities; if a low productivity hunter always claims to be a high productivity hunter, he will clearly always do better than receiving no output.

So far, we have not yet offered any sort of distinction between gift-giving and sharing; indeed, it is perhaps impossible to distinguish between the two types of behavior in practice.

Now, we adopt the practical convention that “sharing” refers to a transfer of a share of output created, while “gift-giving” refers to a lump-sum transfer given from one agent to another. We can now show how, under certain conditions, the incentive of low productivity hunters to claim to be high productivity hunters can be removed by introducing gift obligations for high-productivity hunters. Agents cannot opt out of this system regardless of their skill level; perhaps refusal to participate in such an important group behavior would mean that the offender would be shunned or ostracized from other group activities. Along these lines, consider the following mechanism:

1. Nature moves first and randomly determines the types of the two agents. The (common knowledge) probability that an agent is a high (low) type is p ($1 - p$). Agents learn their types, and then simultaneously announce either $\hat{\phi}_i = h$ or $\hat{\phi}_i = l$.
2. Dependent upon the revealed types of each agent, the corresponding sharing system in (11) is instituted, with the following caveat: In the event that one agent is a high type and the other is a low type, the high type is obligated to pay a lump-sum gift of G to the low type.
3. Production occurs, outputs are observed, and all gift and sharing transactions are executed.

Our task is to find a gift obligation G under which truthful type revelation is a Bayes-Nash equilibrium for either type of agent, given incomplete information about the other agent’s type. Consider figure 1, which describes the incomplete information game instituted by the mechanism from the perspective of the high-productivity player. Figure 1 shows the payoffs for a high type given the sharing system implemented under each possible outcome of the game.¹⁷ For truth-telling to be an equilibrium, given the expectation that the opposite player is tells the truth, it is required that (using the result on figure 1) the following inequality hold:

¹⁷ One detail of interest in computing these equilibrium payoffs: due to the linearity of production functions and the sharing rules, a low productivity agent never exerts effort in equilibrium when paired with a high type agent, and a) the high type agent has lied about his type while the low type agent has told the truth, and b) when the low type agent claims to be a high type agent yet the high type agent has told the truth.

$$p \frac{A^2}{8\alpha} + (1-p) \left(\frac{A^2}{4\alpha} - G \right) \geq pG + (1-p) \frac{A^2(A+3c)}{8\alpha(A+c)}. \quad (12)$$

The similar condition for low types (given that the other player is expected to tell the truth about his type), is obtained from figure 2 as:

$$pG + (1-p) \frac{(A-c)^2}{8\alpha} \geq p \frac{A^2}{8\alpha} + (1-p) \left(\frac{(A^2 - 2c^2)(A-c)}{8\alpha(A+c)} \right). \quad (13)$$

Equation (13) is an inequality requiring that G be sufficiently large so that low types will prefer to correctly reveal their type. The inequality in equation (12) requires that G be sufficiently small so that high types will prefer to correctly reveal their type, rather than claiming to be low productivity. Rearranging (12) gives the following constraint on G :

$$G \leq G_1 = \frac{A^2(2pc + A - c)}{8\alpha(A+c)}. \quad (14)$$

Rearranging (13) for G gives the bound:

$$G \geq G_2 = \frac{-Ac^2 + c^3 + pA^3 + pA^2c + pAc^2 - pc^3}{8\alpha(A+c)p}. \quad (15)$$

For the gift giving scheme to be feasible, $G_1 \geq G_2$. Using (14) and (15), this requires:

$$p \leq \frac{c(A-c)}{2A^2}. \quad (16)$$

Equation (15) indicates that the frequency of high types in the population must be sufficiently small. The logic behind this result is simple. The chief reason low productivity agents wish to misrepresent their type is to get a larger share of the high productivity agent's output. However, if the other agent is likely to also be low productivity, it is unlikely misrepresentation conveys this benefit, and lying more often than not just distorts the sharing scheme.

In a world in which the constraint (16) is not satisfied, there are alternative sharing schemes which will typically involve some sort of welfare loss relative to the first-best in some states of nature, which may or may not rely on gift-giving. For example, consider the sharing rule $t_{hh} = t_{ll} = t_{hl} = t_{lh} = \frac{1}{2}$, which is derived from applying the first-best sharing rule for high types in every situation. In this case, each agent always pays half of his output to other agents. One can show that this rule results in no distortions, and removes any incentives for agents to misrepresent their abilities, but involves a distortion in the state of nature where both agents are low-productivity hunters: rather than earning payoffs $\frac{(A-c)^2}{8\alpha}$, each agent earns the lower payoff $\frac{(A-2c)A}{8\alpha}$. The question then becomes whether the simplicity of the system is worth the expected output loss that must be tolerated.¹⁸

A further point to note about the sharing and gift-giving mechanism is that it is somewhat fragile, in that there are other equilibria (one where agents are expected to lie, and a mixed-strategy equilibrium), and agents must be compelled to participate. This is perhaps how it should be; in that sharing and gift giving are typically complex social processes and as such are fragile, and depend on the goodwill of the participants. On a more positive note, the example exploits the additional degrees of freedom in sharing rules that were glossed over in the previous part of the paper. Inspection of (5) and (6), for example, shows that in any state of the world, there are n first order conditions associated with agents' maximizing behavior, but there are potentially many more sharing instruments (for any given population, there are $n(n-1)$ potential sharing instruments). An interesting subject for future research would be an investigation of the sharing and gift giving system under more general conditions.

¹⁸ A second possibility is to set the sharing rule at the low-type optimal sharing rule, or to use a rule that is some

Given its apparent theoretical complexity, why might hunter-gatherers resort to such sharing and gift-giving systems to regulate a commons problem, instead of some other possibility? The nature of production in the Kalahari Desert discussed in section III suggest some answers. Typical methods discussed in the literature for governance of common property generally center around observation of effort; for example, punishment strategies in repeated-interaction settings as in Sethi and Somanathan (1996), and the proportional-effort sharing rules discussed in Cauley, Cornes and Sandler (1999). Lueck (1994), in comparing shared access and private ownership, points out that private ownership is one solution to the commons problem, but also requires monitoring of effort, which may be costly in particular situations. The advantage of the sharing and gift-giving system presented here is that knowledge of output, but not productive ability or effort, is required.¹⁹ In the typical hunting and gathering society, this system seems to place a minimal informational burden on the members of society, since dispersed decision-making is required due to the nature of hunting, but agents typically must bring home their output and live in relatively close quarters. Under these circumstances, it seems as though observation of output might be relatively easy, while actually monitoring effort or ability is a bit more difficult.

2.3 Conclusion

We have shown how sharing rules can function as tools providing optimal use incentives when resources are commonly owned. Gift obligations can, under some conditions, be used to extract information about hunter type, but may also result in a relatively egalitarian distribution of output. These results align well with several features of life in hunter-gatherer

sharing rule in between.

¹⁹ This advantage is also stressed by Schott, Buckley, Mestelman, and Muller (2004).

societies that are not adequately explained by existing theories of sharing or gift-giving: the extensiveness and tolerance of what appears to be free-riding, and why better hunters continue to provide most of the output for the group even when production decisions are greatly decentralized and participation is optional. One topic of interest for future research is a more thorough investigation of the general properties of the sharing and gift giving scheme with more than just two agents, and under more general production and cost conditions.

APPENDIX

We begin by describing the method we employed for finding the sharing rules. For reference purposes, it is useful to reproduce (2), which describes socially desirable effort levels:

$$A + \sum_{j=1}^N x_j A' - c'_i = 0; i = 1, 2, 3, \dots, N. \quad (\text{A1})$$

Equation (6) describes optimal effort decisions of agents under the sharing scheme:

$$(A + x_i A'(X))(1 - \sum_{k \neq i} t_{i,k}) + \sum_{k \neq i} t_{k,i} x_k A'(X) - c'_i. \quad (\text{A2})$$

Our task is to choose the sharing instruments $t_{i,k}$ in (A2) so that (A1) is replicated. Rearranging (A1) and (A2) so that the costs of effort term c'_i is on the right-hand side, equating the result and simplifying reveals that the sharing rules, if they are to provide first-best use incentives, must satisfy in equilibrium the following conditions:

$$(A + x_i^* A')(1 - \sum_{k \neq i} t_{i,k}) + \sum_{k \neq i} t_{k,i} x_k^* A' = A + \sum_{j=1}^N x_j A'; i = 0, 1, 2, 3, \dots, N. \quad (\text{A3})$$

The system of N equations in (A3) cannot generally be solved exclusively for the sharing instruments in the case in which $N \geq 3$ because there are more sharing instruments than agents. If, however, $N = 2$, (A3) produces two equations, and there are only two sharing instruments. These two equations are then:

$$(A + x_1^* A')(1 - t_{1,2}) + t_{2,1} x_2^* A' = A + (x_1 + x_2) A' \quad (\text{A4.1})$$

$$(A + x_2^* A')(1 - t_{2,1}) + t_{1,2} x_1^* A' = A + (x_1 + x_2) A'. \quad (\text{A4.2})$$

Solving (A4.1) and (A4.2) for the optimal sharing rules gives the following result:

$$t_{1,2} = \frac{x_2^* A'}{A}, \quad t_{2,1} = \frac{x_1^* A'}{A}. \quad (\text{A5})$$

The sharing rules in (A5) are of the general form used in the paper; our general sharing rules presented in (7) simply extend the form of (A5) to the case in which $N \geq 3$. We now proceed to show that these sharing rules indeed result in Nash equilibrium first best effort, and then show that the sharing rules are budget-balancing for the general case.

We first show that exerting optimal effort is a Nash equilibrium under the sharing rules. It is helpful to call the sum of efforts excepting agent i as X_{-i} , where X_{-i}^* indicates that every other agent besides i is exerting first-best effort. The idea is to show that, given the rules, if

$X_{-i} = X_{-i}^*$, the best response of agent i is to choose $x_i = x_i^*$. The first-order condition for effort under any sharing rules for agent i may be written as:

$$(A(X_{-i} + x_i) + A'(X_{-i} + x_i)x_i)(1 - \sum_{i \neq k}^N t_{i,k}) + \sum_{k \neq i}^N x_k A'(X_{-i} + x_i)t_{k,i} - c'_i = 0. \quad (\text{A6})$$

Substituting the sharing rules (7) into (A6) gives:

$$(A(X_{-i} + x) + A'(X_{-i} + x)x_i)(1 + \sum_{i \neq k}^N x_k^* \frac{A'(X^*)}{A(X^*)}) - \sum_{k \neq i}^N x_i^* \frac{A'(X^*)}{A(X^*)} A'(X_{-i} + x)x_k - c'_i = 0 \quad (\text{A7})$$

(A7) can be expanded to read:

$$A(X_{-i} + x) + A'(X_{-i} + x)x_i + A(X_{-i} + x_i) \sum_{i \neq k}^N x_k^* \frac{A'(X^*)}{A(X^*)} + A'(X_{-i} + x)x_i \sum_{i \neq k}^N x_k^* \frac{A'(X^*)}{A(X^*)} - A'(X_{-i} + x) \sum_{k \neq i}^N x_i^* \frac{A'(X^*)}{A(X^*)} x_k - c'_i = 0. \quad (\text{A8})$$

To test that choosing $x_i = x_i^*$ is indeed a best response for agent i , given that all other agents choose $x_k = x_k^*$, substitute $x_k = x_k^*$ and $X_{-i} = X_{-i}^*$ into (A8) to get:

$$A(X_{-i}^* + x_i) + A'(X_{-i}^* + x_i)x_i + A(X_{-i}^* + x_i) \sum_{i \neq k}^N x_k^* \frac{A'(X^*)}{A(X^*)} + A'(X_{-i}^* + x_i)x_i \sum_{i \neq k}^N x_k^* \frac{A'(X^*)}{A(X^*)} - A'(X_{-i}^* + x_i) \sum_{k \neq i}^N x_i^* \frac{A'(X^*)}{A(X^*)} x_k^* - c'_i = 0. \quad (\text{A9})$$

$x_i = x_i^*$ is a solution of (A9), as the substitution $x_i = x_i^*$ causes this expression to collapse to equation (4). Thus, if every other agent is exerting optimal effort under the sharing rules, it is agent i 's best response to choose $x_i = x_i^*$.

To show that the rules sum to an amount strictly less than one, rewrite (2) as

$$A(X^*) + \sum_{j=1}^N x_j^* A'(X^*) = c'_i. \quad (\text{A10})$$

(A10) implies that

$$A(X^*) + \sum_{j=1}^N x_j^* A'(X^*) > 0, \quad (\text{A11})$$

(A11) implies that

$$A(X^*) > -\sum_{j=1}^N x_j^* A'(X^*). \quad (\text{A12})$$

From (A12), it follows that:

$$1 > \frac{-\sum_{j=1}^N x_j^* A'(X^*)}{A(X^*)}. \quad (\text{A13})$$

Since the right-hand side of (A13) are the sharing rules, we may conclude that they sum to an amount strictly less than one.

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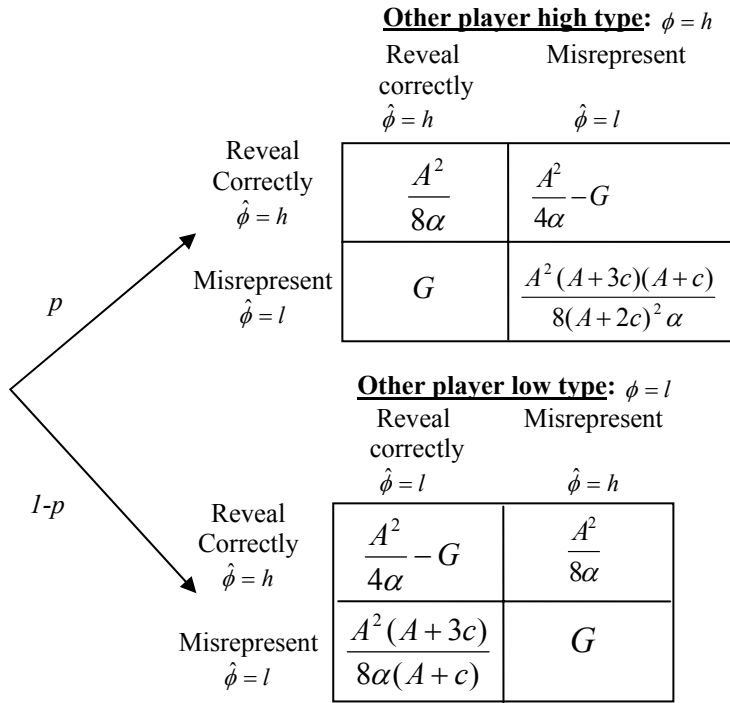


Figure 1: The Incomplete Information game from the perspective of a given high productivity hunter (strategies in rows; opponent's strategies are in columns).

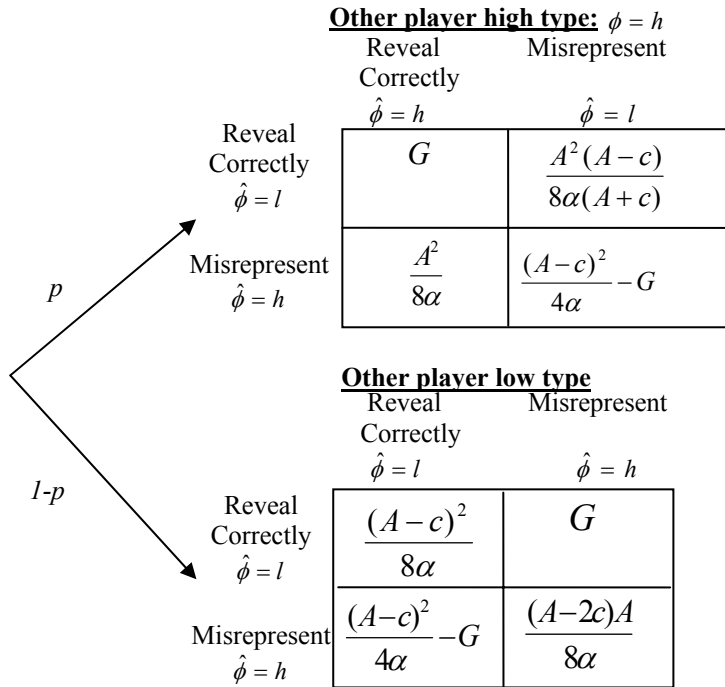


Figure 2: The incomplete information game deriving from the mechanism from the perspective of a given low type (strategies in rows; opponent's strategies in columns).