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Payments for environmental services as an alternative to logging under weak property rights: The case of Indonesia☆

Stefanie Engel, Charles Palmer*

Chair of Environmental Policy and Economics, Institute for Environmental Decisions, ETH Zurich, Switzerland

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ABSTRACT

Decentralization reforms in Indonesia have led to local communities negotiating logging agreements with timber companies for relatively low financial payoffs and at high environmental cost. This paper analyzes the potential of payments for environmental services (PES) to provide an alternative to logging for these communities and to induce forest conservation. We apply a game-theoretical model of community–firm interactions that explicitly considers two stylized conditions present in the Indonesian context: (i) community rights to the forest remain weak even after decentralization, and (ii) the presence of logging companies interested in the commercial exploitation of the forest. Intuition may suggest that PES design should focus on those communities with the lowest expected payments from logging deals. However, we show that these communities may not be able to enforce a PES agreement, i.e., they may not be able to prevent logging activities by timber companies. Moreover, some communities would conserve the forest anyway; in these cases PES would not lead to additional environmental gains. Most important, the introduction of PES may increase a community's expected payoff from a logging agreement. A failure to consider this endogeneity in expected payoffs could lead to communities opting for logging agreements despite PES, simply allowing communities to negotiate better logging deals. Our results indicate that PES design is a complex task, and that the costs of an effective PES system could potentially be much higher than expected from observing current logging fees. Using data collected in Indonesia on actual logging fees received by communities, we illustrate how the theoretical results could be used in empirical analysis to guide PES design. Our results are likely to be useful in other cases where local people make resource use decisions but have weak property rights over these resources, and where external commercial forces are present. The results highlight the importance of understanding the details of the local context in order to design PES programs appropriately.

1. Introduction

This paper is motivated by the case of Indonesia, where decentralization reforms have resulted in the acknowledgement of communities' forest rights (Palmer, 2004). Although formal community rights remain weakly defined and are rarely enforced by the government, communities have exercised such rights by negotiating logging agreements with

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* *Corresponding author.* Professor of Environmental Policy and Economics, Institute of Environmental Decisions, ETH Zurich, Universtitaetstr. 22, CHN 76.3, CH-8092 Zurich, Switzerland.
E-mail address: stefanie.engel@env.ethz.ch (S. Engel).

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timber firms. While logging is not the only threat to Indonesia's forests, it has been a major factor underlying deforestation in previous decades (FWI/GFW, 2002). The outcomes from these agreements have been characterized by pervasive environmental damages, with communities receiving a relatively small proportion of actual timber rents (Palmer, 2006).

Payments for environmental services (PES) could potentially provide an alternative source of income to rural communities while maintaining forest environmental services. However, as we will show below, designing PES in a context like the Indonesian one is a complex task. It requires an improved understanding of the interactions between the communities and logging companies. While our analysis is motivated by, and discussed in the context of community–firm logging agreements in Indonesia, the results are likely to be useful in other cases where local people make resource use decisions but have weak property rights over these resources, and where external forces interested in the commercial exploitation of community resources are present. In the context of globalization, such commercial exploitation has increasingly led to conflict with the people who depend on these for their livelihoods (see WRI, 2005). An example of a PES-type scheme designed as an alternative to logging concessions is that of Conservation International's (CI) conservation incentive agreements (formerly 'conservation concessions'), which have been implemented in Guyana and Papua New Guinea.[1]

We focus on effectiveness and efficiency in PES design in a context of weak property rights and in the presence of commercial interests. Effectiveness requires that PES leads to an actual increase in environmental services compared to the situation that would result without PES. Efficiency refers to maximizing environmental services obtained from a given budget. Designing effective and efficient PES requires, among other issues, estimating communities' opportunity costs. In our context, this implies that an understanding is needed of the levels of expected payoffs to communities from logging deals. In Indonesia, fieldwork revealed wide variation in communities' payoffs from logging agreements (see Engel and Palmer, 2006). What are the sources of this variation, and how can we estimate the expected payoffs for a community being considered for PES? And are these expected payoffs really the relevant payoffs to consider in PES design? Among PES researchers, the common intuition seems to suggest that, for a given environmental service per hectare, PES should focus on those communities with the lowest opportunity costs, which in our context would appear to be those with the lowest expected payoffs from logging deals (e.g., Siikamäki and Layton, 2006; Wünscher et al., 2006).

As we demonstrate below, in a context like the Indonesian one issue is far more complex. First, those communities with low opportunity costs may not be able to enforce a PES agreement, i.e., they may not be able to prevent logging activities by timber companies. Second, some communities would conserve the forest anyway; in these cases, PES would not result in additional environmental gains. Finally, and perhaps most important, the introduction of PES may impact on expected payoffs from a logging agreement. A failure to consider this endogeneity in expected payoffs could lead to communities opting for logging agreements despite PES, by enabling communities to negotiate better logging deals. In all of these cases the PES scheme would not be effective.

To shed light on the above issues, we apply the intuition behind the results of a game-theoretic model presented in Engel, López and Palmer (2006). The model combines conflict and bargaining theory to analyze the interactions between communities and logging firms. Using data collected in Indonesia we also illustrate how the theoretical results could be used to guide PES design empirically. The analysis highlights the importance of understanding the details of the local context in order to design PES programs appropriately. We also show that PES design may impact on communities' ability to enforce property rights over the forest, implying that PES design is not useless in situations of weak property rights, but, if well-designed, can even help to overcome such situations.

The remainder of this paper is structured as follows. Section 2 presents further background on the Indonesian setting and the data collected. The game-theoretic model is presented in Section 3. Lessons for PES design are drawn in Section 4. Section 5 briefly discusses the empirical implementation of the model. Section 6 concludes.

2. Background on the Indonesian context and data collection

This section combines evidence from existing literature with data from fieldwork conducted by the authors during 2003–04 and described in detail in Palmer (2006). In particular, 62 communities in East Kalimantan province were surveyed using community- and household-level questionnaires.[2] All communities were sampled on the basis of having negotiated small-scale logging agreements that became operational and ended before the survey began. Within each sub-district surveyed, most if not all communities that had been involved in these agreements were sampled. Data were also collected on community characteristics and experiences, which are used in Section 5 to illustrate how the theoretical model could be empirically implemented.

The rapid expansion of commercial logging under ex-President Suharto was a key factor in the decline of Indonesia's forest cover by 40% from 1950 to 2000 (FWI/GFW, 2002). While the actual rates of deforestation have long been disputed, there is general agreement that it has increased in recent years, to almost two million hectares lost per year (see Pagiola, 2000). In East Kalimantan alone, data presented by Pagiola (ibid) suggests that forest cover declined by approximately four million

[1] See: www.conservation.org/xp/CIWEB/programs/economics.

[2] These were taken from a total of 65 community-level and 687 household interviews. For direct comparability, only those agreements that took place prior to firms entering community territory and initiating logging activities were considered, reducing the sample to 62. There were a number of cases with multiple agreements in which only the first one to be negotiated was surveyed. The household survey was designed to allow for the cross-checking and corroboration of community-level responses (see Palmer, 2006).

hectares between 1985 and 1997, representing a 22% forest loss. Another survey predicts that lowland forests will vanish from Sumatra and Kalimantan by 2010 if current trends continue (Holmes, 2000, as cited in FWI/GFW, 2002). The consequence is a loss of local environmental services, carbon sinks, and habitat for the country's disproportionately high share of world biodiversity.

Since the fall of Suharto's government in 1998, Indonesia has rapidly decentralized, resulting in changes to the institutions and processes relating to natural resource management (Barr and Resosudarmo, 2002). Forest governance shifted from a centralized system of logging concessions and protected areas to one informally controlled by district governments (Palmer, 2004). Consequently, newly empowered forest-dependent communities exerted property rights over customary (*adat*) forest, leading in many cases to communities negotiating directly and legitimately with logging companies in exchange for access to financial and social benefits (Casson and Obidzinski, 2002). Moreover, district heads were permitted to issue small-scale forest conversion licenses for these concessions.[3]

Community rights were, however, still weakly defined in a legal sense (Wollenberg and Kartodihardjo, 2001). Coupled with endemic corruption in the Indonesian forestry sector and a general decline in state law enforcement, this means that local government rarely, if ever, enforced community–firm logging agreements. About 84% of communities sampled claimed that the government played no role whatsoever in contract enforcement (Palmer, 2006). Consequently, communities came to depend more on self-enforcement rather than on the state to enforce their property rights (Palmer, 2004). For example, community–company conflicts due to firm non-compliance occurred in 50% of cases surveyed. Companies could claim property rights by making agreements that are not complied with later (Barr et al., 2001; Palmer, 2004) or simply logging without community consent (Engel, López and Palmer, 2006).

In exchange for access to commercially valuable timber on land claimed by the communities, timber companies typically agreed to pay a fee per cubic meter (m^3) of timber harvested in addition to the provision of social developments. Engel and Palmer (2006), illustrate the variation in payoffs received by communities. For example, the mean level of financial payments plus non-monetary benefits was around USD3.60 per m^3.[4] The minimum and maximum levels were USD0.30 and USD11.80, respectively. By contrast, average sawmill prices in the domestic market were between USD30 and 70 per m^3, and in Malaysia, between USD80 and 125 per m^3, for the most commonly harvested Meranti species over the period 1999–2002 (see Palmer and Obidzinski, 2002).

Resosudarmo (2004) notes that the Ministry of Forestry estimated the total area of Indonesian forest allocated for small-scale concessions by district governments since the system was established to be in the order of two million hectares in January 2003. However, data on the proportion of these concessions that were operationalized and the quantities of logs harvested from these are unavailable.

Logging has resulted in substantial environmental damage. Over 70% of the sampled communities indicated a decline in drinking water quality and over 65% indicated an increase in flooding since 1998, which respondents claimed were a consequence of logging over the period 1998–2003 (Palmer, 2006). While care needs to be taken with respondents' perceptions of environmental damages and their causes, field research by Iskander et al. (2006) on the environmental impacts of small concessions confirms that forest damage has led to a decline in wildlife habitats and a decreased potential for forest regeneration. In general, the conversion of Indonesian forest to other uses has a number of potential adverse effects including soil erosion and downstream sedimentation and a decreasing capacity for carbon sequestration (see Pagiola, 2000). Throughout this paper, we assume that forest loss due to logging leads to a degradation of environmental services provided by the forest.

The opportunities for communities in Indonesia to utilize their forest claims for income generation thus appear to have concentrated on the timber values of the forest at the cost of a decline in the value of forest environmental services. An alternative to logging agreements would be for communities to negotiate agreements for environmental services in exchange for benefits. While there are currently no formal PES schemes established in Indonesia, they have been increasingly discussed as a policy option. For example, Rewarding Upland Poor for Environmental Services (RUPES), a project established by the World Agroforestry Centre (ICRAF) is experimenting with various schemes around the country (see Arifin, 2005). Given the tremendous scope of logging in Indonesia, PES is a potential alternative to communities deciding on forest use. Moreover, given the relatively small amounts of logging fees received by communities (starting at little more than a quarter USD per m^3), it would appear that PES could achieve forest conservation at low cost. As we will show below, however, implementing effective PES in this context may be considerably more costly than this intuition would suggest.

3. Conceptual model

In the presence of commercial actors like logging firms and insecure property rights, the design of an effective and efficient PES scheme as an alternative to logging benefits requires an understanding of the interactions between communities and loggers. In this section, we present the intuition behind a game-theoretic model of these interactions, following Engel, López and Palmer (2006).[5] We simplify and apply this model in that we do not allow for endogenous policy interventions and by considering logging areas as exogenously given. Rather, in

[3] These are either known as Timber Extraction and Utilization Permits (*Izin Pemungutan dan Pemanfaatan Kayu* or IPPK) or Rights to the Harvesting of Forest Products (*Hak Pemungutan Hasil Hutan* or HPHH). Although central government banned these permits in 2000, many districts continued to issue them until 2002–03 and they continued to be perceived as 'legal' at least from the local perspective.

[4] The exchange used here and in the remainder of the article is IDR 9,000: USD 1.00.

[5] A more general version of the model is developed in Engel and López (2004).

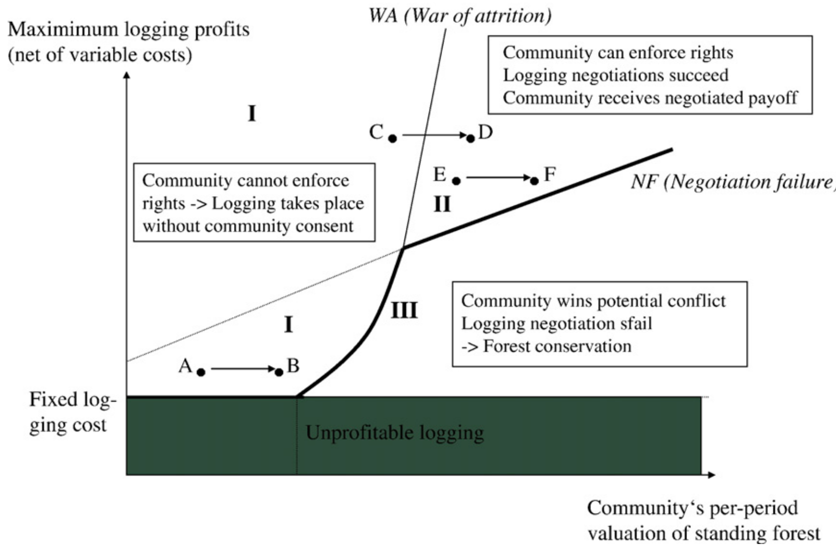

Fig. 1 – PES and the outcomes from community–firm interactions.

this paper, we focus on community payoffs and analyze the impacts of a specific intervention, PES, on community–firm interactions.

The model links conflict and bargaining theory. We argue that in a context of weak property rights, the community's ability to self-enforce its rights over the forest is crucial for understanding its performance in negotiating a logging agreement. Conflict theory, by modeling what would happen in the absence of negotiations, sheds some light on this self-enforcement ability. The results are then incorporated into bargaining theory to analyze why some communities receive higher payoffs from logging agreements than other communities, and to predict under which conditions negotiations will succeed or fail. In what follows we present the model and its main results in intuitive terms; formal derivations are presented in Engel, López and Palmer (ibid). In Section 4, we consider the impacts of PES in our model.

3.1. *Conflict theory and property rights formation*

De facto property rights are modeled as the outcome of a "war of attrition" between a logging company (referred to as 'the firm' hereafter) and a community. Our model and is similar to the one presented by Burton (2004). Conflict theory (see Dixit and Nalebuff, 1991) usually assumes the existence of two actors. In our case one of the actors (the firm) has the ability to exploit the resource while the other (the community) may under some circumstances prevent such exploitation.[6] Logging requires a specific factor (capital) that is available to the firm but not to the community.[7] The possibility of bargaining arises from the complementarity between the firm and the community in terms of access to the factors of production required for logging, with the community potentially controlling access to the forest. For simplicity it is assumed that both actors have perfect information about each other's parameters. This implies that the player that would lose the conflict withdraws immediately.[8]

Because the model assumes weak community property rights, each of the actors can in principle obtain *de facto* rights over the forest, e.g. the firm may unilaterally exploit the forest if it has enough power to win a potential conflict with the community, or the community may prevent that if the power conditions are reversed. The former case has been observed through firms exploiting the community through poor deals or non-compliance with agreements in East Kalimantan (see Palmer, 2006). The latter case has also been observed, with half of the communities experiencing conflict (e.g., in the form of community blockades) with their respective firms due to contractual non-compliance. Our model assumes that the community can set up a blockade in any given period and that doing so is always effective in preventing logging in that period.[9] Yet blockading is costly to the community as it requires collective action and time. In each period that the community is able to stop the firm's operations it obtains use and non-use values from the undisturbed forest. If, however, the firm wins the conflict it receives profits from logging unilaterally.

In general, the war of attrition is won by the actor that is able to stay in a potential conflict longer. This will depend on the actors' costs of fighting, their benefits from winning the conflict, and their time preferences (discount rates). The boundary condition can be seen as line WA in Fig. 1, where the horizontal axis of the figure depicts the community's per-period valuation of the benefits from the standing forest,

[6] See Burton (2004), Alston et al. (1999) and Angelsen (2001) for applications of conflict theory.

[7] Communities tend to have low savings and a disadvantage in the credit market *vis-à-vis* the firm, associated with capital market imperfections (see Bose, 1998).

[8] With imperfect information, actual conflict is possible, but the outcome will generally depend on the same parameters listed here. See Burton (2004) for a related model with imperfect information.

[9] It should be noted that where blockades occur there may also be some reputational damage to the firm, at least at the local level. In the context of decentralization and community empowerment in Indonesia, local firms build and maintain political capital with local government officials, typically through formal and informal payments as well as the provision of some level of benefits to communities (Palmer, 2006).

while the vertical axis represents the firm's maximized profits (net of variable costs) from logging unilaterally. For points above and to the left of the boundary condition, the firm is able to stay in the conflict longer than the community and thus wins the conflict, while for points below and to the right of WA the community would win the conflict and thereby effectively exert its property rights over the forest. To understand the intuition behind the shape of WA, consider first the case where the benefits from the standing forest to the community are so low that the cost of blockading even one period already exceeds the value obtained from protecting the standing forest forever. Here, the community will never fight and the firm will simply go ahead and log as long as logging is profitable.[10] This case is represented by the horizontal part of WA. Now consider the case where the community's benefits from protecting the standing forest for just one period are so high as to already outweigh the costs of blockading in that period. In this case, the community will always fight, and the firm, knowing this, will withdraw. This is why WA approaches a vertical line. For intermediate values of the community's benefits from the standing forest, the boundary condition is derived by computing for each actor the maximum time that he can stay in conflict and still receive a non-negative payoff, and by then equating these maximum times. The exact location of WA will depend on model parameters.

As stated above, for points above and to the left of WA, the firm wins the conflict. In this case the firm effectively has access to both the forest and capital and thus is able to exploit the forest unilaterally without community consent (area I). For points below and to the right of WA, the community is able to stay in conflict longer than the firm, and thus is able to self-enforce its property rights over the resource. In this case, two outcomes are possible. The community may prevent logging altogether (area III), or it may bargain with the firm over a logging agreement (area II). In Section 3.4 below we discuss the boundary condition between areas II and III. For now, note that the community is more likely to win a potential conflict with the firm (and thus obtain *de facto* rights over the forest) if logging profits are low or if the community's valuation of the standing forest is high. Intuitively, an increase in an actor's benefits from winning (profits for the firm, and benefits from the standing forest for the community) allows this actor to stay in conflict longer, and thereby raises the likelihood that he is able to win the conflict. Moreover, an increase in fighting costs (logging costs for the firm, blockading costs for the community) lowers the ability of an actor to stay in conflict. Similarly, an increase in an actor's discount rate induces him to value the immediate fighting costs more than the long-run benefits from winning thereby reducing the maximum length of time this actor would stay in conflict and thus his chances of winning.[11]

[10] If logging is not profitable, the firm will not log. In this case the forest is conserved; the result then is equivalent to the community winning the war of attrition even though the community would not have fought if the firm had attempted logging.

[11] Thus, the community is more likely to win the attrition war if blockading costs and the community's discount rate are low, and/or if logging costs and the firm's discount rate are high. All of these conditions effectively shift the location of boundary condition *BC 1* in Fig. 1 to the left.

3.2. Community–company bargaining over a logging agreement

Negotiations over a logging agreement are only feasible if the community is able to win a potential conflict with the firm. Otherwise (in area I in Fig. 1), the community would effectively lose its property rights over the forest; the firm would have access to both factors of production (capital and forest) and would have no incentive to share logging profits in a negotiated agreement.[12] We now focus on the case where the community is able to enforce its property rights over the forest by winning a potential conflict with the firm. In this case, there is scope for bargaining over a joint logging agreement, because the firm has access to capital while the community effectively controls the resource base. The negotiation outcome can be presented in the form of an asymmetric Nash Bargaining Solution (NBS), which implies that each player obtains his reservation utility, and the remaining surplus is divided in proportion to bargaining power. Thus, community payoffs increase as the 'size of the cake' (given by the net profits from logging), the community's bargaining power, and the community's reservation utility increase. Community payoffs decrease as the firm's bargaining power and the firm's reservation utility increase. The community's bargaining power *vis-á-vis* the firm is generally higher the lower its discount rate, and the higher the firm's discount rate, but may also depend on other factors. Reservation utilities on the other hand are the outcomes that would result in the absence of negotiations. This is where the conflict outcomes come in. When the community is able to win a potential conflict, in the absence of negotiations the community would protect its property rights to the forest and prevent any logging by the firm. The community's reservation utility would therefore be the present value of its benefits from the standing forest forever, while the firm's would be its net profits from using its capital in the next-best alternative activity. Thus, community payoffs in a negotiated agreement are likely to be increasing in the community's valuation of the standing forest and decreasing in the firm's profits from its next-best activity.

3.3. Combining results

Engel and Palmer (2006) combine the results of the two stages and use Indonesian data on payoffs and on proxies for the various model parameters to test the resulting hypotheses through econometric analysis. In general, their analysis supports the theoretical model's predictions. Most importantly for our context of PES, they find that communities that value the forest more, in particular those that derive a large proportion of their income from the forest, are more likely to obtain higher payoffs, both because they have a greater ability

[12] In reality, a *pro forma* agreement may still be negotiated and a minimum payment made to the community in order for the firm to maintain political capital with the local government (Palmer, 2006). This could be easily incorporated in the model of Engel, López and Palmer (2006), but would not affect the qualitative results that are of relevance for our purposes.

to self-enforce property rights and because they request more compensation for environmental losses.

One approach for PES design would be to use these results to predict communities' expected payoffs from logging deals, and to use these predictions as a proxy for communities' opportunity costs. Thus, given data on model parameters for potential PES communities, the results could be used to predict where on the observed range of USD0.30 to 11.80 per m^3 of timber extracted the communities' expected payoffs under a logging agreement would be likely to lie. Payments under a PES scheme should then be at least as large as these expected payoffs. Moreover, if the objective of the scheme is to maximize environmental service provision with a given budget, and if we assume that environmental services per hectare are approximately equal across communities, we might find it most efficient to choose those communities for PES that have the lowest expected payoffs from a potential logging agreement, i.e., those communities with expected payoffs at the lower end (around USD0.28 per m^3).[13] However, as we will see in Section 4, such an approach would be neither effective nor efficient. To consider effective PES design, we need to go one step further and consider corner solutions to the bargaining game, i.e., conditions for negotiations to fail. These are discussed next.

3.4. *Negotiation failure*

Negotiations will fail and the players simply obtain their reservation utilities if the sum of both players' reservation utilities exceeds the 'size of the cake' to be divided in a negotiated agreement. The boundary condition determining the success or failure of logging negotiations is represented by the line NF in Fig. 1. Again, this line is only relevant in the case where the community can win a potential conflict with the firm. Mathematically, this line represents all points where the sum of both actors' reservation utilities (i.e., the present value of the standing forest to the community and the firm's profits in its next best activity) just equals the 'size of the cake' (firm's maximized net profits minus fixed logging costs).

In summary the two boundary conditions in Fig. 1 yield three potential outcomes of community–firm interactions. First, the firm may be able to effectively control both capital and the forest resource, resulting in unilateral logging without community consent and little or no community payoffs (area I in Fig. 1). Second, the community may be able to self-enforce its rights over the forest and this may result in a negotiated logging agreement between the community and the firm (area II). In this case, community payoffs are increasing in the community's valuation of the standing forest. Third, the community may be able to self-enforce its rights over the forest, but its valuation of the standing forest may be so high or logging profits so low, that there is no negotiated outcome that both actors would agree to. In this case, negotiations would fail and the forest would be preserved (area III).

4. Implications for PES design

4.1. *Effective PES design*

How does PES affect the outcomes of community–firm interactions, and what does this imply for PES design? In the absence of PES, the community's valuation of the standing forest may include direct uses of the forest (e.g., the collection of fuelwood and non-timber forest products); it may also consider ecological services from the standing forest that benefit them (e.g., erosion prevention, water retention) as well as non-use values (e.g., the cultural value of living near forest)[14]. The introduction of PES adds an additional value to the standing forest for those communities receiving PES. This value may reflect all or part of the benefits from the forest obtained by society at large. For simplicity, we assume that PES is simply for conservation of standing forest and not for any specified service such as carbon or biodiversity. Thus, the per-period payment made under PES is conditional on the conservation of the forest. The conditions for PES to be an effective intervention for forest conservation can be summarized as follows.[15]

i. The community, given PES, needs to be able to win a potential conflict with the firm (Boundary condition WA). Otherwise the firm can log despite PES agreement.
ii. PES needs to induce a breakdown of any potential logging agreement — (Boundary condition NF). Otherwise PES would only raise community payoffs from logging.
iii. PES needs to focus on communities where logging is likely to occur in the absence of PES (i.e., communities initially located in area I or II). Otherwise PES fails to induce additionality, i.e. additional environmental benefits.

We now discuss the intuition behind each condition and its implications in detail.

Condition (i) states that the community, given PES, has to be able to effectively enforce its property rights over the forest. If this condition is not satisfied then PES may not be an effective tool for forest conservation. To see this, consider a community initially located at point A in Fig. 1. Introducing PES would raise the community's per-period valuation of the standing forest and thus induce a horizontal shift to the right to point B. The length of the horizontal shift equals the per period net amount of PES. The community would now prefer conservation over a negotiated agreement (since point B is located to the right of boundary condition NF). However, since point B is still located in area I, the community is unable to win

[13] Of course, in practice environmental services provided by a hectare of standing forest may differ according to geographic and ecological conditions. These aspects are beyond the scope of this paper.

[14] For example, in a recent meta-analysis of 54 case studies on the value of forest resources to the rural poor, Vedeld et al. (2004) showed that the average annual household income from forest resources varied from USD0 to USD3458.

[15] Formal derivations can be seen in Engel and Palmer (2005). Note that we also assume a constant conservation value of forest across communities.

a potential conflict with the firm and hence cannot enforce its property rights over the forest. Therefore, the logging firm logs unilaterally and PES is ineffective. This case highlights the fact that for any PES contract to be effective, the contracting party needs to be able to enforce its property rights over the forest covered in the contract. Intuitively, while PES increases the benefits of the standing forest to the community, this increase may not be sufficient to enable the community to self-enforce its rights over the forest. In the absence of external enforcement, this implies that PES needs to increase the community's valuation of the standing forest sufficiently so that it is now to the right of boundary condition WA, i.e., where the community is able to self-enforce property rights over the forest and prevent the firm from logging unilaterally (condition (i)). Note also that our results imply that introducing PES in situations of weak property rights need not be futile. Rather, if PES raises the value of the standing forest sufficiently it can help to induce the community to successfully enforce its property rights (i.e., property rights are endogenous to PES).

Condition (ii) states that the community needs to be better off under PES than under the most favorable potential logging agreement. Thus, to be effective, PES needs to induce a shift into area III, irrespective of the community's starting point in Fig. 1. In area III, the community is able to self-enforce its rights over the forest, and the community's reservation utility is high enough to induce logging negotiations to fail, i.e. 'the cake' from logging becomes too small to compensate both actors for the loss of their reservation utilities. To illustrate the importance of condition (ii) consider a community initially located at point C in Fig. 1. As before, the community cannot enforce its rights over the forest prior to PES implementation. Suppose PES is introduced to shift the community to point D in the figure. Then, the introduction of PES enables the community to self-enforce its property rights over the forest. Nevertheless, PES fails to induce forest conservation, since point D is located in area II. The community uses its newly achieved self-enforcement ability to negotiate a logging agreement and share in the financial benefits from logging. Thus, PES leads to a community–firm logging agreement, but is ineffective in achieving forest conservation. Similarly, consider a community initially located at point E in Fig. 1. Suppose PES induces a shift to point F. Then, PES raises the community's reservation utility leading it to negotiate a better logging deal, since point F is still located in area II. In other words, the introduction of PES simply results in the firm offering a better deal than it would have done in the absence of PES. Again, PES is ineffective in achieving forest conservation. Note, however, that in both cases the community will be financially better off with PES than compared to the case without PES. Thus, PES would have an impact, but not in terms of forest conservation.

Condition (iii) indicates that to achieve additionality, environmental service buyers should focus on communities that, prior to PES introduction, are located in areas I or II. In communities where logging is unprofitable, the forest would be conserved anyway and there would be no additionality from offering PES. The same holds for communities initially located in area III; these communities, in the absence of PES, already value the forest so highly in comparison to logging profits that they would reject any logging agreement anyway.

In summary, PES–by raising the community's valuation of the standing forest–has two effects in our setting. First, it raises the community's ability to win a potential conflict with the firm, thereby increasing its ability to self-enforce property rights to the forest. Second, it increases the community's valuation of the standing forest, raising the community's reservation utility and thereby its expected payoff in negotiations over a logging deal. Essentially this happens because the firm, realizing that the community's reservation utility has improved through PES, will also raise its offer to the community. This happens unless (or until) PES is high enough such that the community prefers forest conservation (thus receiving PES as well as its own value of the standing forest) over even the best possible offer by the firm.

4.2. *Achieving efficiency*

Note that condition (ii) implies that the level of PES necessary to induce effective forest conservation is *not* the current actual logging payment (an average of approx. USD3.60 per m^3 in our sample). Our results imply that basing PES amounts on currently observed logging fees may only allow communities to negotiate better logging deals, but may not be effective in achieving a real increase in environmental service provision.[16] Rather, the payment required depends on the maximum that the logging firm would ever offer. This maximum possible offer by the firm is likely to be unobserved and may substantially exceed the maximum payment observed in the field (USD11.80 per m^3 of timber). Note that the firm is able to raise its offer as long as it can still retain enough logging profit to be better off than under its next-best activity. To be precise, the periodic PES amount should equal the per-period equivalent of the firm's highest potential offer (i.e., all logging profits in excess of its reservation profit) minus the per-period value of the standing forest to the community (because the latter would still be available to the community under a PES agreement).

Let us now turn to the issue of efficiency, i.e. how a PES scheme can maximize environmental service provision with a given budget. Again, for simplicity, we assume that the environmental services provided by a hectare of forest are the same in all communities.

To be effective, the PES payment has to be large enough to induce a shift from area I or II into area III. From Fig. 1, such a shift could be achieved at low cost for communities close to, but to the left of the thick line reflecting the binding condition among the two boundary conditions. Note, however, that the communities close to and to the left of the thick line are not necessarily the communities with the lowest expected payoffs from a negotiated agreement. In fact, at least within area II,

[16] Our model assumes homogenous conservation benefits and scarcity of forest areas leading to competition between conservation and logging. If forest areas are large enough so that the amount of forest that is of high value for conservation is a small proportion of it and firms have the option to shift extraction elsewhere, then targeting PES offers to these high-value areas may not induce firms to raise their offers in these areas. Rather, logging would be displaced to areas of lower conservation value.

these are the communities with the highest expected payoffs prior to PES. Points in area I do reflect communities with the lowest expected payoffs, but unless located close to the thick line a small payment would fail to induce effective PES as communities would not be able to enforce forest conservation.

Finally, it should be noted that where PES is ineffective, it is not necessarily inefficient. If a low-payoff community in area I is offered a PES that is insufficient to shift it into area III, it will be unable to enforce its property rights and the forest will be logged. As a consequence, it may not receive any payment, i.e. the PES program will have achieved zero benefit, but will do so at zero cost, with the budget remaining available for other uses. In reality, however, initial payments may be made prior to the first observable conservation outcome. Moreover, the transaction costs of negotiating PES contracts with communities that are ultimately ineffective may be high. Hence, it would be more efficient to target those communities where PES contracts are likely to be effective. This raises the question how the theoretical results presented above can be used to guide PES design empirically.

5. Empirical application

As shown in Section 4, PES design would require an understanding about the location of communities in terms of the areas in Fig. 1. In particular, we need an estimate of the starting location (without PES) of a potential PES candidate community relative to the two boundary conditions for the war of attrition and for negotiation failure. We now use our Indonesian data described earlier to illustrate how the theoretical results could be combined with empirical analysis to guide PES design. It should be noted, however, that our data were originally collected for a different purpose and thus the application to this purpose is lacking in many regards. The application below is thus merely illustrative.

Palmer (2006) used data on the financial payments received by the 62 communities surveyed to analyze the probability of these communities falling either into area I or II. A minimum payment of USD1.70 per m^3 of log production was established as the cutoff point on the basis of this being the lowest *negotiated* payment in the sample. He interprets this as the minimum acceptable payment. *Actual* payments frequently differed from negotiated payments. Palmer (2006) assumed that an actual payment below the minimum acceptable amount indicates that the community was unable to self-enforce its logging agreement *vis-à-vis* the firm and hence, its property rights over the forest. 19 communities (31% of the sample) received a fee level that came below this threshold, while the remainder received USD1.70 or more per m^3. A sensitivity analysis varying the level of the threshold was conducted to test the robustness of the results to this assumption. Given the discrete nature of the dependent variable, a logit model was run on a combination of proxies for the theoretically relevant parameters with the dependent variable equal to 1 where the community received a payment above the USD1.70 threshold (and hence, is assumed to fall into area II) and equal to zero otherwise (assumed to fall into area I). Table 1 below shows the results of the econometric analysis.

Table 1 – Econometric results on probability of community being able to enforce property rights

Variable	Coefficient	Standard error	t-stat.	P[|T|>t]
Constant	−3.2680	2.6455	−1.235	0.2167
Average proportion of household incomes derived from sale of forest products	0.1587	0.2272	0.698	0.4850
Forest quality: area logged before by commercial operation (Yes=1, No=0)	2.1276	1.1978	1.776	0.0757*
Actual area logged (ha)	−0.0096	0.0044	−2.154	0.0312**
Proportion of households containing at least one government employee	−0.7598	0.5081	−1.495	0.1348
Proportion of households that participate in community organizations	0.7434	0.3270	2.273	0.0230**
Proportion of households containing members of dominant ethnic grouping	0.3034	0.2534	1.198	0.2311
Distance to nearest market (km)	−0.2566	0.1570	−1.635	0.1021
Proportion of households holding savings before agreement	0.1267	0.5515	2.298	0.0216**
No. of observations	62			
Restricted log likelihood	−38.2			
Chi-squared	37.8			
% of outcomes predicted correctly	71.0			

Source: Palmer (2006).
Note: *significant at 0.10 level; **significant at 0.05 level. All results corrected for heteroskedasticity.

The results generally confirm the theoretical hypotheses presented in Section 3.1. Community blockading costs were proxied by the proportion of households participating in community organizations and the proportion of households containing members of dominant ethnic groupings (both variables proxy for social capital), the proportion of households with government employees and distance to the market (both proxy for opportunity costs).[17] The directions of the effects in Table 1 are in accordance with the predictions of the theoretical model, i.e., the probability of a community being able to enforce its rights over the forest is decreasing in the

[17] In the Indonesian context, where all households go to the market regularly to sell excess produce for cash income regardless of distance, and where other market opportunities for work are negligible, opportunity costs are likely to increase with distance to the market (Palmer, 2006). This is in contrast to other contexts where household participation is elastic to distance from market and therefore greater distance implies lower opportunity costs.

community's blockading costs. Only household participation in community organizations and market distance are statistically significant, however. Community discount rates were proxied by the proportion of households holding savings before the onset of negotiations, with poorer communities expected to have higher discount rates. The results indicate a significant positive effect on the ability of communities to enforce their property rights, supporting the theoretical hypothesis that lower discount rates are associated with an improved ability to fight. Average household incomes derived from forest products proxied for community valuation of the standing forest. As expected the effect was positive, although not significant. This may be due to the fact that the variable reflects a percentage of total income rather than the absolute value of income derived from forest products. Finally, the probability of a community being able to enforce property rights significantly increases if the community's forest was logged before and is significantly decreasing in the size of the area logged. Both of these factors are proxies for logging profitability. The model correctly predicts 71% of the observations. The results can be used to assess the location of a community relative to boundary condition WA as follows. If estimates of the explanatory variables are available for the community[18], one can use the regression results to compute the predicted probability of that community to be able to enforce its property rights over the forest. If the probability is less than 0.5, the community would be expected to be located in area I (with values closer to 0.5 being located closer to WA), otherwise it would be expected to be located in area II or III.

While our analysis provides empirical support to the theoretical model and illustrates how the location of a community relative to WA could be estimated using empirical data, a few words of caution are in order. Most important, due to the original research focus on the factors underlying the variation in outcomes from these agreements, the communities sampled in this survey had all been involved in negotiations with logging companies leading to an agreement between the parties (see Engel and Palmer, 2006; Palmer, 2006). Thus, it is likely that area I communities were undersampled and additional data would be required to improve our analysis. Moreover, proxies used were often not ideal (as, for example, in the case of community valuation of the standing forest) or missing altogether (as was the case for firm discount rates and logging costs). The latter could potentially introduce omitted-variable bias, although it is not unreasonable to assume that in our context firm parameters did not vary much across the sample.

What about boundary condition NF? Unfortunately, due to the focus of our fieldwork on negotiated agreements, data were not available on communities falling into area III, although there was anecdotal evidence for at least two communities that had declined all offers for logging agreements, opting for forest conservation instead (for one of these cases, see Iwan, 2004). Similar to the analysis on areas I and II, which yields the boundary condition for the war of attrition, the collection of data on communities falling in area III would allow us to estimate the predicted probability for negotiation failure. The dependent variable in this case would be a dummy indicating whether a community opted for forest conservation or for a logging agreement. The results in Section 3.4 indicate that relevant explanatory variables should include proxies for net logging profits, the community's present value of the standing forest (which itself depends on the community's per-period valuation of the standing forest and its discount rate), and the firm's alternative investment opportunities (which may be proxied by market interest rates).

If more complete data were collected the following procedure could be used in PES design. Data on the empirically relevant independent variables for all communities that could be potentially included in a PES scheme would need to be collected. Alternatively, communities could be required to self-report these characteristics when applying for PES.[19] The econometric results could then be used to estimate each community's predicted probabilities of (a) winning a war of attrition, and (b) opting for forest conservation (probability of negotiation failure). We would then want to consider those communities for PES that satisfy two conditions. First, they should have one of the two predicted probabilities greater than 0.5 (indicating that they lie on the right of one of the boundary conditions). Second, the other predicted probability should be below, but close to 0.5 (indicating that the community lies close to and to the left of the other boundary condition). In summary, these conditions imply that the communities lie to the left, but close to the thick line in Fig. 1.

Estimating the payment required to induce the selected communities to opt for PES and forest conservation is an even more complex task. Our results indicated that this minimum payment depends on model parameters.

In practice, there are obvious logistical and financial constraints in collecting all the data required for the design of the PES scheme. Perhaps more promisingly, an approach like the one described above could be used to identify communities predicted to lie in area III (namely those with predicted values greater than 0.5 in both regressions). These communities should not be considered for PES design to assure additionality. For the remaining communities under consideration, auction or contract design could be used to elicit their opportunity costs (see article by Ferraro in this volume).[20]

6. Conclusions

We have analyzed PES design in a context where community property rights over the forest are weak and logging companies interested in the commercial exploitation of the forest are present. Our starting point was the common intuition that PES should compensate communities for their expected logging payoffs, and that an efficient PES design should focus on those

[18] If only estimates on some of the variables are available, the average observed sample value could be used for the other variables for simplicity.

[19] Of course, self-reporting may induce problems of asymmetric information. This is an important issue that is beyond the scope of this paper.

[20] Auction design would, however, require that communities are aware of the firm's potential to raise its payments.

communities with the lowest expected logging payoffs. Based on the observation from fieldwork that actual payoffs vary greatly among communities involved in logging agreements, we presented a game-theoretic model of community–firm interactions that provides a potential explanation on the causes of this variation.

We then analyzed the model's implications for effective and efficient PES design in the context of weak property rights and commercial interests. The results indicate that the common intuition is misleading for two main reasons. First, communities with very low expected payoffs from negotiations tend also to be those that are not able to self-enforce property rights and prevent unilateral forest exploitation by firms. Therefore, PES agreements with these communities may not be effective. Second, the introduction of PES affects communities' valuations of the standing forest. This will not only impact on the community's ability to self-enforce its property rights, but may also affect its expected payoff from a negotiated agreement. If this endogeneity of community payoffs is ignored, the implementation of PES may result in better logging deals for local communities, without achieving forest conservation. That said, better logging deals for communities could well have a positive welfare impact.

Of course a PES agent can also renegotiate and raise its offer with respect to the firm, although given the rents available in logging this implies that the costs of an effective PES scheme could potentially be much higher than expected from considering currently observed logging fees. Much depends on the starting point of the community and how much it values the standing forest. It should also be noted that this problem is not unique to PES; any conservation program that attempts to use positive incentives will suffer from a similar problem in that the value of the required incentive may need to exceed the foregone logging fees. Even if PES were more costly and less effective than originally thought, it may thus still be more effective and/or efficient than alternative conservation approaches.

We have also illustrated how the theoretical results could be used in empirical analysis to guide PES design. Further research on how to reduce transaction costs in such an endeavor is needed. In particular, auction design may be an alternative to solicit opportunity costs. The theoretical and empirical results presented here could guide such design, for example in helping to ensure additionality.

An important positive result of our analysis is that PES design is not necessarily futile where property rights are weak, as often assumed by practitioners. Rather our analysis highlights the fact that property rights may be endogenous, and that the introduction of PES, by raising the value of natural resources to local communities may enhance their ability to enforce their property rights.

Overall, our analysis highlights that designing an effective and efficient PES scheme is a very complex task and that it requires an understanding of the details of the local context.

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