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To Bribe or Not to Bribe

Incentives to Protect Tanzania's Forests

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To Bribe or Not to Bribe: Incentives to Protect Tanzania's Forests

Elizabeth J.Z. Robinson and Razack B. Lokina

Abstract

Where participatory forest management has been introduced into Tanzania, "volunteer" patrollers take responsibility for enforcing access restrictions, often receiving a share of the fine revenue that they collect as an incentive. We explored how this shared revenue and alternative sources of forest products for villagers determine the effort patrollers put into enforcement and whether they choose to take a bribe from illegal harvesters rather than honestly reporting the illegal activity. Using an optimal enforcement model, we show that, without transparency or funds to pay and monitor the volunteers undertaking enforcement, policymakers face tradeoffs between efficiency, enforcement effectiveness, and revenue collection.

Key Words: optimal enforcement, participatory forest management, Tanzania

JEL Classification: K42, Q23

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Introduction

Participatory forest management (PFM) has been introduced in Tanzania, either as joint forest management (JFM), where the government owns the forest and the villagers are mainly involved in protection, or as community-based forest management (CBFM), where villagers own and manage the forests. A key feature of both JFM and CBFM is that village committees are responsible for enforcing harvest restrictions within the protected forests. Enforcement typically means that village groups patrol the forest, confiscating illegally extracted goods and fining the perpetrators. Usually these villagers are members of committees, variously known as "village environmental, forest, or natural resource committees" (referred to as VECs in this paper).

In almost all the cases that we documented, these village patrollers are unpaid volunteers. Yet in practice, they are not volunteering, per se, because they almost always have a financial stake in catching those who engage in illegal activities. This stake may be explicit—in some villages, the patrollers are entitled to a share of the fine revenue generated—but it may also be implicit. We have anecdotal but credible evidence that the patrollers may also take bribes, rather than formally report the illegal activity. The small number of illegal activities that are actually recorded in the villages suggests one of three scenarios: 1) enforcement is highly effective in deterring villagers from illegal extraction, 2) the patrollers are not putting any effort into enforcement, or 3) the patrollers are accepting bribes rather than reporting illegal activities. Determining what is actually happening is tricky. Members of the VECs are not likely to admit that they take bribes instead of reporting illegal activities, and little if any information is available about the extent of illegal activities.

Although there are few available data concerning the level of illegal extraction from the various PFM forests and whether people are caught and punished, we found different

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arrangements existed for sharing the fine revenue collected from those caught extracting illegally. The VEC patrollers, the village, and the government all variously receive shares of the fine revenue. Given that patrolling is an unpaid activity and no funds are available from the government or other agencies to pay the patrollers, allowing such revenue sharing makes some sense as it gives the VEC patrollers an incentive. However, this situation has a number of consequences that may not have been thought through sufficiently.

We used these various revenue-sharing arrangements to inform a model of optimal enforcement to explore how the structure of rewards and monitoring activities influences the effectiveness of the VEC patrols, regarding the effort that they put into enforcement, the opportunities for bribes, and the fine revenues collected by the village. We analyzed explicitly the incentives that different revenue-sharing arrangements created for the village patrollers, in particular; the tradeoffs of allowing village patrollers to keep some or all of the fine money, generating revenue from fine income; and bribe taking rather than formally fining violators and reporting illegal acts.

In the next section, we look at the literature that addresses optimal enforcement, enforcement incentives, and bribe taking. In section 2, we discuss in more detail the empirical motivation for the paper. In section 3, we develop a model of optimal enforcement, effort, and bribes. Section 4 presents some of the key findings from the model and, finally, in section 5, we discuss the policy implications of our findings.

1. Literature and Theoretical Underpinnings

The Becker (1968) optimal enforcement framework is a useful starting point to analyze issues of enforcement, effort, and bribe taking. Becker’s seminal paper was one of the first to recognize that enforcement is costly and therefore might not be optimal to prevent all illegal activities. In Becker’s paper, as in much of the optimal enforcement literature that followed, enforcement effectiveness—and therefore, implicitly, enforcement effort—is a function of the amount spent on enforcement. There is an implicit assumption of no moral hazard; that is, those responsible for enforcement do not choose how much effort to put into enforcement and so cannot influence the probability that someone is caught through their own efforts. Such an assumption may be appropriate for a camera that detects motorists speeding, but it is far from appropriate for rangers protecting tropical forests, who might put their effort into avoiding being attacked while on patrol or simply minimizing effort expended on patrols, rather than detecting or deterring illegal activity.

In reality, it is those who are responsible for the enforcement activities who decide how much effort to put into enforcement. General economic theory suggests that the effort that patrollers put into enforcement is likely to be a function of the rewards that they face: patrollers put forth the greatest effort when they get all the revenue (collected fines) from the illegal activities themselves and the least effort in situations when they get no share. In this respect, enforcement effort can be addressed in a similar way to issues of sharecropping and moral hazard, yet few papers have addressed enforcement in this way. A key exception is Mookerjee and Png (1995), who recognized that when corruption is defined as enforcement officials taking bribes instead of imposing official fines (although this is a second-best solution), at least there is an incentive for the enforcement agents to put effort into detection activities—an example of moral hazard. Their paper concluded that although the opportunity for bribe taking increases the amount of effort put into enforcement, it is better to eliminate bribe taking through increased monitoring of the enforcement agents.

Corruption, in the form of bribe taking among those responsible for patrolling, is an area that has been more comprehensively covered in the literature. Burlando and Motta (2007), in contrast to Mookerjee and Png (1995), found that governments with high administrative costs for administering fines or with poor ability to spot and prosecute corruption may prefer to let corruption happen. Klerman and Garoupa (2002) focused on the government's objective, comparing public and private law enforcement and the motivations behind a rent-seeking government. They found that whether the government's enforcement efforts are more (or less) aggressive than a social-welfare-maximizing government's efforts depends on the wealth of offenders and the severity of the crime. Macho-Stadler and Pérez-Castrillo (2006) showed that, when firms have different characteristics and the enforcement agency wants to minimize the level of polluting emissions, firms are likely to cheat by not complying with the environmental objective unless the budget for monitoring is very high, and that governments with limited enforcement budgets should focus on firms that are the easiest to monitor.

2. Empirical Motivation

We collected data from 30 villages where either CBFM or JFM has been introduced,[1] and where a small group of villagers, organized as a "Village Environmental Committee" (VEC), is

1 In a small number of villages, there were both CBFM and JFM forests.

responsible for enforcing protected-forest extraction restrictions. In all the villages that we visited, the strategies of these VECs are similar. They typically patrol several times a week in small groups, have little if any equipment, only patrol in the day time, and rarely have a clear strategy for where in the forest they patrol. Although these patrols are described in almost all cases as voluntary, the VEC committee members are often formally rewarded with all or a share of the fine revenues that they collect.

Table 1 details which groups are formally allocated a share of the fine revenues collected by the VEC patrollers when they catch someone collecting non-timber forest products (NTFPs) illegally from the protected forest. Although the sample size is small, we found a variety of sharing arrangements, from the patrollers getting none of the fine revenue (six out of 36 observations) to the patrollers getting all of the fine revenue (13 observations). The most common arrangement is for the patrollers to get all the fine revenue or share with the village. Other sharing arrangements distribute the fines to village and the government with no share allocated to the VEC patrollers—implying true voluntarism by the patrollers. In those circumstances where the fine revenue is shared, the share going to each party is almost always 50 percent.

Table 1. Share of Fine Revenue Going to Each Group

Fine money kept by …	Community-based forest management	Joint forest management
Patrollers only	5 (42%)	8 (33%)
Patrollers and village	6 (50%)	10 (42)
Patrollers and government	0 (0%)	1 (4%)
Village only	1 (8%)	3 (13%)
Village and government	0 (0%)	2 (8%)
Total instances	12	24

Source: Authors' data, 2008.

We also asked whether there were any written records of violations and found that the data available concerning the number of people actually caught and fined are far from adequate. In some villages, there were no written records of the fines that had been imposed; and where there were written records, VEC members were reticent to show us the data. Even if written records existed, often very few violations were recorded. Typical responses from villages included that "only two violations were recorded back in 2006 and nothing since then," and that "only two cases of cutting poles have been detected and punished in the past eight years." In one village, the committee members told us that they had detected hundreds of cases of illegal activity, but only one person had been caught in the act and brought before the village for formal punishment in the past five years. In several other villages, we were told that no one had been caught in the past five years, arguably an unlikely event unless no one bothered to patrol. Again, although the sample size is small, we found that written records are more likely to be kept if the patrollers keep all the fine revenue rather than if they share the fine revenue with the villagers or government (table 2).

Table 2. Written Records of Violations

Fine money kept by …	**Written records of violations**	
	Yes	***No***
Patrollers only	12	0
Patrollers and village	9	7
Patrollers and government	1	0
Village only	3	1
Village and government	2	0
Total instances	27	8

Source: Authors' data, 2008.

We suspected that the official data did not reflect the number of people caught undertaking illegal activities because we had anecdotal evidence that bribes were sometimes exchanged between those collecting illegally and the VECs, and that the VECs allowed certain people to collect, albeit illegally, without being punished if they were caught.

Our fieldwork observations highlighted a key problem that we and others face when undertaking this type of research: it is very difficult to get data on what is really happening. We do not know and cannot determine the effort that individual rangers put into patrolling. If we see very few arrests and fines, we cannot be sure whether no one chooses to enter the PFM forest because there are alternative resources; whether the rangers deter people from coming into the PFM forest; whether the rangers make any effort at all to check illegal activity; or whether people are caught, but pay bribes rather than formal fines. However, by recognizing that patrollers can choose whether they put effort into enforcement or whether or not they take bribes (rather than go through formal channels), we can explore the likely consequences of the different mechanisms for sharing fine revenues that have been implemented in the different PFM forests with an optimal enforcement model.

3. The Model

Our model represents the key elements of PFM enforcement strategies that we observed in practice. We considered three distinct groups within a game theoretic framework: 1) the Forest Management Committee (FMC), which sets the enforcement strategy, namely what share (if any) of the fine revenues the “volunteer” VEC patroller keeps; 2) a representative VEC patroller who, knowing the share, chooses how much effort to put into patrolling and what proportion of illegal activity she or he reports (and therefore collects a fine for), and what proportion she or he does not report (and instead takes a bribe); 3) and the villagers who, knowing the VEC’s incentive structure, choose whether to collect illegally from the PFM forest or to collect from a more distant forest instead.

As such, the game structure is a Stackelberg interaction, common in most of the optimal enforcement literature and consistent with our empirical observations. However, in contrast to much of the literature, we assumed three sets of players, rather than the typical two, the enforcement agent and the perpetrator. We assumed that if a bribe is offered it is lower than the official fine and villagers accept it. We did not introduce the additional complication that villagers and patrollers can negotiate over the size of the fine or that villagers can refuse a bribe and insist on paying the formal fine. In keeping with what we found in practice, we also assumed a fixed enforcement strategy in terms of the number and length of patrols and the size of the fine if an individual is caught.

3.1 Representative Villager’s Optimization

In our model, following Robinson et al. (2002), we have N villagers with opportunity costs of labor uniformly distributed between $w_{\min}$ and $w_{\max}$. Villagers collect a fixed quantity of NTFP of value Q, which they can collect either from the protected forest, distance D_1, or from a more distant but unprotected forest, distance D_2 ($D_2 > D_1$). Villagers take into account the distance costs of getting to the forest, the value of the NTFP collected, and the probability of being caught.[2] A representative risk-neutral villager with opportunity cost of time w_i chooses to collect from the PFM forest (and risk being caught, the NTFP confiscated, and a fine or bribe

2 Without detracting from the model, we assumed that the only costs incurred are the travel costs of getting to a particular forest. Naturally, we could include a time cost of collecting the particular resource, but this would merely add complexity to the model without changing the findings substantially.

imposed), rather than collecting from the more distant unprotected forest, if the expected returns to the former are greater than the certain returns to the latter; that is, if:

$$(1-p)Q - p(rF + (1-r)B) - w_i D_1 > Q - w_i D_2 \ , \qquad (1)$$

which implies that the villager collects from the PFM forest, if:

$$w_i > w^* \ ,$$

where:

$$w^* = \frac{p(Q + rF + (1-r)B)}{D_2 - D_1} \ . \qquad (2)$$

Villagers with opportunity costs of labor higher than w^* collect from the PFM forest. Those with lower opportunity costs of labor choose to go to the more distant forest, where they do not risk being caught. The number of villagers collecting from the PFM forest can therefore be written:

$$\begin{cases} N \text{ if } w^* < w_{\min} < w_{\max} & \text{Scenario 1} \\ N\dfrac{w_{\max} - w^*}{w_{\max} - w_{\min}} \text{ if } w_{\min} < w^* < w_{\max} & \text{Scenario 2} \\ 0 \text{ if } w_{\min} < w_{\max} < w^* & \text{Scenario 3} \end{cases} \qquad (3)$$

There are two particularly interesting scenarios. The first is when all the villagers choose to collect from the PFM forest even when there is enforcement, scenario 1, such that marginal changes in enforcement effort do not affect the number collecting. The second is when the number of villagers collecting from the PFM forest (and therefore the scope for bribe and fine collection) varies as a function of the probability of being caught, scenario 2. Naturally, any of the scenarios used is endogenous to the specific model parameters. The above equations provide the appropriate representative villager's reaction function, depending on the endogenous scenario, that we use as an input into the VEC patroller's decision.

There are many ways to model the villagers' collection of NTFPs. Moreover, how villagers react to the VEC patrols is likely to depend on the role that the NTFP that they collect plays in their livelihoods, on whether they have alternative sources of the NTFP, and on whether they can purchase the NTFP or a close substitute from a market. For example, in Tanzania, villagers typically have an almost fixed requirement for fuelwood, and most rural villagers collect their full requirement rather than relying on the market. Moreover, few households sell fuelwood to the market. In contrast, villagers who sell NTFPs, such as weaving and building materials, are more likely to make a marginal decision of how much to collect, based on their access to markets and opportunity cost of labor.

In our model, we assumed a fixed NTFP requirement that villagers collect either from the closer protected forest or a more distant unprotected forest. Although this fixed requirement may at first appear overly restrictive, it provides a mechanism through which to explore how much households reduce their collection of NTFPs from the protected area, in response to enforcement, varies. Central to our model, and true to what we observed, is that, in some circumstances, greater enforcement effort has little impact on the extent of illegal activity undertaken in the PFM forest (e.g., if villagers have very low opportunity costs of labor, low elasticities of demand, or there are no nearby alternatives). In other circumstances, however, greater enforcement effort results in a relatively large reduction in illegal activity in the PFM forest. (Villagers substitute other resources; reduce their use of the forests; switch to alternate, less-protected forests; or rely more on alternate income-generating activities if available.) Our scenarios allowed for these possibilities without requiring a large (and arguably tedious) number of different model formulations to be solved.

3.2 Representative VEC Patroller's Optimization

Given the villagers' reaction functions above, we next explored the VEC patroller's equilibrium enforcement strategy (the patroller's reaction function), which is the effort e ($0 \le e \le 1$) he puts into enforcement and the proportion of those he catches that he reports r ($0 \le r \le 1$), as a function of the official share of the fine revenue that he receives s ($0 \le s \le 1$), depending on whether the equilibrium is scenario 1 or scenario 2. We assumed that the probability that the representative villager is caught is a function of effort, $p = p(e)$ and $0 \le p(e) \le 1$, and the cost of effort $c = c(e)$. We explored scenarios 1 and 2 separately. Which scenario is used is determined by the specific model parameters.

Scenario 1: All villagers collect from the PFM forest despite the level of enforcement effort.

In this scenario, the number of people collecting illegally equals N and is not a function of the effort that the VEC patroller puts into enforcement or the share he reports. (Thus, we do not have a strategic interaction between the villagers and the patrollers in this scenario.) Such a scenario is a reasonable proxy, if we consider women who have only the PFM forest as a source of fuelwood for which the demand is highly inelastic (Palmer and Macgregor, 2009). Villagers who are caught must either pay an exogenous fine F that the VEC patroller reports or an exogenous bribe B ($0 \le B \le F$).3 It is the VEC patroller who chooses whether the villager must pay the fine or the bribe. Taking bribes carries some risk for the VEC patroller (but not the villager, who always takes a bribe if it is offered). We let there be some probability q that the VEC patroller is caught taking a bribe, where q is a function of the number of bribes the VEC patroller takes. The punishment for the VEC if caught is some fixed amount L. The VEC patroller maximizes V:

$$\max_{e,r}[V] = \max_{e,r}\left[p(e)\cdot N(r\cdot F\cdot s + (1-r)B) - c(e) - Lq(p(e)\cdot N(1-r))\right] ,$$

where:

$$0 \le q \le 1,\ 0 \le r \le 1,\ 0 \le p \le 1\ . \tag{4}$$

We get the following first order conditions (FOCs):

$$V_e = \left[p'(e)\cdot N(r\cdot F\cdot s + (1-r)B) - c'(e) - L\frac{\partial q}{\partial p}\frac{\partial p}{\partial e}\right] \tag{5}$$

$$V_r = p(e)\cdot N(F\cdot s - B) - L\frac{\partial q}{\partial r}(p(e), r)\ .$$

We assume some relatively simple functional forms, $p(e) = e^{\alpha}$, $c(e) = e^{\beta}$, and $q(e,r) = \left(e^{\alpha} N(1-r)\right)^{\gamma}$, so that we can derive analytical solutions. The optimization becomes:

$$\max_{e,r}\left[e^{\alpha}\cdot N(r\cdot F\cdot s + (1-r)B) - e^{\beta} - L\left(e^{\alpha} N(1-r)\right)^{\gamma}\right],$$

and the respective FOCs are:

$$\frac{\partial}{\partial r} = e^{\alpha}\cdot N(F\cdot s - B) + e^{\alpha\gamma}\gamma L N^{\gamma}(1-r)^{\gamma-1} \tag{6}$$

3 We treated the bribe as an exogenous variable that we could vary parametrically to explore the role of the VEC patroller's bargaining power in his equilibrium level of effort and the consequent pattern of enforcement and revenue collection. Although we assumed that the bribe is not greater than the official fine, if there are non-monetary costs associated with being fined formally, such as loss of reputation within the villager, then villagers might be willing to pay a bribe greater than the official fine to avoid having their illegal activity made public.

$$\frac{\partial}{\partial e} = \alpha e^{\alpha-1} \cdot N\left(r \cdot F \cdot s + (1-r)B\right) - \beta e^{\beta-1} - \alpha\gamma L N^{\gamma} e^{\alpha\gamma-1}(1-r)^{\gamma} \ .$$

If we have an interior solution:

$$e^{\alpha} \cdot N(F \cdot s - B) = -e^{\alpha\gamma} \gamma L N^{\gamma} (1-r)^{\gamma-1} \quad (7)$$

$$\alpha e^{\alpha-1} \cdot N\left(r \cdot F \cdot s + (1-r)B\right) = \beta e^{\beta-1} + \alpha\gamma L N^{\gamma} e^{\alpha\gamma-1}(1-r)^{\gamma} \ .$$

From the first FOC, we can see immediately that if $F \cdot s > B$ it is always better to fine the villager and take the official share of the fine revenue rather than take a bribe. That is, if $s > B/F$, then r^* = 1, in which case, we get the standard result $p'(e) = \frac{c'(e)}{N(F \cdot s)}$, and naturally, the greater the share the patroller receives, the greater is his effort.

For small $s \leq \bar{s}$, the VEC patroller may not find it optimal to report any illegal activity; that is, r = 0, and naturally, over this range of shares, the effort that the VEC patroller expends is constant and the optimization becomes:

$$\max_{e} \left[e^{\alpha} \cdot NB - e^{\beta} - L\left(e^{\alpha} N\right)^{\gamma} \right]. \quad (8)$$

The FOC is simply $\alpha e^{\alpha-1} \cdot NB - \beta e^{\beta-1} = \alpha\gamma L N^{\gamma} e^{\alpha\gamma-1}$, from which the optimal effort can be determined. Between these two extremes, for intermediate shares, the VEC patroller fines and reports a proportion of those he catches and takes a bribe from the remainder. In this scenario 1, villagers do not change the forest where they collect NTFPs; rather, they continue to collect illegally from the protected forest even after enforcement is introduced. However, the VEC patrollers do change the effort they put into enforcement, depending on the share of fine revenue that they are formally allocated.

Scenario 2: Some villagers switch forests.

Next we consider scenario 2, where a proportion of the villagers switch from the PFM forest to the unprotected forest in response to changes in the probability of being caught by the VEC patrollers. In this case, the number of villagers collecting from the PFM forest is not constant, but is a function of the share of illegal activity that they report, as shown in equation (3). Whether we are in scenario 1 or scenario 2 depends on the range of villager opportunity costs of labor and other model parameters and thus is endogenously determined when the model is solved. In scenario 2, the number of villagers collecting from the PFM forest is equal to:

$$N\frac{w_{\max}-w^{*}}{w_{\max}-w_{\min}} = N\frac{w_{\max}-\dfrac{p\left(Q+rF+(1-r)B\right)}{D_1-D_2}}{w_{\max}-w_{\min}} . \tag{9}$$

So, the VEC now optimizes the following:

$$\max_{e,r}[V]=\max_{e,r}\left[\begin{array}{l} e^{\alpha}\cdot\dfrac{w_{\max}(D_1-D_2)-e^{\alpha}\left(Q+rF+(1-r)B\right)}{(w_{\max}-w_{\min})(D_1-D_2)}\left(r\cdot F\cdot s+(1-r)B\right) \\ -e^{\beta}-L\left(e^{\alpha}\dfrac{w_{\max}(D_1-D_2)-e^{\alpha}\left(Q+rF+(1-r)B\right)}{(w_{\max}-w_{\min})(D_1-D_2)}(1-r)\right)^{\gamma} \end{array}\right].$$

For clarity, we let:

$$H=(w_{\max}-w_{\min})(D_2-D_1) \text{ and } K=w_{\max}(D_2-D_1) ,$$

in which case, we can rewrite the optimization as:

$$\max_{e,r}[V]=\max_{e,r}\left[\begin{array}{l} \dfrac{e^{\alpha}}{H}\cdot\left(K-e^{\alpha}\left(Q+rF+(1-r)B\right)\right)\left(r\cdot F\cdot s+(1-r)B\right) \\ -e^{\beta}-L\left(\dfrac{e^{\alpha}}{H}\left(K-e^{\alpha}\left(Q+rF+(1-r)B\right)\right)(1-r)\right)^{\gamma} \end{array}\right].(10)$$

3.3 Forest Management Committee's Optimization

The forest management committee decides what share of fine revenues goes to the VEC patrollers and what share goes to the villagers. It is not obvious what, in practice, the forest management committee's objective function is or should be. Moreover, the social optimum is unlikely to be relevant under these circumstances. The objective could variously be to minimize the level of illegal activity, to maximize fine revenues, or to maximize villagers' well-being. However, if the VEC patrollers also determine the forest management rules, it might be to maximize their own revenues from patrolling, in which case, there are to all intents just two sets of players, the VEC and the villagers. Therefore, rather than choosing one specific revenue-sharing policy, we show in the next section the variety of sharing arrangements that we found in practice. These sharing arrangements are also shown with a series of comparative statics exercises demonstrating the impact of the forest management committee's choice of revenue share on the effort made by the VEC patrollers (and therefore the extent of deterrence), the revenue collected by the VEC patrollers, the revenue collected by the village, and the extent of illegal activity (both illegal collection of NTFPs and bribes taken).[4] We could also consider a "monitoring function" in which the forest management committee can choose how much to spend on monitoring to deter the likelihood that a bribe is offered.

4. Results

In this section, we explicitly illustrate the tradeoffs facing forest departments that must set enforcement policy with little if any access to external funds. We explored a number of situations that characterized what we found in Tanzania and are common elsewhere. Scenario 1 corresponds to villages where there is only one forest, which is a protected area, so villagers have no alternative but to collect from this forest—other than not collecting at all. Scenario 2 corresponds to villages where there is at least one forest that is a protected area and an alternate forest that is unprotected.

4.1 Scenario 1: No Alternate Forest

In scenario 1, the villagers continue to collect the same amount of NTFP, whatever the level of enforcement. Although extreme, this scenario is relevant where villagers have a resource requirement and the protected forest is the only source of that product—fuelwood is one example. In the long run, we recognize that villagers might start planting their own trees, but this is a long-term response and could be proxied by scenario 2.

Illustrating the model, figure 1 makes clear the tradeoffs that the community faces when choosing the share of fine revenues that goes to the VEC patrollers. For a small share, the patroller does not report any illegal activity and only collects bribes. As a consequence, the village gets no revenue and there are no records of anyone caught for illegal activity in the PFM forest. Above a threshold share, the VEC patroller reports a proportion of people caught for illegal activities and so receives both bribe and fine revenues. As the formal share of the fine revenues that he receives increases, so does his effort increase and also the proportion of offenders reported. When the patroller receives all the fine money, he puts maximum effort into enforcement and consequently receives maximum income. This also has the greatest deterrence effect. But, again, the village receives no income. The optimal share, therefore, varies, depending on whether the forest manager wants to maximize enforcement effort (in which case, the

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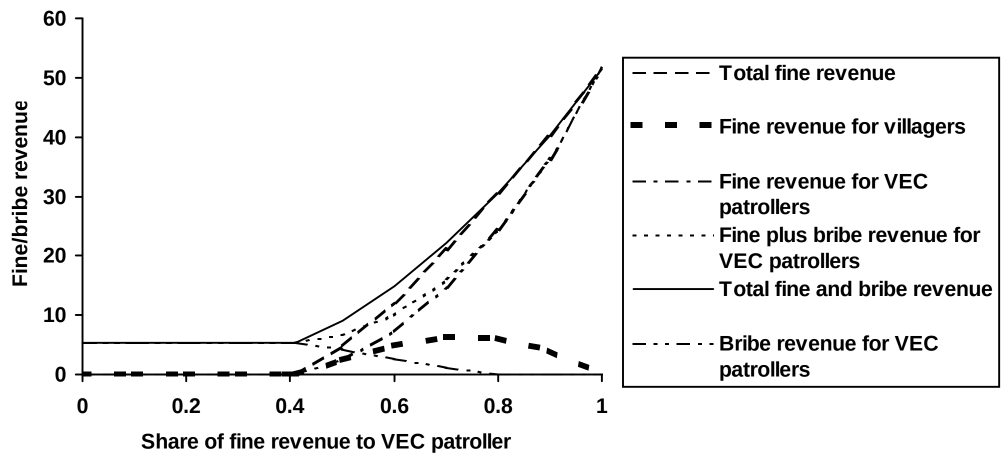
[4] In practice, the sharing arrangement tends to be 50/50. In our model, we varied the share continuously from zero to one to explore the range of possible sharing agreements.

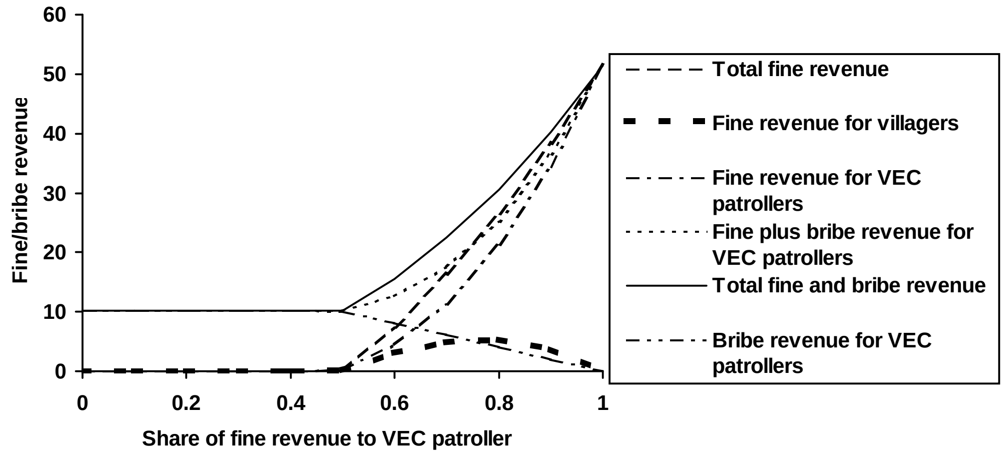
manager simply lets the patrollers keep all the fine revenues) or maximize fine revenue for the village.

Figure 1. Villagers Do Not Adjust Their Extraction in Response to Changes in Patroller Effort: Fine F = 9 and Bribe $B = F/1.3$



The revenues collected by the VEC patroller and the village vary, depending on the "bribe effectiveness," that is, the size of the bribe relative to the official fine (B/F). In figure 2, we assumed that the VEC patroller is able to collect a bribe as large as the fine (B/F = 1). In this example, the patroller now does not report any illegal activity until he is offered a share just greater than one half of the fine revenue. And, to maximize village revenue, the forest management committee must offer a share just greater than 0.8. However, even with a high share, the VEC patroller still chooses to report some of the illegal activity because if he is caught taking a bribe he will be punished.

Figure 2. Villagers Do Not Adjust Their Extraction in Response to Changes In Patroller Effort: Fine F = 9 And Bribe B = F



Conversely, with an ineffective bribe, the VEC patroller needs only to be offered a small share before he starts reporting the illegal activity, as confirmed in figure 3. At lower shares, the VEC patroller puts almost no effort into enforcement. It is not worth his while to put effort into enforcement and collect bribes because the level of the bribe is low and there is some chance of being caught and fined; it is also not worth his while to put in effort and take a share of the formal fine because his share is so low.

Figure 3. Villagers Do Not Adjust Their Extraction in Response to Changes in Patroller Effort: Fine F = 9 and Bribe B Is Highly Ineffective, Equal To = $F/4$

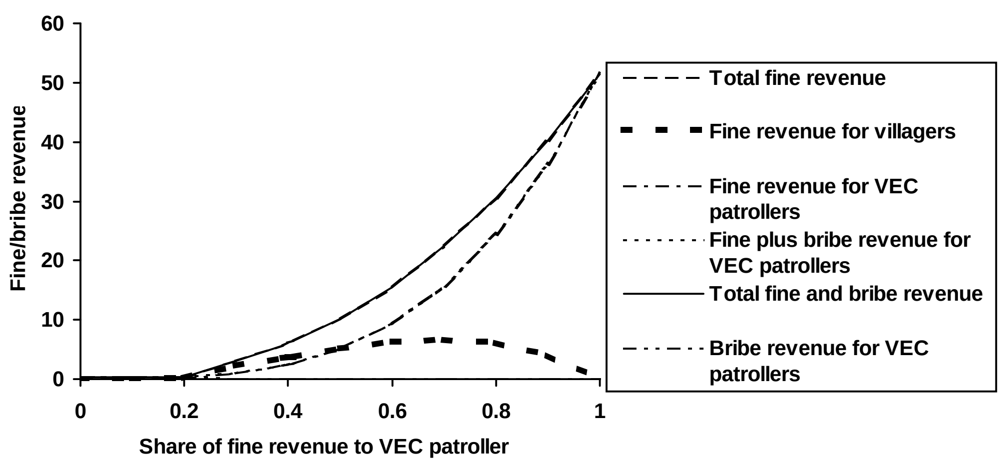
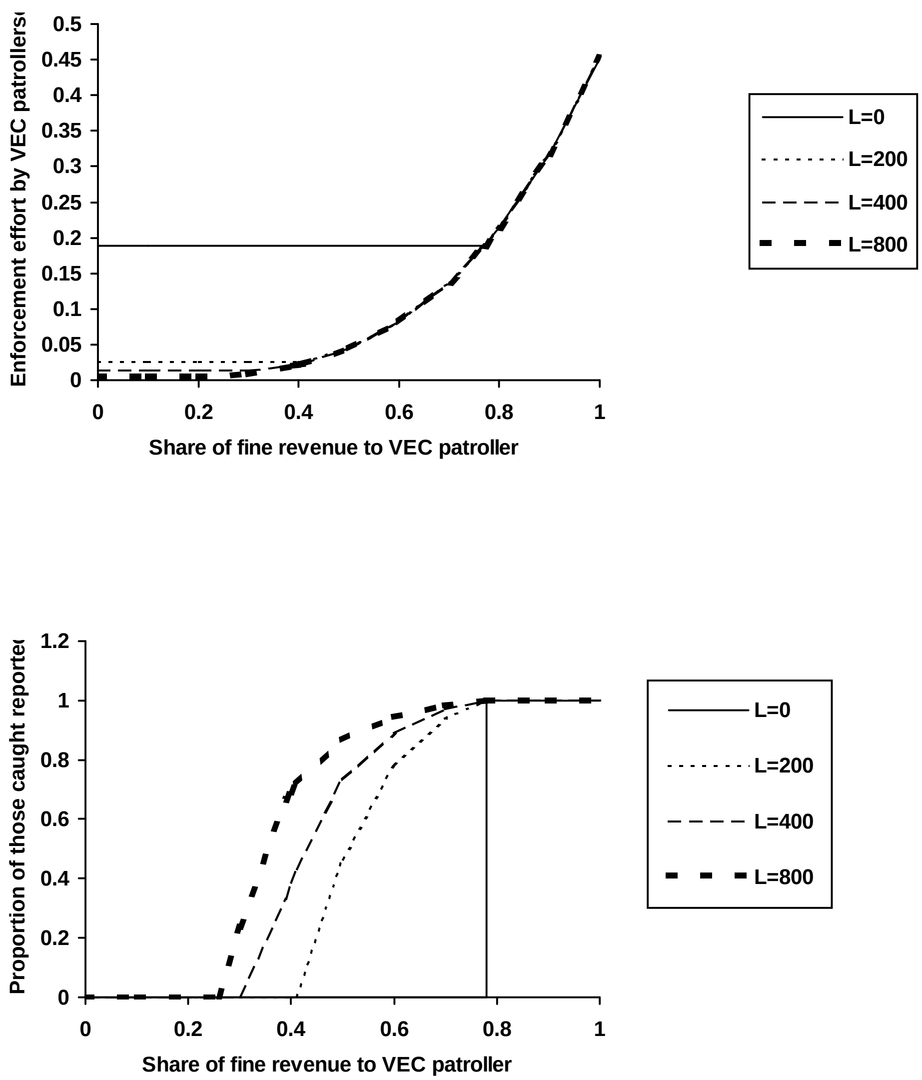


Figure 4 summarizes a comparative statics exercise in which the fine the VEC patroller faces if he is caught accepting bribes varies from zero to 800. As one would expect, when the cost to the VEC patroller of being caught accepting bribes is higher, he puts less effort into enforcement when he receives a smaller share of the fine revenues. When accepting bribes is more risky, the VEC patroller starts to report illegal activities with lower shares.

Figure 4. Effort and Proportion of Illegal Activity Reported as a Function of the Punishment for Being Caught Accepting Bribes for Various Values of *L*



4.2 Scenario 2: Alternative Forests Are Available for NTFP Collection

When the number of villagers collecting from the PFM forests changes in response to the enforcement effort of the VEC patrollers, the effort expended by the VEC patrollers falls, but the need for enforcement also falls because villagers naturally switch to alternative sources of the resource. Recall from equation (2), that:

$$w^* = \frac{p\left(Q + rF + (1-r)B\right)}{D_2 - D_1} ,$$

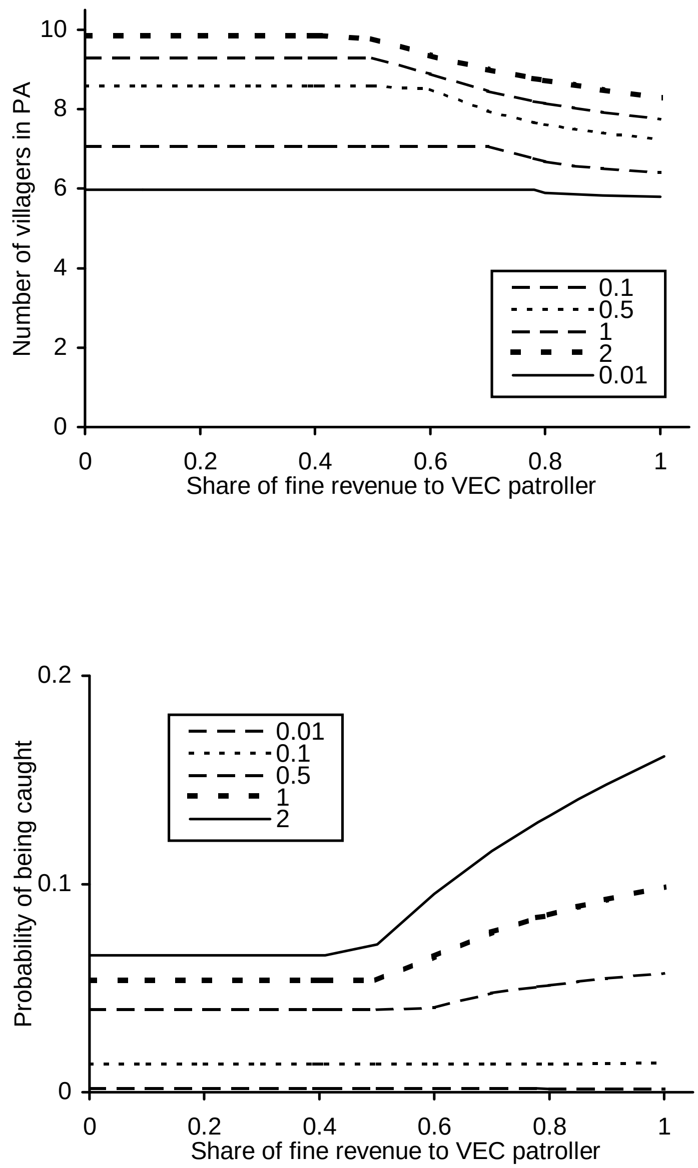
where p is driven by the VEC patroller's optimization.

A larger w^* implies that a smaller number of villagers will collect from the protected (PFM) forest and a larger number of villagers will collect from the more distant unprotected forest, from equation (3). Equation (2) confirms that fewer villagers collect from the PFM forest if the probability of being caught is greater, if the effectiveness of the bribe is greater, and if the unprotected forest is closer. This is not surprising. However, the impact of villagers being able to switch forests, per the VEC strategy and the tradeoffs faced by the forest management committee, is less clear simply from looking at the equations. A key parameter is the distance from the village and the protected and unprotected forests, so we focused on this. Although we considered two forests and their distance, this distance could also be a proxy for the ease of accessing alternative sources of NTFPs. The greater distance is equivalent to more costly access, such as more distant markets, or a greater opportunity cost of a villager planting trees on her own land.

First, we illustrate in figure 5 how the distance to the two forests affects the number of villagers who collect from the protected forest and the probability that they are caught, again, as a function of the formal share of fine revenue that the VEC patroller receives. The choice is variable for the forest management committee.

Figure 5 confirms that, as one would expect, the greater the distance to the two forests, the greater the number of villagers who continue to collect from the protected forest, whatever the formal share the VEC patroller receives. However, the share at which villagers start switching to the unprotected forest is lower, the greater the distance. What we also see is that, even if the unprotected forest is only marginally further from the village than the protected forest ($D_2 - D_1 = 0.01$), it is difficult to eliminate villagers from the protected forest, whatever incentives are offered to the VEC patrollers in terms of the share of fine revenues. Greater

Figure 5. How Distance between the Two Forests Affects Enforcement



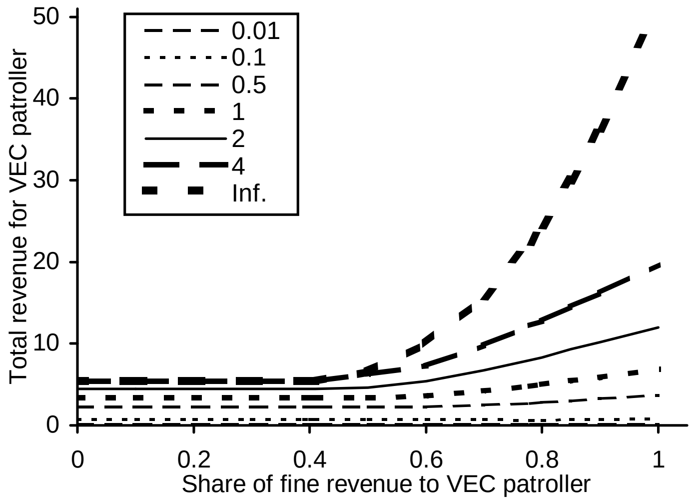
enforcement effort by the VEC patroller simply induces more switching by villagers from the protected to the unprotected forest because switching imposes only a very small time cost on the villagers. The benefits to the VEC patroller of the increased probability of catching villagers are almost completely offset by the smaller number of villagers in the protected area. So, although a nearby unprotected forest relieves pressure on the protected forest for this calibration—even if the unprotected forest is just one percent further than the protected forest—more than 50 percent of villagers will continue to collect in the protected forest and the probability of being caught is negligible.[5]

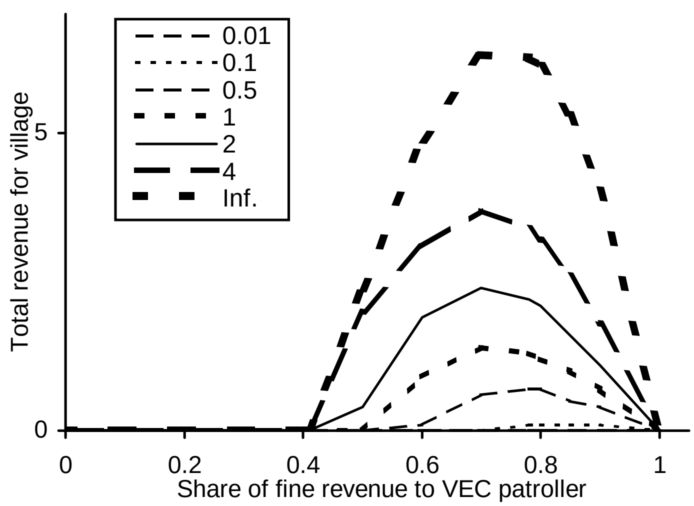
We can see, then, that even with nearby alternative forests from which to collect, without external funds for enforcement, it is very difficult to significantly reduce the number of villagers collecting from the protected forest. This finding suggests that even the provision of seedlings for villagers to plant on their own land—which can be a proxy for reducing the distance cost—might not have the anticipated impact in terms of reducing pressure on the protected forest and reaffirms the need for external funding to protect forests.

Finally, in figure 6, we compared the revenue that the VEC patroller and the forest management committee or villagers get, depending on the distance to the unprotected forest. Figure 6 shows clearly that the loss of revenue potential is particularly high when the VEC patroller gets a large formal share of fine revenue. It is at these higher revenues—when the patrollers would put considerable extra effort into enforcement if no villagers moved to an alternate forest—that we see the largest difference in revenue for the VEC patroller as a function of distance to the unprotected forest. This is because villagers find it more worthwhile to switch forests rather than risk being caught. Similarly, the potential for the village to raise revenues through the collection of fines is also reduced when there is an alternate forest to which villagers switch their collection, but the impact is not as large as for the VEC patrollers.

5 If the distance is sufficiently small, all villagers will switch to the unprotected forest.

Figure 6. Revenues as a Function of Distance to the Unprotected Forest





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5. Policy Implications and Discussion

This model and its findings are similar to other models that incorporate elements of moral hazard, such as sharecropping. Without the ability to monitor effort, the forest management committee must face tradeoffs between providing the patrollers with incentives and its own revenue generation. The choices that a forest management committee makes, concerning the share of fine revenues that the VEC patrollers keep and the effort that the committee expends on monitoring, strongly influence the effort that the VEC patrollers put into enforcement and, therefore, the success of the PFM venture in terms of protecting the specific forest. These choices also influence the scope of funding enforcement and monitoring effort through fine revenues because the formal share of fine revenue influences the extent to which the VEC patrollers report (if at all) the fines that they collect. In a more involved model, we could assume that the funds available for monitoring the VEC patrollers are also endogenous to the model—for example, fine revenues could fund monitoring efforts. Such a set up could simply reduce the incentives further for VEC patrollers not to report any illegal activities, thereby reducing the monitoring funds available.

If the key concern is to protect the PFM forest as best as possible, then one solution—when there is no external funding—is to let the VEC patrollers keep all the fine revenues, implying de facto privatization of enforcement (Polinsky 1980). However, issues of forest management in poor countries are more complicated because of the traditional reliance of local communities on forest resources. Potential problems from taking such a privatization approach include a lack of transparency (we found that some villages did not bother to keep records of illegal activity), elite capture, and favoritism by the VEC toward particular groups in the village. Moreover, the village does not get any direct benefits in terms of fine revenues from forest protection because all the fine revenue goes to a small group of villagers who have a de facto monopoly on enforcement. If the forest manager requires income for additional conservation efforts, such as maintaining forest boundaries, the fine revenue that the forest management committee and village receive becomes important. The forest management committee might want to maximize fine revenues; in which case, they must balance between providing incentives for patrollers to collect fines rather than bribes and put effort into patrolling. Fine revenue that is collected could also be used to compensate villagers for lost access to forest resources and so, again, it is more than simply a transfer.

Not surprisingly, our model predicts very different outcomes in terms of the numbers of villagers deterred from undertaking illegal activities, the number caught and fined, and therefore the total level of forest degradation, depending on the incentives provided to the VEC patrollers in terms of the share of fine revenue that they receive. The predictions of our model are in keeping with the varied reports from the villages regarding the number of people recorded as being caught in illegal activity in the PFM forest.

The options open to the forest management committee, both to improve forest protection and reduce corruption, are relatively limited. Increasing formal fines potentially can bring in more revenue, but the higher the official fine the greater the bribe can be. Increasing efforts to monitor the VEC patrollers (proxied in this paper by the parameter L), can increase the level of reporting, but will also reduce the effort VEC patrollers put into enforcement and, therefore, the scope for revenue generation. Increased monitoring also requires funding that is not available at present. Legalizing the collection of some resources that have the least negative impact on the ecosystem services provided by the PFM forest and selling permits to collect these resources is one approach to increase funding for enforcement that is independent of the number of people caught collecting illegally. It can also reduce conflict between villagers and those involved in enforcement activities because villagers will continue to have access to the forest resources, albeit at a price (Robinson 2008).

Because villagers have traditionally relied on forest resources often found in the PFM forests—and these resources contribute to a considerable part of their livelihoods in terms of nutrition, medicine, fuel, and income—preventing access to the PFM forests can easily lead to conflict. However, ultimately, the less that a community has to rely on adversarial enforcement efforts to protect its forests, the less that corruption and elite capture will occur or preferential treatment will be given to particular groups within a forest-dependent community. In the long term, therefore, rewards—such as buffer zones from which collection by local households is permitted and better efforts to encourage tree planting on farms and community land—combined with penalties (funded patrols that protect primarily against “outsiders,” for example) is most likely the better way forward.

References

Becker, G.S. 1968. "Crime and Punishment: An Economic Approach," *Journal of Political Economy* 76: 169–217.

Burlando, A., and A. Motta. 2007. "Self Reporting Reduces Corruption in Law Enforcement." "Marco Fanno" Working Papers 0063. Padua, Italy: Università degli Studi de Padova, Dipartimento di Scienze Economiche "Marco Fanno" [University of Padua, Marco Fanno Department of Economics and Management].

Klerman, D.M., and N.M. Garoupa. 2002. "Optimal Law Enforcement with a Rent-Seeking Government," *American Law and Economics Review* 4(1): 116–40.

Macho-Stadler, I., and D. Pérez-Castrillo. 2006. "Optimal Enforcement Policy and Firms' Emissions and Compliance with Environmental Taxes," *Journal of Environmental Economics and Management* 51(1): 110–31.

Mookherjee, D., and J.P.L. Png. 1995. "Corruptible Law Enforcers: How Should They Be Compensated?" *The Economic Journal* 105: 145–59.

Palmer, C., and J. Macgregor. 2009. "Fuelwood Scarcity, Energy Substitution, and Rural Livelihoods in Namibia," *Environment and Development Economics,* online journal and research articles, doi:10.1017/S1355770X08005007

Polinsky, A.M. 1980. "Private versus Public Enforcement of Fines," *Journal of Legal Studies* 9: 105–127.

Robinson, E.J.Z. 2008. "Wanted Dead and Alive: Are Hunting and Protection of Endangered Species Compatible?" *Environment and Development Economics* 13:607–620.

Robinson, E.J.Z., Jeffrey C. Williams, and Heidi J. Albers. 2002. "The Influence of Markets and Policy on Spatial Patterns of Non-timber Forest Product Extraction," *Land Economics* 78(2): 260–71.