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Essays in Honor of Sir Partha Dasgupta

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Preface

s an unusual Festschrift, but it would have to be, for it is honoring a sin- economist. Partha Dasgupta has devoted himself to more than research /riting, seminars and lectures. Perhaps because he was born in India and lived and worked in England and the United States, Partha has endeav- to bring academics from these two worlds (the "South" and the "North," ›metimes call them) into contact with each other. This book is a tribute ıt enterprise.

e contributors to this book include Nobel laureates and young academics ;tarting out, professors privileged to work at the world's top universities ›eople making the best of the opportunities afforded by their home insti- ns in developing countries. Many of the authors are his closest friends. include his former teachers and students and his current and former borators. Unusual for a Festschrift, some other authors barely know him ›nally (we'll explain why below).

ırtha has long chastised development economists for neglecting the natu- nvironment, despite its importance to the livelihoods of the rural poor. He ılso leaned on environmental economists for thinking about the environ- t as an amenity, while overlooking its relevance to poverty. If the literature ›red the connections between poverty and the environment, he believed, ı so would the lecturers and professors teaching these subjects in devel- ıg countries; and then so would *their* students neglect these issues. The ıomics they would learn would be divorced from the world in which they so many of their fellow citizens lived. Together with one of us (Mäler), aunched an initiative with the Beijer Institute of Ecological Economics ıe Royal Swedish Academy of Sciences to conduct teaching and research kshops in environmental economics for lecturers and professors living working in developing countries. Partha's convening power was such that ılty on these workshops included some of the world's leading economists, ıy of them contributors to this volume. A better teaching and research pro- m on this subject could not be found anywhere in the world.

:he workshops were held "on location," in places like Elmina, Ghana; hmandu, Nepal; near Mount Kinabalu on the island of Borneo; and on the st of Bahia, Brazil. The logistics of gathering everyone in these places were netimes a headache, but the payoff was huge: by bringing together peo- from the same region—in most cases, for the first time—the Beijer work- ›ps spawned a number of professional networks. These include the South ıan Network for Development and Environmental Economics (SANDEE), Latin American and Caribbean Environmental Economics Program

11

An Optimal Contract for Monitoring Illegal Exploitation of Co-Managed Forests in Benin

Albert N. Honlonkou and Rashid Hassan

11.1 INTRODUCTION

In Benin, natural forest reserves are under serious threat from legal and illegal loggers, poachers, hunters, farmers, herders, and wood traders. High population growth and technological change have led to increased exploitation of, and excessive pressure on, these resources. Available statistics show that one thousand square kilometers of forests are destroyed every year against only ten square kilometers of reforestation (MEHU 1993).

Until the late 1980s, public policymakers adopted a command-and-control approach to protecting the country's forests. Clearly this approach was ineffective, as the pressure on forest resources steadily increased and local populations continued to ignore all regulations applying to protected forests. This traditional protectionist approach also clashed with the argument that the sustainable management of natural resources did not require that they be fully preserved. Finally, it ignored the growing evidence that state and communal management regimes could be combined into hybrid systems, yielding better solutions than alternative, "pure" systems (whether state, communal, or private property). This provided the basis for co-management systems that promote decentralization of controls and active involvement of the local populations in the management of natural resources (Ostrom 1990; Eggertsson 1993). Common property management[1] is defined by Baland and Platteau (2002) as the collective regulation of both membership and the use of rights

[1] The literature makes a distinction between open common pool resource and closed common pool resource (Furubotn and Richter 2005) and we refer here to the latter.

supported by monitoring and sanctioning procedures, to effectively enforce the set rules. It offers an alternative to impersonal markets and coercive states (Dasgupta 2008).

Since 1990, the government of Benin introduced co-management as an institutional device to promote the sharing of power and responsibility among local forest resource user communities and resource management agencies. It was expected that this would promote more collaborative and coordinated actions among resource users and enhance adaptive management of natural forest reserves. The forest co-management system used by the government creates different roles for the various partners. The principal (the government) designs and executes contracts with cooperatives of local populations for monitoring local users who produce private and public goods aimed at protecting the forests (e.g. controlled logging and firewood collection, coal and honey production, and fishing). The role of the monitoring cooperatives is to protect the forest from poaching, illegal logging, illegal farming, and fires (PAMF 2002).

Contracts between the government, local cooperatives, and users display the traits of a typical agency relationship (Seabright 1993), and are plagued accordingly by problems of incentives and commitment common to agency relations. In the context of asymmetric information, agency theory deals with the structuring of contracts between the principal and his agents to manage the trade-off between risk sharing (when the principal and the agents have different attitudes towards risk) and incentives (to align the conflicting goals of the principal to that of the agents; Holmstrom 1979; Eisenhardt 1989). For example, local people retained as monitors in a forest co-management project have more information about the forest endowment in wild animals and timbers than the officials. This confers on them bargaining power, which they may use to continue to allow poaching (collusion with local users) while still benefiting from the government's support. Thus, some cooperatives may not fully cooperate with project officials if the contract between them and the community/government is not optimally designed. If this happens, the co-management system will fail to attain the stated objective, which is the sustainable management of the forests.

This chapter draws on agency theory literature to analyze the optimality of the typical contract between the government, local cooperatives, and users. In the following section we show some connections between common resource management and agency theory. We then present a model to analyze the agency relations among the parties. In Section 11.4, we employ the theoretical results from the previous section to evaluate the experience of common resource management in Benin. The last section distills key findings and implications of the study.

11.2 COMMON RESOURCE MANAGEMENT AND AGENCY THEORY

Since publication of the influential paper "The Tragedy of the Commons" by Hardin (1968), studies on common property resources have become widespread. The key lesson of these studies is that the outcomes of actual experiences with common property management are mixed; and there is a general concern about the reasons for these varying levels of performance among user-managed resource systems. Baland and Platteau (2003) argue that the support of the state impacts the efficiency of common management. There are two main ways in which the government can impede village-level management of common property resources. The first is by not providing services, such as technical expertise, conflict-resolution mechanisms, and legal support; the second is by interventions, deliberate or not, that undermine villagers' ability or willingness to cooperate. Dasgupta (2008) asserts that in studying common property resources, we are not only in the realm of natural resources, but institutions. Furubotn and Richter (2005) argue that even "self-organized and self-governed common property resources need an institutional structure that takes care of appropriation, provision, monitoring, enforcement, conflict resolution, and governance activities—as does the private ownership economy." In fact, any organization can be seen as a network of overlapping or nested principal-agent relations (Tirole 1986).

Faure-Grimaud et al. (2003) analyzed two types of agency relations. In a centralized organization, the principal can communicate and contract with both the supervisor and the agent. These two agents can then collude against the principal. In a decentralized organization, the principal only communicates with the supervisor, who in turn subcontracts with the agent. They show that the two organizations achieve the same outcome. Laffont and Rochet (1997) argue that the assumption made in the standard principal-agent model (that the cooperation of agents desired by the principal is induced by the contracts he offers to the agents, whereby each can maximize his own welfare according to the behavior of the other agents) is unrealistic. The principal is supposed to have complete control of the game played by the agents, so that unwanted communication or side contracting between agents can be prevented. Under asymmetric information, when the principal structures the contracts so as to minimize the informational rents given up to the agents because of their informational advantages, it is quite natural to expect a collective reaction on the part of the agents to protect their rents. Thus it becomes important to understand how agents can react to the rules of an organization and how a principal who is aware of potential collusion (formation of horizontal and vertical cliques) should design an incentive contract.

The delegation of monitoring to a supervisor, making the agency model a principal-supervisor-agent relationship (delegated principal-agent relation), is accompanied by the threat of collusion between the supervisor and the supervisee (agent) to "exploit" the principal. The principal then faces a double hazard problem and needs to create two types of incentives: one for the agent and the other for the supervisor. Paradoxically, Strausz (1997) succeeded in showing that with two contracts (principal-supervisor, principal-agent), the principal can regulate behaviors more accurately. This enhances the incentive effect of double contracting in delegations as explained below.

Because monitoring signals are private information, the supervisor has to decide if he should withhold them or make them public. Then, it is optimal for the principal (in the case of mediated relationship) to use a carrot and stick approach to incentives. This creates a commitment effect on the delegation of monitoring. In a direct (one-shot) relationship, the principal has an incentive to withhold information revealing that the agent has high performance, because this will force him to hand out carrots. But under this relationship, the reward structure creates incentives by letting the agent receive a greater reward when evidence of his performance is inconclusive than when it shows it to be high. This operates as a punishment for the principal and induces him to monitor. However, this higher monitoring has the drawback of reducing incentives for the agent to work harder than contracted. With delegation, this condition disappears. But against the incentive and commitment effects of delegation, the principal has to pay the cost to ensure that collusion between the supervisor and the agent does not occur. Nevertheless, Strausz (1997) showed that the incentive-effect is powerful enough to make delegation profitable even in the absence of the commitment-effect. Melumad and Mookherjee (1989) showed that in the presence of incomplete contract, delegation may perform better than centralized arrangements.

Even if an agency contract is optimal, the challenge remains to measure the output of the agents by investing in information systems. Monitoring (creating additional layers of management) is then necessary when effort and output are not observable and/or not verifiable. Based on the theoretical literature, it is possible to isolate some factors determining the choice of optimal contract in the presence of asymmetric information. When the contract designer needs to pay great attention to the incentives of the agent, the outcome is measurable, and the principal is risk averse, then an outcome-based contract is optimal. But when investments in information systems are available to verify the behavior of the agent, the outcome is uncertain, and the agent is risk averse, there will be a conflict in goals between the parties. In such cases, the behavior-based contract is preferred. Generally, however, full observation of actions is either impossible or prohibitively costly. In such situations, interest centers on the use of imperfect estimators of actions in contracting (Holmstrom 1979). At any rate, to devise optimal incentive contracts in a PAR, all available information should be used. This "sufficiency condition" creates demands for monitoring (Mirrlees 1999; Strausz 1997; Hart and Holmstrom 1987; Eisenhardt 1989; Shavell 1979; and Tirole 1986).

Instead of using absolute performance measure, outcome-based or behavior-based, it is possible to use relative performance measure. Nalebuff and Stiglitz (1983) explore the role of competition measured by relative (instead of absolute) performance as an incentive device. But the problem with penalties is that they can become self-perpetuating. The losers become demoralized, fail to continue competing, and thus continue to lose. Furthermore, in large groups, prizes alone are ineffective in motivating effort as the expected prizes are too small to stop shirking. Worse, the presence of a sure loser destroys everyone's incentive to work hard. For competition to work, participants should be similar. Handicapping is possible to equilibrate relative different abilities; but this may be harder, and inequitable to implement (Miller 2005).

This brief review of the literature shows that agency theory may help construct socially powerful incentives, supported by external enforcement, in situations where mutual affection, pro-social disposition and long-term relationship are lacking or insufficient (Dasgupta 2008). We have used this theoretical framework to develop an analytical model to study the experience of villages' forest commons management in Benin.

11.3 THE ANALYTICAL MODEL

In this section, we set up a model to analyze the role of incentives in the management of a villages' forest common. We also analyze the effect of some parameters on the behavior of agents involved.

11.3.1 The Model

Our setting consists of a village common. This is a forest to which villagers (users) have historical rights but no deed that can be enforced by a court. This is a common situation in developing countries (Dasgupta and Mäler 2004). Prior to government intervention, the forest common was managed by the villagers who set up an organization to control utilization of the forest and exclude outsiders. Typically, the government will intervene using the argument that the forest is misused. The government's first intervention would be to consolidate multiple village forests into a single area. While some use rights would still be granted to the communities, compliance with rules would now be monitored by an official forest police force, in charge of detecting and punishing any misuse of the forest. This policy has proven inefficient in Benin as it has resulted in continuing battles and/or collusion between the forest police and community users. After the second United Nations' Conference on Environment and Development in Rio de Janeiro (Brazil), government policy shifted to promote co-management of forests. We will now model the organization instituted by the new policy. By doing so, we will be able to appreciate if the incentives created are conducive to a more effective management of the forests.

The new co-management organization involves complex relationships between the government (the public project officials and forest police), the forest cooperatives, and the community of users—agency relationships that are difficult to model. But from this complexity, we can isolate the main contract: a principal-supervisor-agent hierarchy involving three players whose objectives are to maximize their expected payoffs.

The first player is a risk-neutral government (G). This is actually a group of players, comprised of public officials and project agents. We are then assuming that all of these players have the same objective defined below, and succeed in solving any free rider problem. Note that in the agency relationship, G is the uninformed principal.

The second player is a risk-neutral supervisory agency (S). This is also a group of players, made up of forest police and local cooperatives of hunters. In the spirit of co-management principles, the new organization uses the former local supervisory device to detect illegal users; and while the forest police and the local cooperative of hunters are not collapsed into a single agency, their objective is congruent. The spotting and reporting of cheating to forest guards as social fencing is practiced for example, in India (Lise 2005). The cooperative of hunters is hired by the principal to detect and report any forest misuse to the forest police. The latter is the only legal structure entitled to punish illegal users.

The third agent is a risk-neutral user of the forest (A)[2]. Here again, we have a group of users, which may be divided into two categories. The first is a proportion ρ of users, called strategic users, who are potential violators of the forest use rules—violating only when it is rational to do so. The second category is comprised of the proportion $(1 - \rho)$ of users who never violate (conformists). Their behavior may be determined by their full internalization of the former social norm that prescribes a friendly use of natural resources. The categorization of the users into conformists (habitual compliers) and strategists is a way to incorporate explicitly ethical standards (normative valuations and obligations) as parameters in the analysis. This allows us to study the effect of their erosion. Some people (especially in traditional society) routinely obey rules not based on cost-benefit analysis, but because of overriding norms (see Graetz et al 1986, for the case of tax compliance).

The simplification described above conforms to the three axioms of Tirole (1986) necessary to model a three-level hierarchy:

[2] A potential violator should not be risk averse.

1) The principal (here the government) lacks time and knowledge for a direct supervision of the agents (forest users). Strausz (1997) criticized this assumption as reminiscent of why the principal needs an agent in the first place. But this criticism does not hold because in our case study local users are already present within or in close proximity, and direct government supervision (forest police) has failed in the past.
2) There is a unique supervisory agency. The co-management system we describe involves many villages but at each village level, there is only one supervisor (a combination of the forest police and a local cooperative).
3) The supervisory agency lacks either the time or the resources to run the vertical structure directly (axiom trivially implied)[3].

Furthermore, we add the assumption that while our model analyzes potential collusion between the agent and the supervisor, it ignores the free-riding problem within groups of players. We also assume away complications like common agency and repeated relations (Arrow 1986; Bernheim and Whinston 1986).

Let us now describe the actions of the players and the information structure of the game.

Two-agent (A) types: the conformist user and the strategic user. The conformist user always plays legal low harvest (L) The strategic user, a potential violator, has the choice between illegal high harvest (H) and legal low harvest (L). We normalize L, the low rate of individual use of the forest, to be 0. We assume that the value of the forest and its provisioning services are converted into monetary values. The low harvest may mean an allowed right to gather wood, fodder, and fruits in the forest. We suppose that the cost of harvesting is 0. This is a reasonable assumption in a setting where the opportunity cost of labor is close to 0 (Lise 2005). We suppose that the strategic user plays L with probability a, and H with probability $(1 - a)$. If the user chooses H and is caught, he pays a fine w_h that draws his payoff below 0. The harvest of the agent is not observable. We assume that the user has access to an external (non-forest) income I.

The supervisory agency (S) chooses to monitor with probability s or not to monitor with probability $(1 - s)$. We assume that a costly monitoring technology is available, controlled by the supervisor, and can be implemented at cost c. This could be the cost of a number of trips per month to the forests to monitor illegal users. The efficiency parameter of the technology is λ, such that, after monitoring, the supervisor observes the true action with probability λ and nothing with probability $(1 - \lambda)$. Then $c = c(\lambda)$ and $c(.)$ is assumed to be increasing and convex in λ. The monitoring technology is imperfect, but there is no

[3] Strausz (1997) asserts that monitoring is profitable because of two assumptions: 1) monitoring is not verifiable and therefore non-contractible, and 2) monitoring signals are private information.

type II error (the probability of assuming that a user violates when he doesn't) in the sense that any result is hard evidence against the agent's behavior. The monitoring procedure itself is not verifiable. The evidence is private information for the supervisor; but if it is revealed, it can be verified by a third party.

Since the monitoring signals are private information, the supervisor can conceal information. Thus, if the supervisor claims that he observes nothing, this may be the outcome of one of three possibilities: the supervisor did not monitor at all (N); he effectively monitors (M) but obtains no results; or he effectively monitors (M), obtains results but decides to conceal them by colluding with the agent. The only verifiable states of the world are therefore (1) state H, where the supervisor reveals that the harvest is H; (2) state L, where the supervisor reveals that the harvest is L; and (3) state N, where the supervisor reveals nothing. In cases where S knows the true harvest and finds that it is high, he chooses to reveal it with probability r and to conceal it with probability $(1 - r)$.

The supervisor will conceal information when he succeeds in reaching an agreement with the strategic user to share the gain from violation. In this case, they share the gain from collusion (w_h), a part βk for S and a part $(1 - \beta)k$ for the strategic user. As in Strausz (1997), we assume that collusion is accompanied by a transfer from the strategic user to the supervisor, conditional on the supervisor's report. k is a transaction cost parameter ($0 \leq k \leq 1$). The higher the value of k, the lower the cost of transaction. The reasons for introducing transaction cost are that side transfers have to be given in stealth, that a mechanism has to be designed to ensure enforceability and the inefficiency of bargaining, that the supervisor and agent may have moral costs (shame and social embarrassments) or fear detection of higher order supervision (see also Laffont 2000)[4]. β ($0 \leq \beta \leq 1$) depends on the bargaining power of the strategic user relative to the supervisor (Baiman et al. 1991). Furthermore, only the coalition between the supervisor and the agent matters because of its possibility to lower the expected utility of the principal (Tirole 1988).

The government (G) offers contract w to the agent (A) and contract t to the supervisor (S). We assume that $w = (w_l, -w_h, w_n)$ and $t = (t_l, t_h, t_n) \geq 0$. For w, w_h stands as penalty or fines for damages for high-level (illegal and non-sustainable) harvesting. Because we normalize the low harvest to 0, we shall assume that $H - w_h < 0$; otherwise, violators lose nothing (and in fact gain) by playing high. We further normalize w by assuming that the principal pays nothing to the agent when he does not play H, and nothing to the supervisor when he reveals nothing. That is $w_l = w_n = t_n = 0$. With this normalization $w = (0, -w_h, 0)$ and $t = (t_l, t_h, 0) \geq 0$. The rationale behind these normalizations of the payments to the agent is that the latter is not punished when the

[4] As usual in the relevant literature, we do not model the bargaining nor address the enforceability of the side contract.

supervisor reveals nothing. Here, "the benefit of doubt" may be invoked as in the judiciary system. As usual we assume that the supervisor is more encouraged to spot violation than to spot conformism, that is, $t_h > t_l$.

We assume that the net revenue of the user cannot be very negative, so that $H < w_h \leq H + I$, where I is the non-forest income. This assumption also permits avoidance of a situation whereby no violation can be obtained with small proportion of conformists and small probability of monitoring by setting an infinite fine.

The timing of the game is defined by the following seven stages:

(1) G offers a contract w to A and a contract t to S;

(2) S accepts or rejects the contracts;

(3) Nature chooses the type of user: the strategic user with probability ρ and the conformist with probability $1 - \rho$;

(4) A and S play a simultaneous move game: A chooses the level of harvest (H or L) and S chooses to monitor (M) or not (N);

(5) If S monitors, Nature reveals the true harvest with probability λ;

(6) In cases where S knows the true harvest and finds it to be high, he chooses to reveal or to conceal it;

(7) Payoffs are realized.

Useful notations and definitions are compiled in Table 11.1.

The extensive form of the game is represented in Figure 11.1.

We analyze the relevant part of the game where the government proposes a contract and the supervisor accepts it. Using the different assumptions and notations, we can now compile the expected payoffs of the players in Table 11.2.

For the different outcomes' scenarios, the expected payoffs of the three agents are given in Table 11.3. We assume that protecting the natural forest resource (public good) has a monetary value of G (social benefit). The protection is financed through t and w, which represent, respectively, payments by the principal to the supervisor, and to the agent, from some government (public) budget.

From Table 11.3, we can now sum up and record the expected payoffs of the three agents.

Government's expected payoff U_G:

The government's expected payoff from the contract is:

$$U_G(w,t,a,s,r) = [1-\rho(1-a)s\lambda(G-t_l) + \rho(1-a)s\lambda r(G-H-t_h+w_h)] + \rho(1-a)(1-s\lambda r(G-H) + [(1-\rho)(1-s\lambda) + \rho a(1-s\lambda)]G \quad (1)$$

Table 11.1 Notation and definitions for the extensive game

Name	Notation	Definition
Government, the principal	G	The group of players made of public officials and project agents
Supervisory agency	S	The group of players made of forest police and local cooperative of hunters
Forest user	A	The group of forest users
Proportion of strategic users	P	The group of potential violators of the forest-use rules. Then $1 - \rho$ is the proportion of users who never violate (the conformists)
Legal low harvest	L	The level of harvest that causes no forest degradation
Illegal high harvest	H	The level of harvest that degrades the forest
The supervisor's action of monitoring	M	Pure strategy
The supervisor's action of not monitoring	N	Pure strategy
Strategist's behavior strategy of playing L	A	The strategist's probability of playing low harvest. Then $(1 - a)$ is the probability of playing high harvest
Supervisor's behavior strategy of monitoring	S	The supervisor's probability of monitoring. Then $1 - s$ is the probability of not monitoring
The supervisor's strategy of revealing information when he gets a strategist playing H	R	Thus $1 - r$ is the probability of concealing information when the supervisor gets a strategist's user
External (non-forest) income of the user	I	
The cost of implementing the monitoring technology	C	The cost to monitor the illegal users inside the forest
The efficiency parameter of the monitoring technology	λ	The probability of observing the true action of the user when monitoring. Thus $1 - \lambda$ is the probability of observing nothing

(Continued)

Table 11.1 (Continued)

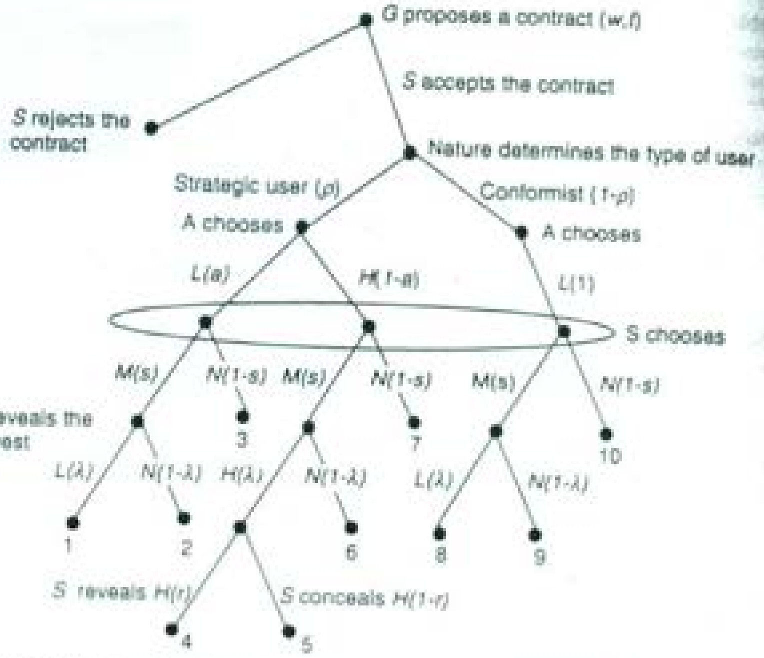
Name	Notation	Definition
Transaction cost parameter	K	The proportion of the proceeds from collusion between the supervisor and the agent kept by the supervisor. $1-k$ is the proportion kept by the strategist user.
The proportion of the gain from collusion going to the supervisor	B	Thus $1-\beta$ is the gain from collusion going to the strategic user
The fine paid by a strategic user to the Government when caught	w_h	
The payment of the principal to the agent when he plays low harvest	w_l	
The payment of the principal to the agent when the supervisor observes nothing	w_n	
The payment vector to the agent	W	$w=(w_p - w_{h'})$
The payment of the principal to the supervisor when he observes and reveals that the strategic user is playing high	t_h	
The payment of the principal to the supervisor when he observes and reveals that the strategic user is playing low	t_l	
The payment of the principal to the supervisor when he observes or reveals nothing	t_n	
The payment vector to the supervisor	T	$t=(t_p - t_h, t_w)$
The expected payoff of player i	U_i	Examples: U_G, U_S, U_A

Agent's expected payoff U_A:
The agent's expected payoff is

$$U_A(w,t,a,s,r)=\rho(1-a)[s\lambda r(I+H-w_h)+s\lambda(1-r)(I+H-w_h \\ +(1-\beta k w_h)+(1-s\lambda)(I+H)+(\rho a+(1+\rho))I \qquad (2)$$

It is important to note that the expected payoff of a random user who is playing low is $[1-\rho(1-a)]I$[5]. Obviously, the aggregate probability of playing low and the associated expected payoff decreases with ρ and increases with a.

[5] To obtain this, add outcomes 1, 2, 3, 8, 9, and 10.



(.) defines probabilities of behavior strategies and the numbers at the final nodes are numberings of outcomes

Figure 11.1 The principal-agent game in extensive form

Table 11.2 Extensive game outcomes' scenarios

Outcome number	Strategic user (ρ)	A chooses L (a)	S monitors M (s)	Nature reveals the true harvest (λ)	S reveals H (r)	Outcome
1	YES	YES	YES	YES	—	$\rho a s \lambda$
2	YES	YES	YES	NO	—	$\rho a s(1-\lambda)$
3	YES	YES	NO	—	—	$\rho a(1-s)$
4	YES	NO	YES	YES	YES	$\rho(1-a)s\lambda r$
5	YES	NO	YES	YES	NO	$\rho(1-a)s\lambda(1-r)$
6	YES	NO	YES	NO	—	$\rho(1-a)s(1-\lambda)$
7	YES	NO	NO	—	—	$\rho(1-a)(1-s)$
8*	NO	YES	YES	YES	—	$(1-\rho)s\lambda$
9*	NO	YES	YES	NO	—	$(1-\rho)s(1-\lambda)$
10*	NO	YES	NO	—	—	$(1-\rho)(1-s)$

* *Note that for outcomes 8, 9, and 10, $a = 1$ for the conformist user.*

Table 11.3 Expected payoffs of the three agents (L is normalized to 0 and hence does not appear in Table)

Outcome number	A	S	G
1	$\rho as\lambda^{*}I$	$\rho as\lambda^{*}(t_{l,}c)$	$\rho as\lambda^{*}(G-t_l)$
2	$\rho as(1-\lambda)^{*}I$	$\rho as(1-\lambda)^{*}(0-c)$	$\rho as(1-\lambda)^{*}G$
3	$\rho a(1-s)^{*}I$	$\rho a(1-s)^{*}0$	$\rho a(1-s)^{*}G$
4	$\rho(1-a)s\lambda r^{*}(H+I-w_h)$	$\rho(1-a)s\lambda r^{*}(t_h-c)$	$\rho(1-a)s\lambda r^{*}$ $(G-H-t_h+w_h)$
5	$\rho(1-a)s\lambda(1-r)^{*}$ $(H+I-w_h+(1-\beta)k$	$\rho(1-a)s\lambda(1-r)^{*}$ (βkw_h-c)	$\rho(1-a)s\lambda(1-r)^{*}$ $(G-H)$
6	$\rho(1-a)s(1-\lambda)^{*}(H+I)$	$\rho(1-a)s(1-\lambda)^{*}(0-c)$	$\rho(1-a)s(1-\lambda)^{*}(G-H)$
7	$\rho(1-a)(1-s)^{*}(H+I)$	$\rho(1-a)(1-s)^{*}0$	$\rho(1-a)(1-s)^{*}(G-H)$
8	$(1-\rho)s\lambda^{*}I$	$(1-\rho)s\lambda^{*}(t_l-c)$	$(1-\rho)s\lambda^{*}(G-t_l)$
9	$(1-\rho)s(1-\lambda)^{*}I$	$(1-\rho)s(1-\lambda)^{*}(0-c)$	$(1-\rho)s(1-\lambda)^{*}G$
10	$(1-\rho)(1-s)^{*}I$	$(1-\rho)(1-s)^{*}0$	$(1-\rho)(1-s)^{*}G$
Total	U_A	U_S	U_G

Supervisor's expected payoff U_S:
The supervisor's expected payoff is

$$U_S(w,t,a,s,r)=\rho s\lambda[a(t_l-c)+(1-a)r(t_h-c) \\ +(1-a)(1-r)(\beta kw_h-c)](1-\rho)s\lambda(t_l-c)-s(1-\lambda)c \quad (3)$$

11.3.2 Analysis of Incentives

We now study the (possibly mixed) sub-game "perfect equilibria" with imperfect information described above.

First of all, before the supervisor accepts to be engaged, the payments t_l, t_h, the cost (c), and the efficiency parameter (λ) of the supervision technology, should be such that $U_s \geq 0$, that is,

$$\rho s\lambda[a(t_l-c)+(1-a)r(t_h-c)+(1-a)(1-r)(\beta kw_h-c)]+s(1-\rho)\lambda(t_l-c)\geq s(1-\lambda)sc$$

Or,

$$\rho s\lambda(1-a)[rt_h+(1-r)\beta kw_h]+s\lambda[1-\rho(1-a)]t_l\geq sc$$

This equation asserts that the supervisor accepts the contract if the expected income from supervision is at least equal to the expected cost of supervision. It is also important to note that even if the payments of the principal to the supervisor are 0, there is a penalty level w_k at which the supervisor may accept a contract and expect to collude systematically with violators ($r=0$). That is the case if:

$$\rho s\lambda(1-a)\beta k w_k + \lambda[1-\rho(1-a)]t_i \geq c$$

The odds that this will happen increase with higher proportions of the following: strategic violators, the level of efficiency parameter of the supervision technology, and the extraction power of the corrupt supervisor (β). The odds also increase when the transaction cost of collusion is low (k high).

Using backward induction, we start with the supervisor who has the choice of revealing that a strategic user is in violation, or concealing this and colluding with the user. This is an important issue because managing common property resources involves cooperation which is beneficial (Dasgupta 2008), or side contracts as collusion which are detrimental, especially when the contracts are incomplete (Itoh 1993; Tirole 1988). In such a relationship, the reporting agent (the supervisor) has an incentive to misrepresent because transfers between the parties depend on his report (Moorkherjee and Png 1989; Tirole 1988).

The choice of the supervisor to collude or not to collude depends on the sign of the derivative of his payoff (equation 3) with respect to r. We have:

$$\frac{\partial U_s(.)}{\partial r} = \rho s\lambda[(1-a)(t_k - c) - (1-a)(\beta k w_k - c)$$

or,

$$\frac{\partial U_s(.)}{\partial r} = \rho s\lambda[(1-a)[(t_k - \beta k w_k] \tag{4}$$

Equation (4) establishes important relations between t_k and w_k. To avoid the capture of the co-management system by users and supervisors ($r = 0$), the government should set the payment of the supervisor higher than the expected bribe ($t_k > \beta k w_k$). This is an important requirement because this means that the government should pay the supervisor more than the proceeds of violation when he succeeds in catching a violator.[*] Otherwise, the supervisor will turn his information of low

[*] Since we are not modeling a multi-period setting, we exclude the perverse situation where the supervisor may pay the user to violate more, either to increase the proceeds from violations to be shared, or to induce the government to increase the supervisor's payment. It is shown that if the supervisor obtains additional private information before contracting with the principal, he can increase his informational rent (Melumad et al. 1995). Indeed, the government can counteract this by increasing the fine and then reversing the power relation between the supervisor and

or high level of harvesting into "observe nothing." A supervisor is totally useless if his independence can be compromised with relative ease, that is, the collusion costs are small (Khalil and Lawarrée 2006). It is important not to forget that given the rules, together with the punishment and reward structure for transgressions, the actual responses are determined by the participants' behavioral characteristics (Hurwicz 1973). Solutions lie in recruiting honest supervisors (low *k* or high transaction cost), or using higher order supervision (external auditing). But these solutions also entail agency problems (adverse selection) and costs.

From here on, we assume that the supervisor will always reveal any violation ($r = 1$) if he knows it. The different payoffs become:

$$U_G(w,t,a,s,r) = [1-\rho(1-a)s\lambda(G-t_l) + \rho(1-a)s\lambda r(G-H-t_h+w_h)] + \rho(1-a)(1-s\lambda)(G-H) + [((1-s\lambda)+(1-\rho(1-a))]G$$

or,

$$U_G(w,t,a,s,r) = G-[1-\rho(1-a)]s\lambda t_l - \rho(1-a)s\lambda(t_h-w_h) - \rho(1-a)H \qquad (1')$$

$$U_A(w,t,a,s,r) = \rho(1-a)[H-s\lambda w_h]+I \qquad (2')$$

$$U_S(w,t,a,s,r) = \rho s\lambda[a(t_l-c)+(1-a)(t_h-c)] + (1-\rho)s\lambda(t_l-c) - s[\rho(1-\lambda)+(1-\rho)(1-\lambda)]$$

or,

$$U_S(w,t,a,s,r) = [1-\rho(1-a)]s\lambda t_l + \rho s\lambda(1-a)t_h - sc) \qquad (3')$$

Assuming that the values of other outside options of *A* and *S* are 0, (a, s) is feasible if:

$$U_A(w,t,a,s) \geq 0 \ \ and \ \ U_S(w,t,a,s) \geq 0 \qquad (5)$$

A Nash Equilibrium (a^*, s^*) of the sub-game induced by the contracts proposed by the government is given by the following two maximizing programs:

$$P1: a^* \in \arg \underset{a\in[0,1]}{Max} U_A(w,t,a,s^*) \ \ and \ \ s^* \in \arg \underset{s\in[0,1]}{Max} U_S(w,t,a^*,s) \ subject \ to \ (5) \qquad (6)$$

the user. Moreover, the possibility that the principal bribes the supervisor to retain information that is favorable to the agent (in order to pay the latter a lower wage) can be made innocuous by an adequate organizational design (Tirole 1988).

A contract (w,t) is feasible where there exists a viable Nash Equilibrium between the agent and the supervisor.

Following Strausz (1997), the optimal contract $(w^{**}, t^{**}, a^{**}, s^{**})$ is the subgame perfect equilibrium of the game, and is given by the maximizing program *P2*:

$$P2:(a^{**}, s^{**}, w^{**}, t^{**}) \in \arg \underset{a^*, s^*, w, t}{Max}\, U_A(w, t, a^*, s^*) \text{ subject to } (6) \quad (7)$$

The solutions to *P1* are given by the following first-order conditions (ignoring the feasibility constraints):

$$\frac{\partial U_A(.)}{\partial a} = \rho[s\lambda w_h - H] \leq 0,\ a = 0 \text{ if } \rho[s\lambda w_h - H] < 0,\ a = 1 \text{ if } \rho[s\lambda w_h - H] > 0 \quad (8.1)$$

Equation (8.1) says that the agent will never comply ($a=0$) if the expected fine is less than the expected gain from violation, and will always comply in the contrary situation.

$$\begin{aligned} \frac{\partial U_s(.)}{\partial_s} &= [1 - \rho(1-a)]\lambda t_l + \rho\lambda(1-a)t_h \leq c, \\ & s = 0 \text{ if } [1 - \rho(1-a)]\lambda t_l + \rho\lambda(1-a)t_h < c \text{ and} \\ & s = 1 \text{ if } [1 - \rho(1-a)]\lambda t_l + \rho\lambda(1-a)t_h > c \end{aligned} \quad (8.2)$$

Equation (8.2) says that the supervisor will never supervise ($s = 0$) if the expected marginal income from supervision is less than the expected marginal cost of supervision, and will always supervise in the contrary instance.

If the inequalities are strict, then $a = 0$ for (8.1) and $s = 0$ for (8.2).
If an optimal contract exists, 8.1 and 8.2 should bind in equilibrium. If not, since U_A and U_s are respectively linear in a and s, this would mean that the participation constraints (5) are not satisfied. Furthermore, if $s = 0$, $a = 0$, the strategic user will always violate, and the hiring of a supervisor is useless. In the sequel, we will then assume that 8.1 and 8.2 are binding and derive a^* and s^* accordingly. The fact that $0 < a^*, s^* < 1$ makes auditing random (see Mookherjee and Png 1989).

$$a^* = 1 - \frac{c - \lambda t_l}{\rho\lambda(t_h - t_l)} \quad (9)$$

and

$$s^* = \frac{H}{\lambda w_h} \quad (10)$$

To be sensible, equation (9) implies that $c - \lambda t_l \geq 0$, or $t_l \leq (c/\lambda)$, that is, the payment for discovering low users should be less than the effective cost of the technology. To understand this, suppose the contrary. Then equation (8.2) shows that $[1-\rho(1-a)]\lambda t_l + \rho\lambda(1-a)t_h > c$, so that the supervisor will supervise with certainty. The same reasoning shows that $\lambda w_h \geq H$ or $\lambda w_h \geq (H/\lambda)$ (the effective rent from violation), because otherwise the agent will always play high, that is, violate.

We will then suppose that $1 > a^* > 0$ and $1 > s^* > 1$ so that equation (9) and (10) will be used to characterize the structure of the payments made by the principal to the supervisor and agent.

These equations give some insights concerning the double interpretation of the infinite reward scheme analyzed in the monitoring literature (Strausz 1997). First, an infinite punishment ($w_h \to +\infty$) will induce the agent to comply with certainty (equation 8.1) with almost no monitoring (equation 10). Indeed, unbounded payment schemes can be used to induce any sort of behavior (Border and Sobel 1987). Second, an infinite payment to the supervisor ($t_h \to \infty$) will induce the agent to play low harvest with certainty (equation 9). Those results mean that even if relatively efficient reward schemes can be constructed, an optimal contract does not obtain (see Strausz 1997; Mirrlees 1999). Any structure of rewards' scheme will always be surpassed by a better one capable of ensuring that a^* and s^* are close to 1.

One implication of these findings is that the possibility of collusion between the agent and the supervisor is especially plausible when the contract approaches efficiency (w_h very large). In fact, a wedge between w_h and t_h suffices to trigger corruption practices between the agent and the supervisor. Clearly an incentive contract with a harsh punishment of the offender and low compensation for the monitor is counterproductive. If the punishment should fit the crime, the compensation of the monitor should also fit the crime.

11.3.3 Comparative Statics Analyses

We perform in this section a comparative statistics' analysis of the influence of some key parameters in the model (assuming interior solutions, i.e., $0 < a^* < 1$ and $0 < s^* < 1$). Given the payments of the principal to the agent and the supervisor, a change in the environment (parameters) triggers the reactions of the latter who compute new reactions functions (9 and 10). Knowing these new reactions, the principal updates the payments to assure optimality for himself.

Finally, the agent and the supervisor incorporate the new payments. Given the structure we have given to the model, this involves deriving the comparative statistics for five variables w_A, t_I, t_A, a, s, and five parameters ρ, λ, h, c, and G[7]. This amounts to twenty-five comparative statistics. This is clearly a daunting task. Nevertheless, we can garner some results by assuming that the agent and the supervisor take the payments of the principal as given, that is, as parameters fixed by an administrative or legislative body. This is a realistic assumption because the government rarely alters the payments as a response to environmental change. But then, we are no closer to the equilibrium than we would be from our former game. Table 11.4 gives the results based on the differentiation of equations (9) and (10) with respect to the relevant parameters.

Some results displayed by Table 11.4 may seem counterintuitive. For example, parameters supposed to have effects on one player might affect another player instead. But we should remember that the results depend on the interaction between the agent and the supervisor.

The belief that deteriorating social norms increase the likelihood of degradation of common resources makes the effects of change in the proportion of strategic users (ρ) particularly interesting. An increase in the proportion of strategic users decreases the compliance rate of the strategic users and has no effect on the supervision rate. An increase in ρ has no direct impact on individual strategic users. It increases the proportion of dishonest users and then the productivity of supervision: the discovery of illegal users and the reception of higher payments t_A. So the supervision rate increases. Then a increases, triggering a decrease in s. In equilibrium, s remains constant and a decreases.

Table 11.4 Some comparative statics' results (the payments to the principal are given)

Parameters	a^*	s^*
ρ	-	0
λ	+	-
h	0	+
c	-	0
w_A	0	-
t_I	*	0
t_A	+	0

0=no effect, + = positive effect, - = negative effect, * = undetermined/ambiguous

[7] The non-forest income does not appear in the first-order conditions and then is irrelevant for comparative statics analysis.

Then our model shows that when social norms deteriorate, this is likely to increase the misuse of natural resources.

An increase in the efficiency of the supervision technology (λ) (independent of its cost) decreases the supervision rate and increases the rate of compliance. When λ increases, noncompliance is easily detected so that a increases. But then supervision becomes less profitable, and s decreases. The decrease in s triggers a decrease in a. Our model shows that the net effect on s is negative and the one on a is positive. The main insight is that when the supervision technology is improved, care should be taken so that the effort in supervision is maintained. This will reinforce the direct effect on compliance rate.

When the stake of noncompliance (H) is high, supervision is high, but this has no effect on the violation rate. An immediate effect of an increase in H is a decrease in the compliance rate a. But then s will increase, triggering an increase in a. The net effect is an increase in s and no effect on a. These results show that rich forests are not always associated with higher violation rates than the poor ones, so long as adequate incentives are given to the supervisors.

An increase in the cost of the supervision technology (c), independent of its efficiency, has a negative effect on a, but no effect on s. An increase in c has no direct effect on a, but decreases the payoff from more supervision, so that s decreases. A decrease in s will induce a decrease in a, then an increase in s followed by an increase in a. The net effect of c shows that a massive investment in the supervision technology (by giving subsidies) may be the relevant policy to encourage supervision and deter noncompliance. But care should be taken to sustain the supervision rate.

An increase in the fine (w_k) has no effect on the compliance rate (a), but decreases the rate of supervision. This is at odds with the literature on crime, which consistently found that the level of fines has a negative effect on the violation rate (Becker 1968; Graetz et al. 1986; Davis 1988). To be sure, an increase in w_k has a positive direct effect on the compliance rate (see equation 8.1), but the rise in a is followed by a decrease in s. This decrease in s in turn implies a decrease in a. Our model shows that the net effect is to keep a constant. This result should remind us that it is insufficient to keep the level of fines high if one wants to deter crime. This should be accompanied by an effort to maintain the level of supervision aimed at detecting and punishing violators.

An increase in payment for detecting the compliance of a user has an ambiguous effect on the level of compliance, but none on the supervision level. An increase in t_i increases the return from the supervision of compliers (strategic users or natural compliers), and then has a positive effect on the level of supervision. This is followed by an increase in a, followed by a decrease of s. This result shows that the performance of supervision should not only be measured by and rewarded according to the level of the crime rate, but also by the rate of population that may be certified to be conforming.

Finally, an increase in payment for detecting violators (t_k) has a positive effect on a, but no effect on s. This is in conformity with what is ordinarily believed and applied: a prize for those who can catch criminals. An increase in t_k increases the return from supervision. An increase in s implies an increase in a, compensating for the former increase in s. This cancellation effect is accompanied by a decrease in a. The net effect of the increase of t_k on a is positive. But placed in relation to the preceding result on t_p, we set forth the argument that the effort to "certificate" compliance, and that of succeeding in spotting criminals, should be properly rewarded.

The following section demonstrates to what extent this analytical framework is applicable to co-management experiences in Benin.

11.4 EVALAUATING FOREST CO-MANAGEMENT EXPERIENCES IN BENIN

In this section we apply the agency analytical framework described above to Benin's experience in co-management of its forest reserves. We evaluate against this the features of the contracts designed by the government to support common resource management in the forests of Benin. We will show below that the standards are not adhered to, yielding a poor performance.

11.4.1 Case-study Description

The classified forests of Agoua, Kouffé Mounts, and Wari-Maroare, located in the Center-West of Benin, total 370,000 hectares, spread over several regions (Collines, Donga, and Borgou). Traditional relationships between local populations, the forest, and the state are in conflict. While there is some tolerance of communities' use of the forest products, they have to sustain some vagaries of the forest police. They are often charged and fined if they are convicted of some misuse. Nevertheless, there is some kind of informal sharing of the forest among the local villages. The traditional management of a village's forest is organized around the Chief of the village's land and the Chief of the hunter's brotherhood. In the village hierarchy, the Chief of the village's land is at the top, in charge of distributing the land and ruling on disputes. The hunters' brotherhood assures the security of the village (including human beings and forests) against intruders, under the auspices of a local divinity named "Ogu", the god of iron. Thus, while the state does not recognize ownership rights of the village community to the forests, the local populations develop security measures against inside and outside aggressions. So, "*whatever the source of the authority* *that underpins the ownership structure, the local commons are not open to outsiders: they are not "open access resources"* (Dasgupta and Mäler 2004).

But, with population pressure and increasing conflicts between local populations, outside intruders and the forest police, it became urgent to improve the system of management of the forests. Following the new paradigm of including local populations in the management of their "own resources", a local non-governmental organization (NGO) tried to organize the village brotherhoods into a confederation with the help of donors. The idea was to make the local populations sensitive to the sustainable use and protection of forests beyond village-level interests. But when donors' assistance ceased, this initiative was abandoned.

The Beninese government then stepped in, elaborated, financed, and implemented a project (the "Projet d'Aménagement des massifs Forestiers") with funding from the African Development Bank. Among the main interventions of the project is the implementation of a system of forest co-management involving local populations.

In the setup of the co-management system, local populations are encouraged to create cooperatives, through which they receive support and payments from the environmental project. The support they end up getting depends on the activities they undertake. Thus, we can distinguish three types of cooperatives.

The first type produces private goods that can be sold in markets independently of the project (honey, oil, intensive farming, non-conventional animal breeding, etc.). These activities are encouraged to reduce the pressure on forests. Because of their private nature, the income generated by these activities is directly linked to the efforts that the members of the cooperatives provide.

The second category of cooperatives produces semi-private/semi-public goods (seedling nurseries) that they sell directly to the project to develop the forest. Because of the limited market for these products, the income generated depends strongly on the price fixed by the project officials.

The third category of cooperatives produces public goods such as reforestation, control of illegal users, intruders/poachers. For these activities, the cooperatives are employed by the project/public officials as wage-workers to supervise the use of the forests. Here we have an agency including the government as the principal, the hunters' brotherhood as the supervisor, and the local users as agents.

Since the local users are too unorganized to impact the principal, we can employ the traditional principal-agent theory (enriched by the presence of a supervisor). This lack of organization among local users led the project to focus on making the relation between the government and the supervisor a proper principal-agent relation on its own. In the case-study forests, there are thirty-three hunters' brotherhoods organized in a three-level confederation: local (village) level, inter-district level and inter-forest level. Our analysis concentrates on the performance of supervisors (the brotherhoods) on which we have data.

The elements of a typical contract between the government and the supervisor read as follow:

- Contract holder: village hunters' brotherhood
- Object: Surveillance and protection of forests against late fires, transhumance, illegal wood exploitation, poaching, and land development
- Amount: CFA 1,639,440 (US$ 3,279)
- Duration: 12 months
- The contract is executed with the assistance of the forest police

It is clear that nothing is said in this contract about performance measurement. Later on, however, a relative performance measure was developed and used to award prizes to the five best hunters' brotherhoods. That is the relation we are going to analyze after presenting its performance results.

11.4.2 Hunters' Brotherhood Performance Results

Given that data are scarce, we present only two results here: the relative performance measure for two years, and the results of our interviews of agents on the present state of the forests following the project's culmination in 2008. The performance measure is constructed using governance indices, equipment, and activities. Table 11.5 presents the results of two years of relative performance of the supervisors.

Table 11.5 shows that response results to the introduced incentive (prize) system are very volatile, implying randomness of the ranking, as winners change from year to year. Of the five hunters' brotherhoods that received prizes in 2006, only one survived the following year (2007). This helps to avoid the problem of a sure winner, but makes the average prize very small compared to the gain from collusion as we show below.

From interviews with local community members and key informants we found a general agreement that illegal use of the forests had increased after the project ended. Two explanations were given. The first was to attribute increases to the disappearance of incentive compensations to hunters (having ended with the project), confirming the importance of some form of external intervention. The second put forth that, with the help of the project, hunters were now better informed of the areas of the forests that are wealthy in woods and well stocked with game. Endowed with that better information, hunters were now serving as guides for illegal poachers and loggers for discovering these rich areas. This is a very disappointing result of a project aimed at protecting the forests through a promotion of co-management. In fact, when

Table 11.5 Ranks of some hunters' brotherhood in two successive years ($N = 33$)

Hunters' brotherhood	Rank in 2006	Rank in 2007	Annual Prize (US $)
1	1	>5	2,000
2	2	1	1,600
3	3	>5	1,200
4	4	>5	800
5	5	>5	400
6	>5	2	0
7	>5	3	0
8	>5	4	0
9	>5	5	0
Expected prize			182

>means greater than
Source: compiled from PAMF reports (2006, 2007)

people are uncertain of their rights to a piece of property, they are reluctant to protect and improve it and may even overuse it (Dasgupta 2008; Runge 1981).

The question now becomes: how can the agency help to explain these results? Some answers to this question are attempted in the following section.

11.4.3 Analysis of the Hunters' Brotherhood Performance Results

The unit of analysis in agency theory is the contract. We use the theoretical results to see if the project had designed the efficient contract. We hold the view that if the suitable incentive system is not chosen, the performance will be low; but we are not testing efficiency directly.

Given that a main component of the performance measure is the value of the equipment seized from poachers and illegal users, some brotherhoods claimed that this ranking is unfair. Their argument is that if you are efficient in chasing away illegal users from your forest, you will have no equipment to seize and thus you will get a low ranking. This suggests some kind of ratchet effect: an agent with a high performance today will be expected to achieve more tomorrow. He should thus be reluctant to convey favorable information too early in the relationship (Laffont and Tirole 1988). There is also a kind of hold-up problem, because each village has only one hunters' brotherhood. Once each brotherhood is properly equipped by the Government, its bargaining power to extract rents from any side (government and illegal users) increases and may be used to effect illegal collusion at the expense of the government.

These results show that the composition and constituents of the performance indicator are crucially important in ranking for an effective incentive system. Furthermore, for relative performance to be valuable as a signal for relative effort, individuals should be similar and face similar risks (Miller 2005). It is well known that the village forests are unevenly rich. The expected prize[a] is US$182, while from corruption practices local monitors may gain many times that amount. The value of illegal logging from each village forest is estimated at $2,100. From those figures, we can safely infer that the compensation of monitors doesn't fit the crime. This is clearly in contrast with what our comparative statics' results reveal: that to control illegal use of the forest, detection of violators, and certification of compliance by the supervisors should be properly rewarded.

The agency relation implemented by the project is both outcome-based (supervisors) and behavior-based (forest users). So when providing the right incentives for supervisors, investments in information systems are necessary to verify behavior over a long period of time. Within the time length of a project (six years for the project), these are not guaranteed if no provision is made to assure institutional continuity. The exploitation of the forests may be integrated in the co-management system to insure that continuity. Since it is understood that a classified forest should not be exploited, the development plan should be implemented before delving into a co-management experience. Without that provision, the success of co-management is not guaranteed.

Agency problems may then be one explanation for why some local commons have degraded in many parts of the poorer world despite massive state intervention to encourage co-management. Natural resource degradation persists due to unclear institutional arrangements, and the breakdown of norms and incentives that give meaning to those institutional arrangements. For these, governments are largely to blame for creating perverse incentives (Dasgupta and Mäler 2004; MEA 2005; Bromley 1991).

11.5 CONCLUDING REMARKS

When the government intervenes to co-manage a resource with local users, it creates an agency relationship with its associated problems and available solutions. In this chapter, we analyzed theoretically and empirically just such a relationship for the co-management experience of forest reserves in Benin. We showed that the contract devised by public officials was ill-designed—and, in particular, that the compensation of monitors didn't "fit the crime." We propose that the forest reserves co-management regime of Benin be revised based on agency theory principles. In particular, we recommend that the following

[a] We consider the contest to get a prize in a tournament between 33 competitors with equal chance of winning. Then the probability of getting any rank is 1/33 and the expected prize is (2,000+1,600+1,200+800+400)/33=$182.

steps be considered: 1) recognize the agency relations between agents; 2) ensure development of the commons before setting up the co-management regime, to guarantee institutional continuity; and 3) devise sound incentives for agents involved.

These steps are necessary to achieve the combined public and private goals of environmental protection and enhanced welfare of local communities. It is especially important to avoid a situation whereby interventions by the state damage local institutions and turn common property resources into open access resources.

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12

Comments by Eric Maskin on "An Optimal Contract"

This is an interesting and well-executed effort to use optimal contract theory for illuminating why the policy of co-managing forest reserves in Benin has failed to stop those forests from being degraded. Co-management—wherein local communities have considerable autonomy in how they use a natural resource (in this case, forests)—had been hailed internationally as an improvement over the conventional "command-and-control" model, in which the government dictates how the resource is to be used. Thus, its failure in Benin has been a shock and a disappointment.

The authors make a good case that the Benin story is not an argument against co-management *per se*, but rather a demonstration of what goes wrong when incentives are not designed properly in such an arrangement. To do that, they first develop a theoretical contract model, consisting of a *principal* (who, in the model's application to Benin, becomes the government), a *supervisor* (the "hunter's brotherhood" in the application), and an *agent* (the community using the forests). In the model, the principal hires the supervisor to monitor the agent's action, which can be either "appropriate" or "inappropriate." Monitoring is costly, and so the supervisor may only pretend to monitor. But even if he monitors for real, he may choose not to report the evidence acquired about the agent's action. If he *does* make a report to the principal and the action was inappropriate, the principal can then impose a fine on the agent (though there is a limit to how high this fine can be).

If the contract between the principal and supervisor is designed optimally, the principal will pay the supervisor a fee contingent on the evidence reported (assuming there is a report). This contingent fee, when properly set, will give the supervisor the incentive to undertake monitoring and to report any evidence discovered. Furthermore, it will dissuade the supervisor from "colluding" with the agent (in a collusive arrangement, the supervisor would agree not to report the agent for acting inappropriately—or perhaps not to monitor at all—in exchange for a bribe). Finally, a well-chosen fine will induce the agent to act appropriately.

The authors do a nice job of formulating the model and analyzing it. I have just two comments and questions about their theoretical work:

(1) The model provides for the agent to be fined if she is reported to have acted inappropriately, but it assumes nothing happens to her otherwise. Yet, given that there is a restriction on how severe the fine can be, wouldn't incentives be more powerful if the agent were also *rewarded* by the principal for a good report, that is, for having acted appropriately? This would give the agent greater motivation to choose the appropriate action and would also reduce the temptation for collusion between the agent and the supervisor.

(2) It is assumed that the agent and supervisor collude by dividing up the fine w_H the agent would have paid had the supervisor reported that she acted inappropriately. But this assumption doesn't seem quite right because if the supervisor chooses not to report the agent, he loses the contingent fee t_H he would otherwise get (assuming that he undertakes monitoring). So, the net surplus to be divided appears to be $w_H - t_H$, not w_H. For collusion to be deterred, I believe it is sufficient that the principal should set w_H and t_H so that $w_H \leq t_H$ (presuming, again, that the supervisor has the incentive to monitor).

As for applying this model to the case of Benin, the authors interpret acting inappropriately as acting *illegally*, for example, poaching. They make the valuable point that a major shortcoming of the incentive contract actually used by Benin's government was that the supervisor (the hunter's brotherhood) was rewarded for providing evidence only of inappropriate action and not also of appropriate behavior. This limitation had the perverse property that if the brotherhood had somehow managed to stop all illegal activity, then it would have got paid nothing—and so would have had no compensation for its monitoring. The authors persuasively argue that this was a serious flaw in contract design. Furthermore, it is one that could easily have been fixed.

Left open in the author's discussion is the question of how the contract might have been designed to take account of legal but suboptimal actions by the forest-using community. Perhaps the authors will wish to study this issue in future work. If so, it will be interesting to see what they come up with.