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Exploiting Common Resources with Capital-Intensive Technologies: The Role of External Forces

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Abstract

This paper focuses on the interactions between local communities having at least some degree of informal claims over natural resources and external agents, particularly firms interested in commercial resource exploitation. The paper makes three contributions to the existing literature. First, unlike the literature on devolution and communal resource management, rather than concentrating on intra-community decisions, we extend the analysis to examine interactions between the community and outside agents. Second, unlike both the literature on conflict and bargaining, we integrate these two strands of the literature, so that we can endogenously derive the conditions under which community-firm interactions result in conflict or, alternatively, in bargaining agreements. Third, to the best of our knowledge, this is the first study that formally models the endogenous participation by third parties that may attempt to support communities in the process. We show that, in a context of weak property rights, improvements in the community's bargaining power *vis-á-vis* the firm are likely to increase resource extraction and thereby harm the environment. Moreover, an increase in the wage rate may increase or decrease resource extraction depending on initial conditions.

Kurzfassung

Der Artikel analysiert die Wechselbeziehungen zwischen lokalen Dorfgemeinschaften, die zumindest informelle Ansprüche auf natürliche Ressourcen haben, und externen Agenten—insbesondere Firmen, die an einer kommerziellen Nutzung der Ressourcen interessiert sind. Dabei werden drei Beiträge zur bestehenden Literatur geleistet. Erstens wird durch die Betrachtung von Wechselbeziehungen zwischen Dorfgemeinschaften und externen Agenten die Literatur zu Devolution und kommunalem Ressourcenmanagement erweitert, welche sich größtenteils auf innergemeinschaftliche Entscheidungen konzentriert hat. Zweitens werden die Ansätze bestehender Konflikt- und Verhandlungsmodelle integriert, um die Bedingungen abzuleiten, unter denen Verhandlungen zwischen Dorfgemeinschaften und Firmen im Konflikt bzw. in Vertragsabkommen resultieren. Drittens ist dies, nach unserem bestem Wissen, die erste Studie, die formell die endogene Teilnahme dritter Parteien—die die Gemeinden im Verhandlungsprozess zu unterstützen suchen—modelliert. Wir zeigen, dass Verbesserungen in der Verhandlungsstärke der Gemeinden gegenüber den Firmen bei schwachen Besitzrechten zu einer Zunahme der Ressourcenextraktion führen und damit der Umwelt schaden können. Außerdem kann die Zunahme des Lohnsatzes, in Abhängigkeit von den Anfangsbedingungen, entweder zu einer Zu- oder zu einer Abnahme der Ressourcenextraktion führen.

1 Introduction

Most natural resources of great economic significance—e.g., oil, natural gas, hydraulic resources for electricity generation, mines, and dense forests—require capital-intensive technologies for their commercial exploitation (Bohn and Deacon, 2000).[1] In many countries an important portion of these resources "belongs" to local communities, although property rights are often diffuse and not necessarily fully enforced by the government. Frequently, these communities are poor, geographically isolated, and lack formal title to the resources. As a consequence, they have difficulties in meeting the collateral requirements to borrow the considerable funds needed to acquire the technology and capital necessary to commercially exploit the resources by themselves (Bose, 1998). Thus, communities have to rely on specialized firms for resource exploitation.

This paper focuses on the interactions between local communities having at least some degree of informal claims over natural resources and firms interested in commercially exploiting such resources, explicitly allowing for third-party interventions (e.g., NGOs, international donors and others, that are often interested in the welfare of communities and in the environmental consequences of resource extraction). These interactions involve outright conflict over property rights and/or bargaining over the distribution of the benefits of resource exploitation and over the intensity of resource extraction. For reasons to be explained below, the intensity of resource extraction affects not only the size of the "cake" but also its very distribution between the bargaining parties; distribution and efficiency are not separable.

Over the last decade, more than 60 countries worldwide have decentralized at least some aspects of natural resource management (Ribot, 2002; Kaimowitz, 2002a). Decentralization in many cases has led to some degree of control over natural resources by local communities, a process frequently referred to as "devolution". For example, countries such as Indonesia, South Africa and Mexico, among many others, now require that firms interested in exploiting natural resources get involved in some form of negotiation with local communities.[2] Other countries including Canada, Australia and the United States, have recognized partial rights of indigenous groups to participate in the management of forests, fisheries, and mines. These processes introduce the possibility for communities to bargain with other agents interested in exploiting the

[1] It is possible to exploit some of these resources via more traditional labor-intensive methods as well, albeit at a much reduced scale.

[2] See Palmer (2003) and Barr et al. (2001) for a description of decentralization in Indonesia, Bray et al. (2003) for a discussion about Mexico, and Mayers and Vermeulen (2002) for a review of the situation in other countries. Ribot (2002), the World Development Report 2000/2001 and 2003, and the World Bank's Decentralization website at http://www1.worldbank.org/publicsector/decentralization/index.htm provide a general overview of decentralization in many other countries.

resources (referred to hereafter as "the firm"), but do not necessarily preempt other forms of interactions, including conflicts over *de facto* property rights.[3]

Three features characterize the devolution process in most countries. First, the transfer of authority to local communities is often incomplete; legal rights are diffused and little public enforcement of rights is provided (Ribot 2002; Palmer, 2003; Feder and Feeny, 1991). Second, as mentioned earlier, there is external participation by NGOs, international donor agencies and others affecting the community-firm relationships in at least an indirect way.[4] Third, in most countries firms cannot purchase land or other communal resources either because communities do not have formal legal title or because government regulations explicitly impede it (Kaimowitz, 2002b). Firms thus have to rely on bargaining with communities, or alternatively, on exploiting the resource unilaterally using force and other illicit means, but generally without being able to obtain formal property rights.

Despite the incompleteness of the transfer of authority to communities and shortcomings in their implementation, decentralization and devolution were expected by many to greatly reduce environmental degradation and to significantly improve management of natural resources. This expectation was based on the perception that these processes may contribute to reduce externalities and to ameliorate property right imperfections. There is, however, increasing empirical evidence indicating that decentralization and increased community rights over natural resources have not always reduced the pace of resource degradation and, in some cases, have even accelerated it.[5] The model presented below provides a consistent explanation for this

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[3] Barr et al. (2001) and Palmer (2003) describe conflicts over rights to logging and of both successful and unsuccessful negotiations between communities and logging firms in Indonesia. In Chile a protracted conflict and later a successful negotiation occurred between a hydroelectric firm and indigenous communities, who in the end obtained significant compensation for allowing construction of a dam on their land (*La Tercera*, 10/15/03). In Ecuador, Occidental Petroleum agreed to significant compensation of the Sehuaya community for the right to establish a test well on community land. (http://forests.org/archive/samerica/secoocid.htm). In 1996, indigenous farmers in the Chontal region in Mexico blocked the passage to oil wells to stop petroleum exploitation on their lands unless firms were willing to compensate them (http://flag.blackened.net/revolt/mexico/reports/taboil.html). Native American communities in the United States have renegotiated coal leases and made oil and gas agreements http://encarta.msn.com/encyclopedia_761570777_30/Native_Americans_of_North_America.html). In Colombia, the U'wa indigenous people have been involved in protracted conflicts and negotiations with Occidental Petroleum. In Bolivia, the predominantly Aymara Indian city of El Alto successfully organized protests against natural gas exploitation, an initiative that spread to other areas and eventually led to the fall of the government (*The Nation*, 10/22/2003). In British Columbia, Canada, conflicts over fishing, logging, and mining resources are frequent (e.g., http://www.fonv.ca/newsletters/01_feb8_meeting.html).

[4] Another important third party is the state. Governments intervene by setting the institutional framework. In particular, the processes of decentralization and devolution themselves are the product of governments' active participation. Also, governments are responsible for not clearly delimiting property rights and especially for failing to enforce communal rights (Larson and Ribot, 2004). These diffuse property rights conditions and lack of public enforcement are explicitly considered in the ensuing model.

[5] For example, Larson and Ribot (2004), summarizing a variety of studies on decentralization in the natural resource sector, conclude that decentralization has had mixed impacts on the environment. In Indonesia, decentralization has led to increased logging with little regard to environmental consequences (Resosudarmo, 2004; Casson and Obidzinski, 2002). See Walker (2000) and Lewis (1995) for descriptions of dramatic cases of environmental destruction in large part attributed to devolution and decentralization in South Africa and the USA, respectively. See also footnote 3 for further examples and http://www.gasandoil.com/goc/company/cns82642.htm for an example of petroleum exploitation in Australia.

important stylized fact by showing that devolution, in combination with certain generally accepted interventions, may lead to outcomes often inconsistent with expectations.

This paper makes three contributions to the existing literature: First, unlike conventional analyses of the management of communal resources, which focus on *internal within-community* governance issues (e.g., Bardhan, 1993a and 1993b, Ostrom, 1990)[6], we concentrate on how *external forces* affect the patterns of exploitation of natural resources. This is a vital issue in the context of capital-intensive resource exploitation, which has been mostly ignored by the literature.

Second, we integrate conflict and bargaining theory. Conflict analysis (e.g., Alston, Libecap and Mueller (1999a, b), Angelsen (2001), Burton (2004), Hotte (2001)) emphasizes conflicts over property rights. This literature focuses exclusively on the conflict without allowing for the possibility that actual or potential conflict may lead to negotiation or bargaining, and that potential bargaining outcomes may affect conflict resolution. Bargaining models, on the other hand, do not explicitly consider the role of latent conflict in bargaining outcomes (Muthoo, 1999). We integrate conflict and bargaining theories, in a way in which the feasibility and outcomes of a potential bargaining game depend on the unraveling of a (virtual) conflict stage and vice versa.

Third, to the best of our knowledge, this is the first study that formally models the endogenous participation by third parties in the bargaining process. An important implication of this is that we need to solve a model where reservation utilities are endogenous. More specifically, we develop a bargaining model with endogenous inside options defined as the parties' payoffs while in the process of bargaining (Bulow and Rogof, 1989) and outside options defined as the parties' payoffs available when the bargaining fails (Binmore, 1985). The most important implication of this is that distribution and efficiency cease to be separable as is implicit in the standard bargaining model that typically focuses exclusively on distribution.

We show that intervening in the bargaining process may have unexpected and counterproductive effects. In particular, if third parties increase their support to communities where the environmental threat is large, the outcome of the bargaining process may be one implying a more intense resource exploitation and greater environmental damage than would be the case without intervention. The community and the firm may have incentives to increase resource extraction so that third parties will be enticed to enlarge the size of the "cake" available to be distributed.

We analyze the effects of three other general types of intervention: (i) interventions affecting *de facto* property rights, (ii) interventions affecting market power or discount rates, and (iii) changes in the opportunity cost of labor. We show that explicitly modeling the linkages

[6] For a review of this literature see Baland and Platteau (1996) and Agrawal (2001).

between conflict and bargaining outcomes leads to non-trivial changes in the comparative static analysis. Specifically, improvements in the community's bargaining power *vis-à-vis* those of the firm are likely to increase resource extraction and thereby to increase pressure on the environment. Moreover, an increase in the wage rate may have continuous or discontinuous effects on the environment, depending on initial conditions[7]. We show that the continuous effect generally corresponds to the standard comparative static intuition (i.e., an increase in the wage rate reduces environmental degradation). The discontinuous effect, however, can be paradoxical.

The remainder of the paper is structured as follows. Part 2 presents the model. Part 3 examines the effect of alternative strategies of intervention by third-party actors on the environment. Part 4 concludes.

[7] We denote the effect of a change of an exogenous variable as "discontinuous" when it is powerful enough to switch the nature of the game from conflict to bargaining or vice-versa. By contrast, a "continuous" effect occurs when the nature of the game is not altered by the exogenous change. That is, the effect before and after the change the firm-community relationship continues to be bargaining or conflict.

2 Modeling Community-Firm Interactions

In what follows we use the terms ‘forest’ and ‘logging’ as metaphors but we remind the reader that the problem is really more general; the problem can be equally expressed in terms of “resource”, and “resource extraction”. Similarly, the term “community” stands for any entity that has at least potential property rights over a natural resource, but that cannot exploit it directly as a consequence of, for example, lack of access to capital and technical expertise. The term “firm” is used to denote any entity that does not have automatic access to the resource, but has access to the capital and the know-how necessary to exploit it.

2.1 Conflict

One common way to model conflict is as an attrition war (see, for example, Dixit and Nalebuff, 1991; Bulow and Klemperer, 1999)[8]. Most attrition models assume that competing agents follow a strategy to gain property rights (or win other types of conflicts). In our case, the strategy for the firm involves unilateral logging attempts (without sharing the benefits with the community), while for the community it consists of setting up blockades to prevent this from happening and thus be able to exert *de facto* property rights. The attrition element is related to the assumption that the agent that is potentially able to persist the longest wins the war. Attrition wars do not need to be actual wars, but rather they are often virtual. In the absence of information asymmetries, which we assume here, the agent that would lose the war simply withdraws.

We assume that logging requires a specific factor, capital, that is available to the firm, but not to the community, forest area, and variable inputs. Let the firm’s profits from logging be defined as $v(w;L,K)$, where K is the exploitation capital, L is the area logged, and w is a vector of wages, other variable input prices, and output price. For simplicity of exposition we will omit arguments other than L from v, except when needed for comparative static purposes. The assumption that logging requires a specific factor that is available only to the firm implies that the firm has the ability to exploit the resource unilaterally while the community may under some conditions be able to prevent such exploitation. We now summarize the assumptions used in the ensuing model of conflict.

[8] Perfect information war of attrition models were first introduced by Maynard Smith (1974, 1982) and further developed by Bishop and Cannings (1978) and Bulow and Klemperer (1999). Economic applications include Ghemawat and Nalebuff (1985), Fudenberg and Tirole (1986), Alesina and Drazen (1991), Roth (1996), Bilodeau and Slivinski (1996), and Burton (2004).

Assumption set A:

(A1) The community and the firm know each other's parameters.

(A2) v(w;L,K) is monotonic, homogeneous of degree one, increasing and concave in L and K, and convex in w.

(A3) The firm's discount rate (r_F) and the community's discount rate (r_C) are fixed and strictly positive.

(A4) There are fixed per-period costs of staying in conflict to communities, s (the "blockading" costs), and to firms, c (the cost of unilateral logging attempts).

(A5) The present value of the standing forest considered by the community is $h_0 B(\overline{L}-L) = h_0 \int_0^{\infty} b(\overline{L}-L)e^{-r_C t}\,dt$ *, where b is the per-period service provided by the standing forest,* $\overline{L}$ *is the total forest area prior to exploitation and* h_0 *is the average value (or price) per unit of the environmental service as considered by the community. The function b is increasing and strictly concave in the level of standing forest. Furthermore,* $\overline{b} \equiv b(\overline{L})$ *and* $0 < h_0 < \overline{h}$ *, where* $\overline{h}$ *is the true unit value of environmental services provided by the standing forest.*

With respect to (A5), it is important to realize that the standing forest has values that the community does not necessarily internalize, including regional and global services (e.g. water retention, flood prevention, erosion control, etc., at the regional level, and carbon retention and biodiversity preservation, at the global level). Depending on the community's level of awareness, it may also not even consider all the local environmental values.

For reasons to be seen below, at this point it is also convenient to advance the following definition pertaining to the outcome of the bargaining game:

(A6) Π^C *and* Π^F *are the community's and firm's total payoffs, respectively, under a successful bargaining agreement.*

We now consider the boundary conditions that determine who can win the firm-community attrition conflict. The ensuing analysis can be regarded as a generalization of standard models, which ignore the consequences of the fact that conflict may potentially derive into bargaining (e.g., Bulow and Klemperer, 1999; Burton, 2004). First we determine the critical attrition points, i.e., the maximum length of time that each participant can afford to be in conflict. For each player the conflict involves different costs, including the cost of time (the discount rate) and the actual disbursement to finance the standstill. The critical point for each player is thus defined as the maximum length of the conflict that allows a non-negative net present value.

Define the community's expected payoff if it wins the attrition war in period t_C as follows:

$$Z \equiv \int_0^{t_c} h_0 \bar{b} \exp\{-r_C t\} dt + p \exp\{-r_C t_c\} \Pi^C + (1-p) \int_{t_c}^{\infty} h_0 \bar{b} \exp\{-r_C t\} dt, \quad (1)$$

where p is the *ex ante* conditional probability assigned by the community that it will be able to successfully bargain with the firm given that the community wins the attrition war. The first right-hand-side term in (1) corresponds to the present value of the community benefits from the undisturbed forest while engaged in the attrition war. The second and third terms together represent the expected present value of the community's payoffs once it has won the attrition war. With probability p, the community will be able to successfully bargain with the firm and obtain Π^C. With probability *1-p,* bargaining will fail, and the payoff to the community is just equal to the environmental value of the resource (the last right-hand-side term in (1)).

The community's maximum length of time for which it is able to afford the conflict, $\tilde{t}_C$, is given by equating Z to the present value of the blockading costs that the community spends to fight the attrition war,

$$\frac{h_0 \bar{b}}{r_c} + p\left(\Pi^C - \frac{h_0 \bar{b}}{r_c}\right) \exp\{-r_C \tilde{t}_C\} = \int_0^{\tilde{t}_C} s \exp\{-r_C t\} dt. \quad (2)$$

The left-hand-side of (2) is equal to Z after obvious algebraic manipulations while the right-hand-side is the present value of the blockading costs. Solving for $\tilde{t}_C$, we obtain

$$\tilde{t}_C = \frac{1}{r_C} \ln\left(\frac{p(r_C \Pi^C - h_0 \bar{b}) + s}{s - h_0 \bar{b}}\right). \quad (2')$$

Equation (2') is valid for values of $s - h_0 \bar{b} > 0$. Otherwise the community could stay in conflict forever because the benefit per period while in conflict would be higher than the per-period cost of fighting.

As will be shown later, the firm attains higher profits through unilateral exploitation of the resource than through bargaining. Let $\hat{L}$ denote the level of logging that maximizes *v*. The expected net benefit to the firm of winning the conflict is $(1-p)(v(\hat{L}) - \bar{d}^F) + p(v(\hat{L}) - \Pi^F) = v(\hat{L}) - \bar{d}^F - p(\Pi^F - \bar{d}^F)$, where $\bar{d}^F$ is the firm's opportunity cost or outside option. The value $v(\hat{L}) - \bar{d}^F$ corresponds to the net gain to the firm of winning the war if the opportunity cost of the firm is simply an outside option. This happens with probability 1- p. Alternatively, the opportunity cost to the firm might be Π^F instead of $\bar{d}^F$. This is the case when subsequent bargaining with the community is successful, which occurs with probability p. The firm also incurs a cost *c* in each period the conflict prevails. Thus, the maximum time that the firm is able to stay in conflict, $\tilde{t}_F$, is given by

$$\exp\{-r_F \tilde{t}_F\}[v(\hat{L}) - \bar{d}^F - p(\Pi^F - \bar{d}^F)] - \int_0^{\tilde{t}_F} c \exp\{-r_F t\} dt = 0, \quad (3)$$

or, equivalently, by integrating

$$\exp\{-r_F\tilde{t}_F\}[v(\hat{L})-\bar{d}^F-p(\Pi^F-\bar{d}^F)]-\frac{c}{r_F}(1-\exp\{-r_F\tilde{t}_F\})=0. \tag{4}$$

Solving for $\tilde{t}_F$, we obtain

$$\tilde{t}_F=\frac{1}{r_F}\ln\left(\frac{r_F[v(\hat{L})-\bar{d}^F-p(\Pi^F-\bar{d}^F)]+c}{c}\right). \tag{4'}$$

With perfect information, the community and the firm will be able to consistently forecast the outcome of the bargaining game, i.e., p is a binary variable which is equal to 1 if bargaining is successful or 0 otherwise. As shown in section 2.4, if $\Pi^C-h_o\bar{b}/r_C\geq 0$ and $\Pi^F-\bar{d}^F\geq 0$, then p=1, and p=0 otherwise. That is, bargaining (conditional on the community acquiring property rights) takes place, if and only if the two conditions above are met. From (2') and (4') the following lemma follows directly

Lemma 1: At p =1 the level of $\tilde{t}_C$ is higher and the level of $\tilde{t}_F$ is lower than at p = 0 .□

Thus, if conditional on the community winning the attrition war bargaining takes place ($p=1$) then the community is in a better position to win the attrition war and, therefore, to acquire property rights than when bargaining is not a possible outcome $(p=0)$. This is highly intuitive; when bargaining is feasible the community has more to win by acquiring property rights and the firm has less to gain by winning the attrition contest.

A boundary condition is given by the tie point $\tilde{t}_C=\tilde{t}_F$. Using (2') and (4') we have that the boundary condition is

$$v(\hat{L})-\bar{d}^F-p(\Pi^F-\bar{d}^F)=\frac{c}{r_F}\left[\left(\frac{p(r_C\Pi^C-h_0\bar{b})+s}{s-h_0\bar{b}}\right)^{\frac{r_F}{r_C}}-1\right]\equiv\Lambda . \tag{5}$$

Thus, if $v(\hat{L})-\bar{d}^F-p(\Pi^F-\bar{d}^F)>\Lambda$, the firm would win a potential conflict. This can be interpreted as the case where the community is not able to effectively enforce its (potential) property rights. Given that the firm cannot acquire permanent legal property rights, this amounts to a situation of open access. If, however, $v(\hat{L})-\bar{d}^F-p(\Pi^F-\bar{d}^F)<\Lambda$, then the community is able to establish effective property rights over the resource.[9] This can be regarded as a second best outcome in the sense that the lack of public enforcement of property rights (due to the government's failure to do so) is substituted with private enforcement by the community. Note in (5) that if either $\Pi^C-h_o\bar{b}/r_C<0$ or $\Pi^F-\bar{d}^F<0$ then $p=0$ and expression (5) collapses to

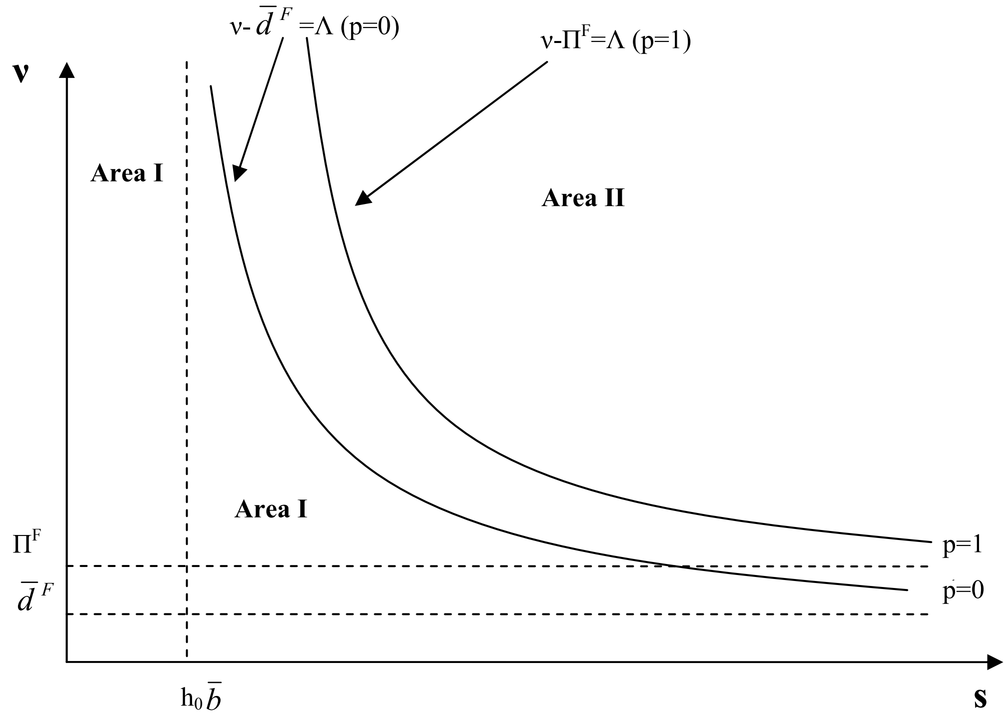
[9] If there is imperfect information on the part of either or both players, then actual rather than virtual conflict is possible. But the final outcome of the conflict will be ruled by the same parameters considered in the perfect information case.

$$v(\hat{L}) - \bar{d}^F = \frac{c}{r_F}\left[\left(\frac{s}{s - h_0 \bar{b}}\right)^{\frac{r_F}{r_C}} - 1\right]. \qquad (5')$$

This is the usual boundary condition derived in conventional attrition war analyses that focus on conflict as the only available interaction possibility (Bulow and Klemperer, 1999; Burton, 2004).

The outcome of the community-firm interaction is asymmetric: If the firm is able to win a potential conflict ($v(\hat{L}) - \bar{d}^F - p(\Pi^F - \bar{d}^F) > \Lambda$), the community will effectively lose property rights to the resource and hence, since by assumption the firm is not allowed to acquire formal property rights, the firm will exploit it unilaterally as an open access resource. This case is represented by area II in Figure 1. If, however, the community is able to win the war of attrition ($v(\hat{L}) - \bar{d}^F - p(\Pi^F - \bar{d}^F) < \Lambda$), then it effectively is able to exert property rights over the resource. This corresponds to area I in the Figure. In this case, bargaining between the community and the firm is possible. The area between the two curves in Figure 1 reflects the increased likelihood that the community wins the attrition conflict when the probability of success of a subsequent bargaining game goes from zero to one (Lemma 1). At p=1 there is a broader set of combinations of v and s that are consistent with the community winning the conflict than when p=0.

Figure 1: Possible Outcomes of the Conflict Game, with and without Feasible Bargaining



From the previous analysis, we have the following proposition

Proposition 1 (Bargaining vs. conflict): The ability of the community to establish and privately enforce de facto property rights is a necessary condition for a negotiated solution to the resource exploitation problem to emerge. The likelihood that the community wins the conflict and thus that privately-enforced property rights emerge increases if: (i) Bargaining is a feasible alternative to conflict; (ii) the community's discount rate and other costs of fighting an attrition war are low vis-à-vis those of the firm. □

2.2 Inside Options in Bargaining

Inside options are defined as the payoffs obtained by each player while parties temporarily disagree and negotiations are ongoing. We assume as the following:

(A7) Inside options of the community (d^C) and the firm (d^F) are given by $d^F = \bar{d}^F$ *and* $d^C = h(L)B(\bar{L})$, *where* $\bar{d}^F$ *denotes the firm's exogenous returns from temporarily using the firm's capital (available for the exploitation of the resource) in other activities, and* $h_0 \leq h(L) \leq \bar{h}$.

If the community is able to establish *de facto* property rights, we argue that the inside option of the community is endogenous if third-party interventions are guided by "*support communities which face the greatest environmental threats*" (SGET) principle. SGET interventions may affect the valuation of the standing forest as part of the community's external support is directed to enhancing the value of the environment to communities; that is, to cause them to internalize a greater portion of the environmental externalities. The more aggressive the logging plan (the greater the environmental threat) the more attention (and support) this will attract from third-party actors, including NGOs, donor agencies, and others concerned about the environment.[10] Such third-party interventions improve the communities' bargaining position by increasing its inside option.[11] Specifically, the degree to which the community considers the true

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[10] For example, conservation groups such as Conservation International and several others focus their activities on global "hotspots", i.e. areas that are under high pressure of deforestation and at the same time rich in biodiversity (see www.conservation.org and www.biodiversityhotspots.org).

[11] We assume that third-party actors will not intervene on the basis of the firm's logging in the case where the firm wins the attrition war. Given the stylized fact explained in the introduction that firms will not be able to obtain legal rights, a situation of open access will emerge in this case. Third-party actors then are not likely to gear their interventions to the level of logging intended by the firm because under open access any agent other than the particular firm can access the resource; at least once the firm is not interested in costly attrition wars to defend *de facto* rights from other firms. Assuming that the firm understands this, its choice of logging area is not affected by the potential of outside interventions when the community is no longer able to exert its property rights. Of course, third-party actors may react to the open access situation by raising h through education or conservation payments enough to permit the community to establish *de facto* property rights (i.e., to move from area II to area I). This policy option is discussed further in part 3. What is important here is that, from the viewpoint of the firm, this third-party intervention is independent of the firm's logging choice, because of the presence of many other potential firms in the open access situation.

value of the standing forest (h) is thus likely to be affected by the level of logging being negotiated (L). For example, we may assume that $h(L) = h_o + \tilde{h}(\overline{L} - L)$. The unit price that the community receives for the environmental service that it provides, $h(L)$, is thus comprised by the benefit per unit of environmental service directly obtained by the community (h_0) plus the unit price for the environmental services paid by third-parties, $\tilde{h}(\overline{L} - L)$. The unit price paid by third parties is assumed to increase at a decreasing rate with the *scarcity* of the environmental service supplied ($\tilde{h}' < 0$ and $\tilde{h}'' < 0$). The term $\tilde{h}(\overline{L} - L)$ may include the provision of technical support, education, and conservation monetary payments to the communities in order to raise environmental values and awareness provided through SGET interventions.

SGET interventions cause the unit price of environmental services to increase when environmental services become scarcer. It would, however, be inappropriate to assume that such interventions cause the total environmental value to increase as the environment is degraded. To avoid this possibility we assume that $h(L)B(\overline{L} - L)$ is non-increasing in L. Below we summarize the assumptions concerning SGET interventions.

Assumption set B:

(B1) With SGET interventions, the unit price of environmental service perceived by the community increases at a strictly decreasing rate as environmental services become scarcer, $h'(L) > 0$ *and* $h''(L) < 0$.

(B2) With SGET interventions, the total value of the environmental service, $M(L) \equiv h(L)B(\overline{L} - L)$*, is non-increasing in* $L \in [0, \overline{L}]$.

That is, $h'(L)B(\overline{L} - L) - h(L)B'(\overline{L} - L) \leq 0$.

To clarify the meaning of SGET interventions, first consider the standard alternating offers game with perfect information (e.g., Rubinstein, 1982): With perfect information the first offer to share a fixed cake between the players considers all information so that, as long as certain feasibility conditions are satisfied, the distribution proposed is accepted by the other party without delay. If SGET interventions can occur, however, and communities and firms are aware of this, a rational response is to also internalize this policy into the bargaining game. Then the (perfect) first offer will take into consideration the fact that the level of logging will affect one of the players' inside options as a consequence of the support provided by the outside intervention. The offer will be a package that will include both the level of logging and the proposed distribution among the players of the ensuing benefits. Note that as in the standard bargaining without SGET interventions, no real "bargaining" time is needed. Assuming that the feasibility conditions for successful bargaining are satisfied, the offer is instantaneously accepted.

In the analysis below, we probe the implication of this type of intervention by comparing the outcome of the bargaining game with SGET interventions ($h'(L) > 0$) and without

($h'(L)=0$) (Proposition 2 below). In addition we compare the effects of other types of intervention (not guided by the SGET principle) with and without SGET interventions.

2.3 Bargaining

We now analyze the outcomes of community-firm bargaining when the community wins *de facto* property rights. We assume a Rubinstein-type bargaining where community and firm make alternating offers to define a mutually agreed logging contract. As discussed earlier, this is a bargaining game with inside and outside options.[12] Unlike in conventional bargaining games, however, the size of the "cake" is here endogenous. The firm and the community bargain not only for their respective shares of the extracted output but also for the intensity of the exploitation, that is, for the determination of the value of the resource extracted. For presentation purposes we consider bargaining over the distribution of the total net benefits and bargaining over the level of logging separately. That is, we first study how benefits are distributed conditional on a logging level, and then we analyze the determination of the logging level.[13] It will be shown that with SGET interventions the distribution and the size of the cake negotiated over are no longer separable.

2.3.1 Bargaining over Payments

Muthoo (1999) has shown that the solution to the alternating-offers bargaining game with inside and outside options can be presented in the form of an asymmetric Nash Bargaining Solution (NBS). Thus, the payments to the community and firm out of a given total revenue are obtained by solving the following Nash bargaining problem

$$\max_{\Pi^F,\Pi^C}\left[\Pi^F-d^F\right]^{\tau}\left[\Pi^C-d^C\right]^{1-\tau} \text{ s.t. } \Pi^F\geq d^F,\ \Pi^C\geq d^C,\ \Pi^F+\Pi^C=\Gamma(L), \quad (6)$$

where $\tau=r^C/(r^C+r^F)$ is the firm's bargaining power *vis-á-vis* the firm, and $\Gamma(L)$ are the total net benefits to the two players under the logging agreement ("the size of the cake"). The latter include the firm's logging profits as well as the value of the remaining forest to the community, i.e.,

$$\Gamma(L)=v(L)+h(L)B(\overline{L}-L)\,. \quad (7)$$

The constraints in (6) imply that each player has to obtain at least the value of his inside option, and that total payments have to add up to the total net benefits to be divided. These conditions are discussed further in section 2.4.

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[12] A standard assumption in alternating-offers models is that prolonged bargaining is costly to the players because players are assumed to have positive discount rates.

[13] For simplicity, we assume that contracts are not renegotiated. See Macleod and Malcomson (1995) and Muthoo (1999, chapter 10) for analyses concerning renegotiation.

Assuming an interior solution, and using (A7), equilibrium payments can be written as

$$\Pi^F = \bar{d}^F + \tau G(L) \tag{8}$$

and $\Pi^C = h(L)B(\bar{L}) + (1-\tau)G(L)$, (9)

where $G(L) = \Gamma(L) - \bar{d}^F - h(L)B(\bar{L})$. (10)

G(L) is the surplus left after paying both players their inside options. Thus, each player obtains the value of his inside option plus a share of the surplus (*G(L)*) that is inversely proportional to the player's discount rate.

2.3.2 Bargaining over Logging Intensity

We now consider bargaining over logging area, which in turn determines the total net benefits to be divided, Γ. Note that from equations (8) and (9), however, L determines not only Γ but also its distribution between the players. Distribution is affected mainly because the community's inside option ($d^C(L)$) depends on *L*. The firm's preferred choice of *L* (denoted by L^F) is the one that maximizes its own payoffs under the logging agreement. From (8), this is equivalent to the level of *L* that maximizes the surplus (*G(L)*), i.e., L^F is defined by

$$\Gamma'(L^F) = h'(L^F)B(\bar{L}). \tag{11}$$

Thus, the firm would want to equate the marginal benefit of logging to the marginal cost of logging faced by the firm. We expect this to be the level of logging resulting when the firm has perfect bargaining power ($\tau = 1$).

By contrast, the community's preferred level of logging (L^C) is the one that maximizes Π^C, given by (9). Thus,

$$\Gamma'(L^C) = -\frac{\tau}{1-\tau} h'\left(L^C\right)B\left(\bar{L}\right). \tag{12}$$

Contrary to the firm, the community considers the effect of logging on its own reservation utility as a benefit. However, the community will be able to fully impose its optimal level of logging (L^C) only if it has full bargaining power, that is if $\tau = 0$. In that case (12) becomes

$$\Gamma'(L^C\big|_{\tau=0}) = 0. \tag{13}$$

When the community has perfect bargaining power, it receives all the surplus beyond the firm's inside options, and therefore does not consider the effect on its own inside options. Therefore, concavity of *v* and *h* in *L* implies that $L^C\big|_{\tau=0} > L^F$.

The bargained level of *L* will generally lie somewhere in between the values preferred by the two players. As shown in the Appendix (Section A.1), the bargaining game that determines *L* can be represented by the following Nash bargaining problem:

$$\max_{L}\left[\bar{d}^{F}+\tau G(L)\right]^{\tau}\ \left[h(L)B(\bar{L})+(1-\tau)G(L)\right]^{1-\tau}. \qquad (14)$$

The nature of this bargaining game is the following: Each player bargains for a level of L that is as close as possible to the level of L that maximizes his or her benefits. In principle both players would like the total benefits (including the environmental benefits) to be as large as possible, but only to the extent that increasing total benefit does not reduce their respective incomes. In the Appendix (Section A.2) we show that the first-order condition can be written as

$$\Gamma'(\tilde{L})=\kappa h'(\tilde{L})B(\bar{L}), \qquad (15)$$

where $\kappa \equiv \left[\dfrac{\left(\dfrac{\tilde{\Pi}^{C}}{\tilde{\Pi}^{F}}+1\right)\tau^{2}-\tau}{\tau^{2}\dfrac{\tilde{\Pi}^{C}}{\tilde{\Pi}^{F}}+(1-\tau)^{2}}\right]$, $\tilde{L}$ denotes the equilibrium level of logging emerging from bargaining, and $\tilde{\Pi}_{i}$ is the equilibrium payment to player *i*, defined by equations (9) and evaluated at $\tilde{L}$.

Lemma 2: $\boldsymbol{0\le\kappa\le 1}$***,*** $\boldsymbol{\kappa(\tau=0)=0}$ ***and*** $\boldsymbol{\kappa(\tau=1)=1}$***.*** □

Proof: see Appendix (Section A.3). □

Lemma 2 implies that the cases where either player has perfect bargaining power ($\tau=1$ or $\tau=0$) are borderline cases of equation (15). That is, for $\tau=1$, condition (15) reduces to equation (11), and the firm's preferred level of logging emerges ($\tilde{L}=L^{F}$). The firm exploits the fact that increasing *L* raises the community's inside options. Similarly, if $\tau=0$, the equilibrium level of logging is $\tilde{L}=L^{C}\big|_{\tau=0}$, as defined in equation (13). If both parties truly bargain ($0<\tau<1$), the solution will only partially capture the effect of *L* on *h* (that is, $0\le\kappa\le 1$). We thus have

Lemma 3: Assume SGET interventions are in place ($h'(L)>0$***).***

For $\boldsymbol{0\le\tau\le 1,\ L^{F}\le\tilde{L}\le L^{C}\big|_{\tau=0}}$***. Moreover,*** $\boldsymbol{\dfrac{\partial\tilde{L}}{\partial\tau}<0}$***.*** □

Proof: See Appendix (Section A.3).

Lemma 3 implies that the higher the bargaining power of the firm, the lower the level of logging negotiated. Thus, contrary to what is often assumed, a higher bargaining power of the community leads to more intense resource exploitation.

If $h'(L)=0$, that is in the absence of SGET interventions, then it is clear that $L^F = L^C = \widetilde{L}_{NI}$, where $\Gamma'(\widetilde{L}_{NI})=0$. In this case the level of $\widetilde{L}_{NI}$ maximizes the size of the "cake" available for distribution between the players and is independent of the degree of bargaining power ($\partial\widetilde{L}_{NI}/\partial\tau = 0$). Lemma 4 summarizes this result:

Lemma 4: Assume that no SGET interventions are in place ($h'(L)=0$). Then $L^F = L^C = \widetilde{L}_{NI}$ (where $\widetilde{L}_{NI}$ is the NBS in the absence of intervention) and $\partial\widetilde{L}_{NI}/\partial\tau = 0$.□

2.4 Outside Options Revisited

There are two ways in which outside options matter for bargaining results (Muthoo, 1999). First, the NBS presented above is valid only if the resulting payment to player *i* ($\widetilde{\Pi}_i$) is at least as large as the value of player *i*'s outside option. Otherwise, player *i* will simply obtain the value of his outside option in bargaining and the other player will receive the residual net benefits from bargaining (Binmore, 1985). Second, if the sum of outside options exceeds the total net bargaining benefits, bargaining will fail. Players in this case will obtain their respective outside option.

Our analysis in section 2.1 implies that the community's and the firm's outside options in bargaining (denoted as R^C and R^F, respectively) depend crucially on which of the two parties is able to establish *de facto* property rights. In the case considered here, where the community wins the war of attrition (area I in figure 1), outside options are given by

$$R^C = h_0 B(\overline{L}) \quad \text{and} \quad R^F = \overline{R}^F = \overline{d}^F, \tag{16}$$

where $\overline{R}^F$ are the exogenous firm profits in the next most profitable activity ($\overline{R}^F < v(\hat{L})$). Our formulation assumes that these profits are independent of whether bargaining takes place or not, so that the firm's inside and outside options are identical.

Now note that if $G(\widetilde{L}) \geq 0$ (there are gains from bargaining), the payment to the community derived under the NBS always at least weakly exceeds the value of the community's outside option:

$$\Pi^C = h(\widetilde{L})B(\overline{L}) + (1-\tau)G(L) \geq h_0 B(\overline{L}), \tag{17}$$

since $h(\widetilde{L}) \geq h_0$. This happens because the community's inside and outside options are closely related; they both reflect the value of the standing forest in the absence of logging. The only difference is that inside options may be positively affected by greater third-party interventions in response to negotiations. Therefore, the community can never loose, but may in fact gain, from negotiations in terms of both an increase in its inside option and a share of logging profits.

Because the firm's inside and outside options are identical, namely the value of the firm's capital in the next best alternative activity, ($\overline{d}^F = \overline{R}^F$), the payment to the firm under the NBS also always at least weakly exceeds the value of the firm's outside option:

$$\Pi^F = \overline{d}^F + \tau G(L) \geq \overline{R}^F . \tag{18}$$

By the same argument, we have

Lemma 5: If $\overline{d}^F = \overline{R}^F$, $G(\tilde{L}) \geq 0$, and the community can establish de facto property rights, then $R^F + R^C \leq \Gamma(\tilde{L})$. Thus, bargaining takes place. □

Proof: The result follows directly from adding up equations (17) and (18). □

2.5 The Effects of SGET Interventions

The socially optimal level of logging (L^*) is the one that equates marginal profits from logging to the true marginal environmental damages for society as a whole,

$$v'(L^*) = \overline{h} B'(\overline{L} - L^*) . \tag{19}$$

This needs to be distinguished from the optimum for the community-firm complex (L^{CFC}), which is given by the level of logging resulting if the community and the firm could coordinate to maximize the total net benefits from an agreement, $\Gamma(L)$. The latter, denoted as is identical to $L^C\big|_{\tau=0}$ and—using (7) —is given by

$$v'(L^{CFC}) + h'(L^{CFC})B(\overline{L} - L^{CFC}) = h(L^{CFC})B'(\overline{L} - L^{CFC}) . \tag{20}$$

There are two differences between the social optimum and the optimum for the community-firm complex. First, as is well known, the community-firm complex does not generally consider externalities beyond the local level and thus undervalues environmental damages from logging ($h(L) \leq \overline{h}$). If outside interventions are responsive to logging, there is an additional effect: The community and the firm, by increasing the area logged, can induce third-party interventions that increase the benefits to the community obtained from the remaining forest. That is, they can increase the size of the cake to be divided. This implies an additional marginal benefit of logging to the two actors in negotiations. Thus, third-party interventions that increase the unit payment for the standing forest when threatened could lead to an even greater over-exploitation of the resource than without intervention. Inspection of (19) and (20) shows that $L^{CFC} > L^*$. When the firm has some positive bargaining power ($\tau > 0$), the above effects are, in part, counteracted by the fact that the firm considers the effect of logging in increasing the community's inside option. Formally, we have

Proposition 2 (Role of interventions on environmental distortion):

(a) Without intervention, bargaining will lead to a solution that implies $\tilde{L}_{NI} > L^{*}$.

(b) With SGET interventions:

(b.1) If $\tau = 0$***, then*** $\tilde{L} > \tilde{L}_{NI}$***, i.e., the initial distortion is worsened by intervention.***

(b.2) If $\tau = 1$***, then*** $\tilde{L} < \tilde{L}_{NI}$***, i.e., the initial distortion is at least partially counteracted by intervention.***

(b.3.) If $0 < \tau < 1$***, then the effect of intervention on the distortion is ambiguous.*** $\tilde{L} > \tilde{L}_{NI}$ ***if and only if*** $v'(\tilde{L}) - h(\tilde{L})B'(\bar{L} - \tilde{L}) < 0$. □

Proof: See Appendix (Section A.4).

Proposition 2 implies that the greater the bargaining power of the community, the more likely it is that the distortion is worsened by intervention ($\tilde{L} > L_{NI}$). Also, part (b.3) of the proposition implies that the distortion is more likely to be worsened by SGET intervention where logging reductions are most needed. To see this, note that $v'(\tilde{L}) - h(\tilde{L})B'(\bar{L} - \tilde{L})$ is the true social marginal value of forest to the community-firm complex (or the effect of logging on total net benefits when interventions are not sensitive to logging). If this is negative, further deforestation is immiserizing. This can be considered the case where adequate interventions are most needed. However, the proposition shows that in this case, SGET interventions make things worse (i.e., they increase the initial distortion).

3 The Effect of Alternative Strategies of Third-Party Interventions

We now discuss the environmental impacts of various other interventions. In particular, we discuss three general types of intervention: (i) interventions affecting *de facto* property rights, (ii) interventions affecting bargaining power, and (iii) changes in the opportunity cost of labor.

3.1 Interventions Affecting *de facto* Property Rights

One way in which third-party actors can try to influence the outcome of community-firm interactions is by affecting the outcome of the latent conflict over *de facto* property rights. In particular, third parties can intervene to affect parameter values to induce a shift in the outcome of the property rights game from area II in Figure 1 (open access and unilateral logging by the firm) to area I (community property rights and negotiation). For example, inspection of the boundary condition in (5) shows that this could be achieved through an increase in c or a decrease in s. Third parties could, for example, lower the level of s by improving the capacity of communities to blockade.

Proposition 3 (Unilateral vs. bargained logging): If assumption B2 holds then the bargain-determined level of logging is less than or equal to the unilaterally determined level, i.e., $\tilde{L} \le \hat{L} \;\; \forall \tau \in [0,1]$. □

Proof: See Appendix (Section A.5)

Thus, interventions shifting the outcome of the attrition war from unilateral logging to a situation where the community can enforce its property rights are expected to reduce resource extraction.

3.2 Interventions Affecting Bargaining Power (with and without SGET)

Third-party actors may intervene by changing the effective relative bargaining power in favor of the community. For example, third parties can attempt to lower the community's discount rate through anti-poverty measures, subsidized credit lowering the marginal cost of capital, or by improving tenure security or increasing economic stability. Such interventions reduce the level of r_C and thereby of τ. To see the impact of such interventions on logging we need to distinguish two effects: (i) a continuous effect on the bargaining outcome, and (ii) a potential discontinuous effect on the outcome of the attrition war.

In the case where bargaining takes place (area I in Figure 1), and SGET intervention is in place, lemma 3 applies, and thus $\partial L / \partial \tau < 0$. Thus, contrary to conventional views, interventions improving the community's bargaining power harm the environment by leading to increased logging under a bargained agreement. If SGET is not in place, then Lemma 4 applies; interventions that increase the community bargaining power have no effect on logging. That is, the policy intervention is ineffective in achieving environmental improvements. These are the possible continuous effects.

The (discontinuous) effect on the outcome of the attrition war is somewhat more complex. Consider the maximum length of time that the community is able to stay in conflict ($\tilde{t}_C$). Equation (2) can be rewritten as

$$Y \equiv \left[p\Pi^C(r_C) + (1-p)\frac{h_0\bar{b}}{r_C} \right] \exp\{-r_C\tilde{t}_C\} - \left[\frac{s - h_0\bar{b}}{r_C} \right] \left[1 - \exp\{-r_C\tilde{t}_C\}\right] = 0, \qquad (21)$$

Equation (21) incorporates the fact that the community's payoffs from bargaining (π^C) are themselves a function of r_C. The community's choice of how long to stay in conflict can be considered as an investment decision. The first term in the middle of (21) represents the benefits of the investment. With probability p this is the present value of the payoffs from a bargained agreement; with probability 1-p bargaining fails and payoffs are simply given by the environmental benefits of the standing forest. The second term in the middle of (21) reflects the net costs of the investment. Each period the fight goes on, the community incurs blockade costs, *s,* net of the immediate environmental benefits ($h_0\bar{b}$). A change in r_C affects both the costs and benefits of the investment. Inspection of (21) shows that when r_C decreases as a consequence of intervention, both terms in the middle of equation (21) rise. Intuitively, for a given Π^C, the present value of the investment benefits increase as r_C falls, but the investment costs also increase. In addition, Π^C is likely to increase as well because a decrease in r_C raises the community's bargaining power. It can be shown, however, that the net effect of reducing r_C is to increase the ability of the community to stay in conflict (i.e., $\tilde{t}_C$ goes up).

Lemma 6: $\tilde{t}_C$ is decreasing in r_C. □

Proof: See Appendix, Section A.6. □

Thus, a *reduction* of r_C necessarily increases the ability of the community to stay in conflict, that is, $\tilde{t}_C$ increases. This does not mean, however, that the community will necessarily win property rights; it only implies that it will have a greater chance to win the contest. If the reduction in r_C is not sufficiently large, the outcome of the conflict game may not be altered. We summarize these results in proposition 4.

Proposition 4 (Effects of increases in community bargaining power): Interventions that increase the community's bargaining power may cause an increase in resource extraction. In particular, this is the case when bargaining takes place before and after intervention and SGET policies are in place (continuous effect). By contrast, an increase in community's bargaining power increases its ability to secure de facto property rights (discontinuous effect). This increased ability does not necessarily mean, however, that the intervention will cause the community to win the conflict; neither does it ensure that resource extraction will decrease.□

3.3 Interventions Affecting the Opportunity Cost of Labor

We can distinguish two types of changes affecting the opportunity cost of labor. First, local interventions may increase the marginal product of labor in a segment of the labor market, affecting the opportunity cost of labor of the community, but not of the labor used by the firm. For example, intervention may increase access to improved agricultural or processing technologies or provide alternative employment opportunities within the community, in a setting where the firm does not hire community labor for resource extraction activities. Second, economic growth or macro-level interventions directed to the labor market may change wages faced by both the firm and the community labor.[14]

The effect in the first case is straightforward. Assuming the firm draws its labor out of the general labor market and not from the community, the only effect of an increase in the community members' opportunity cost of time ($\tilde{w}$) is to raise the cost of blockading (s). This means that communities will be less likely to win the attrition war, and thus, it is more likely that the outcome will be a loss of property rights for the community (the size of area II in Figure 1 is increased). Thus, bargaining is less likely to take place, and communities are less likely to benefit from the exploitation of the resource. By analogy to the discussion in section 3.1., a shift from area I to area II in Figure 1 is likely to induce an increase in the extent of logging.

The impact of interventions that increase market wages faced by community members <u>and</u> the firm is more complex. There are three effects on the boundary condition in (5): (i) s increases as before, (ii) $v\left(\overline{L};w\right)$ decreases, and (iii) Π^{C} decreases. In general, the net effect on the outcome of the attrition war is indeterminate. If, however, the firm's operation is very capital-intensive, and hence, less labor-intensive than the community's blockading operation, then it is more likely that the first effect will dominate. In this case the net effect will be to shift the boundary condition to increase area II, i.e., the community is less likely to acquire property rights. If, as a consequence, the change in market wages induces a shift from an outcome where the community wins de facto property rights (area I) to an outcome of unilateral logging (area

[14] An example of the second type of intervention is a job creation program supported by the government and of sufficient magnitude to affect the economy's market wage.

II), the effect on logging is exactly as discussed in the case of a more local change in the opportunity costs of labor. If, however, a bargaining equilibrium exists before and after the change in market wages, then the wage effect in a bargaining context will under plausible conditions be in the expected direction, i.e., less logging.[15]

We present the main effect of labor market interventions in Proposition 5 below.

Proposition 5 (Effects of increases in opportunity costs of labor): Increasing the community's opportunity costs of labor causes an increase of blockading costs. If blockading costs are sufficiently sensitive to the opportunity costs of labor, this may prevent the community from achieving property rights. In this case, the result may be increased environmental pressure. □

It is usually thought that economic development reduces the pressure on natural resources and induces more tenure security. By contrast, Proposition 5 indicates that in the absence of public enforcement of property rights, economic development, by raising communities' opportunity costs of property-rights self-enforcement, may enhance the potential for invasion of community lands by commercial interests and increase resource extraction.

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[15] Inspecting the first-order conditions it can be shown that a sufficient condition for this result is that $\partial^2 v / \partial L \partial w$ be negative. Using Hotelling's Lemma, $\partial^2 v / \partial L \partial w = -\partial m_F / \partial L$, where m_F denotes the optimal level of labor use by the firm. That is, employment by the firm should be increasing in the area logged.

4 Conclusions

Consider a community that satisfies all the desirable conditions for collective action that have been emphasized in the literature on the management of local commons. In the view of this literature, this would be good news, in the sense that the theory would predict that the resources would be subject to efficient management. If, however, this community is subject to sufficiently powerful external interests, its desirable collective action characteristics would not necessarily prevent the community from losing effective property rights and would not protect the common resource from excessive degradation. The reason for this is clear. While collective action may influence certain aspects of the strength of a community's ability to face conflict with external riders, there are other factors, generally ignored by the collective action literature, that will determine the final outcome of a potential conflict. Even if the community is able to withstand outside challenges it may still be in need of negotiating joint exploitation of the resource with outside agents. Once again, the theory of collective action gives little guidance on how such bargaining would take place and what its consequences would be.

In this paper we have developed a framework that emphasizes important community interactions with external agents ignored by the collective action literature. We have shown that the nature of these interactions critically affects the management of natural resources. Interactions are important not only because communities may unwillingly be faced with external agents (e.g., commercial interests demanding communal resources, especially during times of commodity booms). Cooperation with external agents may also be the most effective way of exploiting certain resources, particularly those requiring large capital investments for their exploitation. We have derived a conceptual approach that naturally leads to an explanation of the birth of effective property rights or, alternatively, their abortion.

Conditional on the development and community enforcement of property rights, we have identified important factors that determine the outcomes of negotiations between communities and external agents. In addition, we have shown some unexpected results concerning the effect of third-party interventions on the environment that should be important to policymakers interested in mitigating the negative environmental consequences of resource exploitation. In particular, our results imply that the effectiveness of third-party interventions depends crucially on initial conditions. Certain interventions often favored by NGOs, governments and international organizations, have been shown to be ineffective or even counterproductive. Though we have highlighted policies that are likely to have paradoxical effects, there are other policies that have the expected impacts in ameliorating the environmental externalities of resource extraction.

An emerging stylized fact suggesting that increasing the rights over natural resources for local communities has often failed to halt natural resource degradation and sometimes even worsened their management is consistent with many of the results shown in this paper. These counterproductive effects appear to emerge from the fact that devolution has generally assigned partial and mostly ambiguous property rights over the resources to the communities instead of formal and publicly enforced rights. This makes it harder for communities to access capital markets and the technologies needed to exploit their natural resources. Some communities thus become disadvantaged vis-à-vis firms if bargaining takes place and some others simply lose any potential rights on the resources. The relatively handicapped position of communities, in turn, induces interventions to shield them from unfair contest that sometimes are counterproductive.

Though under certain conditions private enforcement of property rights endogenously emerges, it is clear that this process is only an imperfect substitute for legal and publicly enforced property rights. Failure to publicly establish and enforce such rights increases the likelihood that the process of devolution may not only worsen resource management but also to cause certain seemingly plausible policies to backfire. The key message of this paper is that under partial and contestable property rights the road to effective intervention is indeed quite uncertain.

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Appendix

A.1 Setup of the Problem Statement in (14)

Recall that payment to the community is maximized at L^C and the payment to the firm is maximized at L^F, with $L^F<L^C$. We can express the problem of bargaining over the logging area as bargaining over splitting the difference between L^F and L^C. Let this difference be denoted by D; thus $D \equiv L^C - L^F$. The payment obtained by the community can then be written as $\Pi^C = \Pi^C\left(L^C - \varepsilon D\right)$, where ε denotes the share of D 'given' to the community ($0 \le \varepsilon \le 1$). Note that the community actually prefers getting as little of the 'cake', D (perhaps better referred to as "'hot potato") as possible (i.e., $\frac{\partial \Pi^C}{\partial \varepsilon} < 0$). Similarly, we can write the firm's payment as $\Pi^F\left(L^F + (1-\varepsilon)D\right)$. The firm would also prefer a smaller share of such cake, implying that it would prefer ε to be close to one ($\frac{\partial \Pi^F}{\partial \varepsilon} > 0$). Thus, the problem is equivalent to a standard asymmetric Nash Bargaining problem and can be written as

$$\max_{\varepsilon} \Pi^F (L^F + (1-\varepsilon)D)^{\tau} \Pi^C (L^C - \varepsilon D)^{1-\tau}, \qquad \text{(a.1)}$$

This problem, as shown by Muthoo (1999), has a natural correspondence with an alternating-offers game á la Rubinstein. Note also that since $L = L^F + (1-\varepsilon)D = L^C - \varepsilon D$, the formulation in (a.1) is equivalent to the objective function in (14):

$$\max_{L} \Pi^F (L)^{\tau} \Pi^C (L)^{1-\tau}.$$

A.2 Derivation of First-Order Condition (15)

Using a logarithmic transformation and the definition $d^C(L) = h(L)B(\overline{L})$, the objective function in (14) can be rewritten as

$$\max_{L} \tau \ln\left[\overline{d}^F + \tau G(L)\right] + (1-\tau)\ln\left[d^C(L) + (1-\tau)G(L)\right].$$

The first-order condition for the bargaining problem specified in (14) can thus be written as:

$$\frac{\tau G'(L)}{\bar{d}^F+\tau G(L)}=-\frac{1-\tau}{\tau}\frac{d^C{}'(L)+(1-\tau)G'(L)}{d^C(L)+(1-\tau)G(L)}\text{, or equivalently,}$$

$$\frac{\tau^2 G'(L)}{\Pi^F}+\frac{(1-\tau)d^C{}'(L)+(1-\tau)^2 G'(L)}{\Pi^C}=0.$$

Some further manipulation yields

$$\left[\tau^2\frac{\Pi^C}{\Pi^F}+(1-\tau)^2\right]G'(L)+(1-\tau)d^C{}'(L)=0.$$

Substituting for $G'(L)=\Gamma'(L)-d^C{}'(L)$, we can rewrite

$$\left[\tau^2\frac{\Pi^C}{\Pi^F}+(1-\tau)^2\right]\Gamma'(L)+\left[\tau-\left(\frac{\Pi^C}{\Pi^F}+1\right)\tau^2\right]d^C{}'(L)=0.$$

This expression is of course equivalent to equation (15).

A.3 Proof of Lemmas 2 and 3

Substituting for $\tau=0$ and $\tau=1$ in the expression for κ given below (15) immediately yields the second part of lemma 2. Moreover, we can rewrite κ as

$$\kappa(L;\alpha,\tau)=\left[\frac{(\alpha+1)-\frac{1}{\tau}}{\alpha+\left(\frac{1-\tau}{\tau}\right)^2}\right],$$

where $\alpha\equiv\alpha(\tau)=\frac{\Pi^C}{\Pi^F}=\frac{h(\tilde{L})B(\tilde{L})+(1-\tau)G(\tilde{L})}{\bar{d}^F+\tau G(\tilde{L})}$.

It is easy to see by inspection, that the direct effect of τ on κ is positive (i.e., $\frac{\partial\kappa}{\partial\tau}>0$). Moreover, the effect of α on κ is also positive since

$$\frac{\partial\kappa}{\partial\alpha}=\frac{\alpha+\left(\frac{1-\tau}{\tau}\right)^2-\left[(\alpha+1)-\frac{1}{\tau}\right]}{\left[\alpha+\left(\frac{1-\tau}{\tau}\right)^2\right]^2}=\frac{\left(\frac{1-\tau}{\tau}\right)^2+\frac{1}{\tau}-1}{\left[\alpha+\left(\frac{1-\tau}{\tau}\right)^2\right]^2}>0$$

for $0<\tau<1$. Also, inspection of the definition of α shows that $\frac{\partial\alpha}{\partial\tau}>0$. Therefore, it follows that $\frac{d\kappa}{d\tau}\equiv\frac{\partial\kappa}{\partial\tau}+\frac{\partial\kappa}{\partial\alpha}\frac{\partial\alpha}{\partial\tau}>0$. Together these two results imply that $0\le\kappa\le1$ (first part of lemma 2). Lemma 3 follows directly from the previous results, equation (15), and the concavity of Γ. □

A.4 Proof of Proposition 2.

From equations (15), (7), and (A7) we have that

$$v'(\tilde{L}) = h(\tilde{L})B'(\bar{L}-\tilde{L}) + h'(\tilde{L})\left[\kappa B(\bar{L}) - B(\bar{L}-\tilde{L})\right]. \qquad \text{(a.2)}$$

In the absence of intervention, $h'(\tilde{L}) = 0$. Result (a) follows immediately from (a.2) together with the concavity of v, and the fact that $h(L) < \bar{h}$. If $\tau = 0$, then $\kappa = 0$, so the second term on the right-hand side (RHS) of (a.2) is negative, implying that the distortion is worsened (result b.1). If $\tau = 1$, then $\kappa = 1$, so the second RHS term in (a.2) is positive, implying that the distortion is reduced (result b.2). For $0 < \tau < 1$, $0 < \kappa < 1$, the sign of the second RHS term in (a.2) is ambiguous. The closer to zero τ is, the more likely the sign of the expression in (b.3) is negative. □

A.5 Proof of Proposition 3.

By the concavity of v, $\tilde{L} \leq \hat{L}$ if and only if $v'(\tilde{L}) \geq v'(\hat{L})$. Now compare the first-order condition for $\tilde{L}$ (equation (15)) to that for $\hat{L}$, which is given by $v'(\hat{L}) = 0$. Then $v'(\tilde{L}) \geq v'(\hat{L})$ holds $\forall \tau \in [0,1]$ if and only if $N \equiv h(\tilde{L})B'(\bar{L}-\tilde{L}) + h'(\tilde{L})\left[\kappa B(\bar{L}) - B(\bar{L}-\tilde{L})\right] \geq 0$ for all $\tau \in [0,1]$, (or equivalently, for all $\kappa \in [0,1]$, see lemma 1). Since N reaches a minimum at $\kappa = \tau = 0$, it suffices to show that $N|_{\kappa=\tau=0} \geq 0$. Moreover, since in this case N =-dM/dL, the condition N$\geq$0 for all $\tau \in [0,1]$ holds if and only if dM/dL$\leq$ 0 .That is, if assumption B2 holds.□

A.6 Proof of Lemma 6.

Totally differentiating (21) with respect to $\tilde{t}_C$ and r_C we obtain,

$$\frac{d\tilde{t}_C}{dr_C} = -\frac{\partial Y / \partial r_C}{\partial Y / \partial \tilde{t}_C}.$$

Note first that Y as defined by (21) is decreasing in $\tilde{t}_C$ since, as stated earlier $s \geq h_0 \bar{b}$, or else the community always wins the conflict. Therefore, $sign(d\tilde{t}_C / dr_C) = sign(dY / dr_C)$. We now proceed to show that the partial differential of Y with respect to r_C is negative, distinguishing the cases where $p=1$ and $p=0$.

<u>*For p=1:*</u>

Partial differentiation of Y with respect to r_C yields,

$$\exp\{r_C\tilde{t}_C\}r_C\frac{\partial Y(p=1)}{\partial r_C}=r_C\left[\frac{\partial \Pi^C}{\partial r_C}-\tilde{t}_C\Pi^C\right]+\frac{s-h_0\bar{b}}{r_C}\left[\exp\{r_C\tilde{t}_C\}-r_C\tilde{t}_C-1\right]. \qquad \text{(a.3)}$$

From Equation (21), using *p=1*, we get that

$$\Pi^C=\left(\frac{s-h_o\bar{b}}{r_C}\right)\left(\frac{1-\exp\{-r_C\tilde{t}_C\}}{\exp\{-r_C\tilde{t}_C\}}\right). \qquad \text{(a.4)}$$

Using (a.4) in (a.3) we obtain:

$$\exp\{r_C\tilde{t}_C\}r_C\frac{\partial Y(p=1)}{\partial r_C}=r_C\frac{\partial \Pi^C}{\partial r_C}-\frac{s-h_o\bar{b}}{r_C}\left(\exp\{r_C\tilde{t}_C\}(r_C\tilde{t}_C-1)+1\right). \qquad \text{(a.5)}$$

Clearly, because $\partial\Pi^C/\partial r_C<0$, the value of (a.5) can be positive only if the expression $\Omega\equiv\exp\{r_C\tilde{t}_C\}(r_C\tilde{t}_C-1)+1$ in (a.5) is negative. But note that Ω is monotonically increasing in $\tilde{t}_C$ for all non-negative values of $\tilde{t}_C$. Moreover, $\Omega=0$ when $\tilde{t}_C$ =0. Therefore, for non-negative values of $\tilde{t}_C$ we have that $\Omega\geq 0$. From equation (a.5) this means that the sign of $\partial Y/\partial r_C<0$.

<u>*For p=0:*</u>

Partial differentiation of Y with respect to r_C yields,

$$\exp\{r_C\tilde{t}_C\}r_C\frac{\partial Y}{\partial r_C}=-\frac{h_0\bar{b}}{r_C}\exp\{r_C\tilde{t}_C\}-\frac{s}{r_C}\left[1+r_C\tilde{t}_C-\exp\{r_C\tilde{t}_C\}\right] \qquad \text{(a.6)}$$

From Equation (22), using *p=1*, we get that

$$\frac{h_0\bar{b}}{r_C}=\frac{s}{r_C}\left[1-\exp\{-r_C\tilde{t}_C\}\right] \qquad \text{(a.7)}$$

Substituting (a.7) in (a.6) we have

$$\exp\{r_C\tilde{t}_C\}r_C\frac{\partial Y}{\partial r_C}=-s\tilde{t}_C<0.\square$$

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