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Performance Bonds in Tropical Timber Concessions: Encouraging the Adoption of Reduced Impact Logging Techniques

Kuusela, O.-P.[1], Amacher, G.S.[2] and Moeltner, K.[3]

[1,2] Virginia Tech, Department of Forest Resources and Environmental Conservation, 313 Cheatham Hall Blacksburg, VA 24061, USA, opkuusela@vt.edu, gamacher@vt.edu

[3] Virginia Tech, Department of Agricultural and Applied Economics, 208 Hutcheson Hall (0401), Blacksburg Va 24061 USA (moeltner@vt.edu)

Abstract

We examine the use of performance bonds in tropical forest concessions. Bonds are a promising new policy instrument that have been discussed in several articles and used in some cases as a way of encouraging adoption of sustainable forest management practices, including reduced impact logging methods, and have been proposed due to apparent failures of traditional Pigouvian instruments. Our research examines the impact of three practical complications hindering the effective adoption of bonding schemes: harvester participation constraints, government repayment risk, and imperfect enforcement. By building a simple two-stage analytical model, we first highlight the role of participation constraints in the concession bond design problem. Model simulations are used to examine policy implications such as potential for REDD+ payments in improving the bonding outcomes, and how high these payments should be in order to guarantee full compliance with reduced impact logging.

Keywords: Environmental Bonds, Capital Constraints, Sustainable Forest Management, RIL, REDD+

1 Introduction

Poor design and harvesting practices in industrial timber concessions are commonly identified as significant, albeit indirect, causes of tropical deforestation. High grading, illegal logging, and collateral stand damages have led to forest degradation, whereas roads have provided access routes to slash-and-burn agriculture and ensuing deforestation. The standard way governments have regulated these actions is through taxes, or royalties, for harvesting either based on volume or area, with the idea of seeking a first best Pigouvian solution. Many, including Ruzicka (2010) recently, have argued for a better evaluation of the obstacles hindering the use of non-tax market alternatives such as bonding in concession design.

Forest concessions typically involve the government allocating the forest use rights to a private concessionaire or contracting with a firm for forest management services, all of which require firms to fulfill a wide range of contract clauses (Gray 2002, Karsenty et al. 2008). The main challenge facing the government is how to guarantee concessionaires' adherence to contract rules in an institutional setting characterized by imperfect enforcement and omnipresent corruption, all of which impede tropical developing governments from managing concession design (e.g., Amacher et al. 2007). Environmental performance bonds have received some attention in the literature as a promising complement to royalties for governments seeking to both capture rents and ensure harvesters follow concessions rules (e.g., Ruzicka 2010, Macpherson et al. 2010, Leruth et al. 2001, Boscolo and Vincent 2000, Paris et al. 1994). The idea is that performance bonds create a stronger incentive for harvesters to comply with concession rules and at the same time provide the government with critical funds to compensate for environmental damages when they occur.[1] Bonds have not, however, gained much traction in practice for a wide variety of reasons. At the most basic level, setting "the right" bond payment has been difficult. In developing countries frequently listed obstacles to bonding include bond repayment risk and concessionaires' liquidity constraints.

The purpose of our research is to examine the properties of performance bond schemes and to identify their potential shortcomings in the context of Reduced Impact Logging (RIL) standards for forest concessions. Previously, Boscolo and Vincent (2000) and Macpherson et al. (2010) have examined the effectiveness of bonds in enforcing RIL standards, whereas Boltz et al. (2003) conclude that the harvesters may not fully implement RIL techniques without additional incentives. Our novel contribution is to concentrate on three well-identified complications: liquidity (credit) constraints on the part of the harvester, imperfect enforcement, and repayment risk stemming from the government's potential inability to pay back the bond at the end of the concession.[2]

Credit constraints are caused by "thin" financial markets, a condition prevalent in many tropical countries, that prevents smaller scale concessionaires from sufficient collateral needed to obtain credit in the first place (Simula et al. 2002; Canby and Raditz 2006; Pescott et al. 2010; Grossheim 2011). Imperfect enforcement has been frequently identified as one of the most problematic features of tropical timber concessions, either due to poor monitoring, inadequate judicial systems, corrupt governments, and vast land areas provide a suitable environment for low enforcement, contract violations and illegal logging (Callister 1999; Hardner and Rice 2000; Contreras-Hermosilla 2002; Amacher et al 2012). Repayment risk stems partly from unpredictable institutional arrangements typical of many of the tropical countries. Governments may not be able honor promises to repay the bond at the end of the concession contract, or bureaucratic red tape may make repayment time unreasonably long. Institutional uncertainty causes skepticism especially with respect to the transparency and fairness of the final assessment method (Merry and Amacher 2005). Credit constraints are further exacerbated by the presence of such concerns since creditors may require a higher risk premium, or they will simply refuse to extend credit**.**

[1] Leruth et al. (2001) advocate the use of performance bonding arguing that they reduce public monitoring costs by relying mainly on a final inspection. Mathis and Baker (2002) track the fundamental concept of "assurance" schemes to "materials-use fees" originating from Solow (1971) and Mills (1972). Other examples come from refundable deposit schemes in beverage industry (Sterner 2003) and mine reclamation in the U.S**.** and Australia (Sullivan and Amacher 2009).

[2] Shogren et al. (1993) list moral hazard, liquidity constraints, and legal restrictions on contracts as potential disadvantages associated with performance bonds in environmental regulation.

[2] See for example Karsenty (2010), Merry and Amacher (2005), Paris et al. (1994), Leruth et al. (2001) and Macpherson et al. (2010). Particularly relevant for our study, Leruth et al. (2001) show that royalty rates may fail to encourage the adoption of environmentally less harmful logging practices pointing out that the negative externality is only weakly related to the quantity harvested, thus rendering the classical Pigouvian solution ineffective. Instead of improving the harvest method, the concessionaire may simply cut costs by adopting an even more harmful harvest technology.

In the context of industrial logging concessions, performance bonds have been actively discussed for the past two decades as an alternative to poorly designed royalty systems that are not effective at capturing rents or creating incentives for sustainable harvesting, at least since Paris et al. (1994).[3] While there have been some actual experiments with forest concession performance bonds in The Philippines and Malaysia during the 1990's, the policy outcomes were disappointing. Too low of an initial bond payment has been faulted as the main cause for policy failure (Moura Costa, 1999). Ruzicka (2010), however, argues that performance bonding schemes have never really been tried properly and calls for further investigation of their potential for concessions. Boscolo and Vincent (2000) and more recently Macpherson et al. (2010) investigate the effectiveness of performance bonding schemes and renewability audits in industrial forest concessions using simulation studies which link their analytical model to practical data. Both studies find that performance bonding schemes can be successfully used to enforce reduced impact logging practices in forest management. Based on their simulation analysis, Macpherson et al. (2012) conjecture that although RIL is found to be superior in comparison to conventional logging methods in net present value terms, concession loggers may still choose to only partially adopt RIL and instead use harvest practices that directly improve profitability. For example, Putz et al (2008) observe that logging companies employ few forest engineers and few foresters and thus have insufficient competency in RIL techniques.

2 Concessions Bond Model with Participation Constraint

We next proceed by setting up the simplest analytical model where the government owns a forest stand, the concessionaire is a privately-owned firm, henceforth called the concession harvester, and there are reduced impact logging (RIL) standards within the concession contract that specify a list of preharvest procedures and harvesting techniques required of the firm.[4] The goal of the government is to achieve the highest possible level of compliance with the RIL standards.[5] Following Boscolo and Vincent (2000) and Macpherson et al. (2010), we define a continuous index variable $x \in [0,1]$ that represents the exact extent of RIL compliance by the harvester. The lower bound, $\underline{x} = 0$, means zero compliance, and the upper bound, $\overline{x} = 1$, means full compliance. Hence, the index variable x can be thought of as simply the percentage of compliance with RIL standards. Conversely, $1 - x$ denotes the extent of noncompliance with the contract rules governing the concession.

[4] For a fully detailed model, see Kuusela et al. (2012).

[5] Putz et al (2008) define reduced impact logging as "intensively planned and carefully controlled timber harvesting conducted by trained workers in ways that minimize the deleterious impacts of logging." De Blas and Pérez (2008) provide the following list defining RIL requirements: the delimitation of protected forests within concessions; the determination and use of minimum tree diameter at breast height (dbh); the development of a management plan and a logging inventory; minimizing the width and density of the logging roads network; planning of logging roads; setting a maximum ceiling on number of trees felled by hectare; use of directional felling; optimizing timber transport roads network; and planning of timber yards.

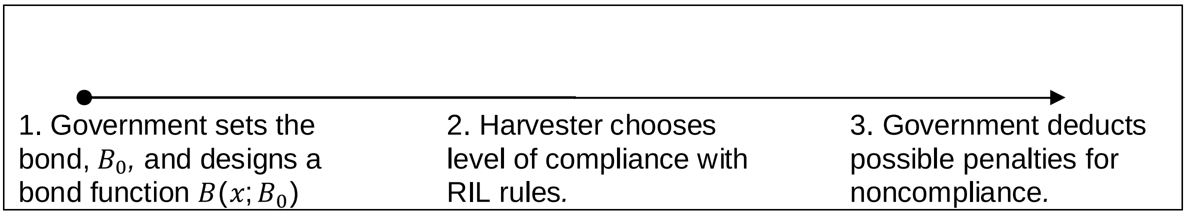

Fig. 1. Timing of effects in the concession model

The concession harvester's goal is to minimize its compliance costs. The harvester's convex RIL cost function is defined as $c(x)$ which is increasing and continuously differentiable over a convex and closed set $[0,1]$. Private RIL costs include capital and labor related costs as well as any other related opportunity cost (these may include forgone profits from not engaging in illegal activity).[6] We assume that $c(0) = 0$ holds, although this is not critical. The interpretation for the convex cost function is that the final RIL activities, such as retaining some of the most valuable species standing in the forest, are much costlier to the harvester than initial site preparation work such as road building and mapping. Finally, we assume the information on the shape of the cost function, $c(x)$, is symmetric knowledge (Amacher and Malik, 1998). This assumption is realistic as RIL requirements are usually designed by NGOs, are typically known and common knowledge, and the information on the costs of compliance is often readily accessible and part of extension activities in tropical concession countries.

To enforce RIL standards, the government requires a bond deposit, B_0, from the concession harvester at the beginning of the contract. To make the bond payment operational, the government devises a bond penalty function $B: [0,1] \to \mathbb{R}^+$ that maps the harvester's level of compliance to corresponding penalties. This function may in principle take any monotone decreasing form, although we rule out "all-or-nothing" bonds. Figure 1 illustrates the timing of events in our concession model. First, the harvester pays the initial bond payment, B_0, and then takes this entry decision and the penalty mapping, $B(x; B_0)$, as given when deciding the level of RIL compliance based on a cost minimization problem. Based on the harvester's RIL decision, the government proceeds to deduct any penalties from the bond as dictated by the penalty mapping.

For any target compliance level $x_0 \in (0,1]$, where $x_0 = 1$ means full compliance, we require the penalty function $B(x)$ to satisfy the compliance based conditions $B(x_0) = 0$ and $B(0) = B_0$. In other words, target compliance results in no penalties and zero compliance results in full initial bond confiscation. The harvester receives back any amount that is left over from the original bond deposit after deducting for penalties. We can therefore think of the bond penalty function explicitly laying out the liability rules imposed on the harvester for all possible concession outcomes. Unlike in our paper, Boscolo and Vincent (2000) and Macpherson et al. (2010) both define a linear bond function $B(x) = B_0 - xB_0$, or simply $B(x) = B_0(1 - x)$. This type of bond function, however, uses only the bond payment as an instrument but does not utilize the information about the harvester's cost structure.

[6] Although the literature provides mixed evidence on the relative profitability of RIL over conventional logging practices (Medjibe and Putz 2012), our analysis will take it as given that switching to RIL methods means real costs for the harvester, in one form or another. Boltz et al. (2003) find that RIL techniques may incur much higher opportunity costs than conventional logging.

Entering a bond scheme is costly for the harvester. This is captured by a convex bond cost function $F = F(B)$ that is increasing in the level of required bond deposit, B. This function captures the harvester's borrowing costs, including transaction costs related to liquidity constraints, or alternatively the opportunity cost of using its own capital.[7] For example, as is the case in many tropical countries, concessionaires must resort to external funding for the bond payment as they lack sufficient funds prior to the concession. The bigger the bond the more expensive it is to borrow funds, that is, $F_B > 0$ holds (e.g., interest payments are increasing in B). Most importantly, when the harvester enters the concession contract, the bond cost is sunk and does not enter the harvester's cost minimization problem.

The harvester participates as long as bond costs do not exceed some threshold level, defined here as $\bar{F}$. That is, the harvester enters the concession bond scheme if and only if $F(B) \leq \bar{F}$. We assume that this parameter $\bar{F}$ is exogenously given, but conceivably, it could be a function of such things as timber prices, availability of competing investment opportunities, and the harvester's liquidity in financial markets. Naturally, bigger concession harvesters have better access to capital than smaller ones, which means that $\bar{F}$ is likely to be higher for big, multinational firms than for local harvesters. The maximum bond payment, denoted by $\bar{B}$, is given by the inverse mapping of the participation cost function: $\bar{B} = F^{-1}(\bar{F})$. This simply means that when access to funds or availability of capital is better, the harvester is able to post a larger bond at the limit as $\bar{F}$ is higher. Next we describe concession bond outcomes conditional on the harvester's participation costs. We call the full compliance case as "first best", and any other outcome as "second best".

First Best: If the harvester's participation constraint is such that the maximum bond payment satisfies $\bar{B} > c(1)$, then achieving full RIL compliance is feasible. In this case, any bond payment B_0 such that $B_0 \in (c(1), \bar{B}]$ is possible.

Second Best: If $\bar{B} \leq c(1)$, then the government chooses $\bar{B}$ as a second best bond. This guarantees the highest possible RIL compliance that is feasible given the harvester's participation constraint.

Proposition 1: Given a target RIL level $x_0 < \bar{x}$, where $\bar{x}$ defines the upper bound for second best targets, the simplest continuous and non-negative bond function $B(x; \bar{B})$ that is feasible under the binding participation constraint is given by

$$B(x; \bar{B}) = \begin{cases} \bar{B} - c(x) - \dfrac{a}{x_0} x, & x < x_0 \\ 0, & x \geq x_0 \end{cases}$$

where $\bar{B} \equiv F^{-1}(\bar{F})$ and $a = \bar{B} - c(x_0)$. For proof, see Kuusela et al. (2012).

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[7] Even if the government offered to pay interest on the bond payment during the holding period, it is very unlikely that this interest rate would coincide with the harvester's private discount rate that may potentially be much higher.

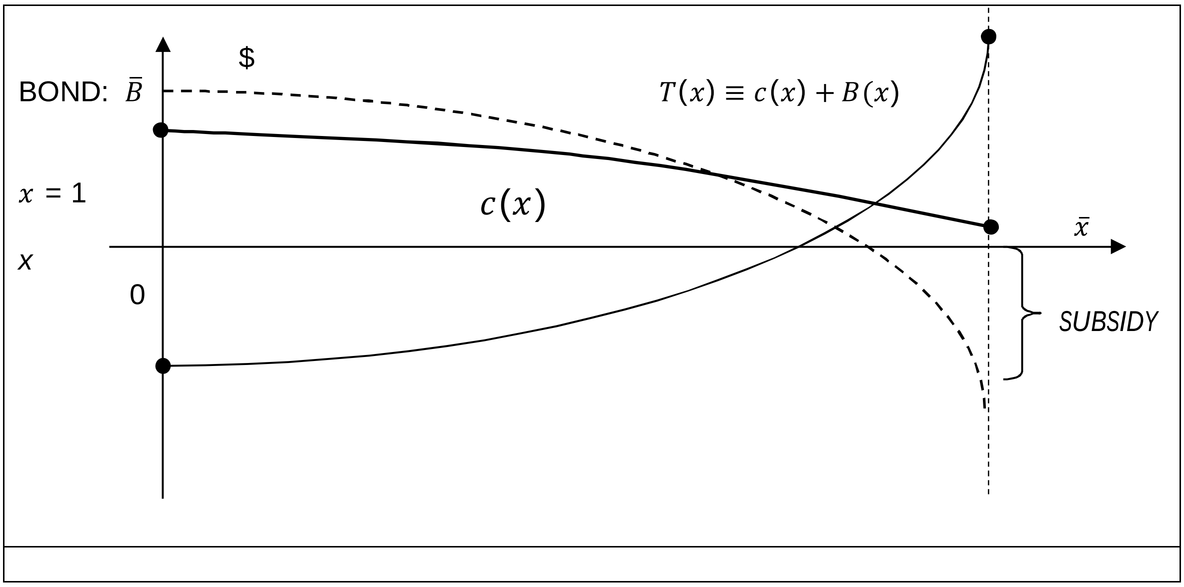

Fig. 2. An example of the second.best bonde.

In the second best case, the government's problem has become one of simply choosing some target RIL level $x_0 < \bar{x}$ since the maximum bond payment $\bar{B}$ is exogenously given. The government does not have an incentive to ask for any smaller bond payment $B_0 < \bar{B}$ as the harvester's participation decision would be unchanged and smaller bond payments would decrease the upper bound $\bar{x}$. Note in this case that by providing a subsidy the government could potentially improve the concession outcome. Figure 2 illustrates an example where the harvester has been unable to post a first-best bond and therefore the government has asked for a second-best bond $\bar{B}$. In order to move the concession outcome to full RIL compliance the government must subsidize the harvester by the amount shown in the figure as the segment below the x axis. As a result, the total cost of compliance, $T(x)$, has its minimum point at $x = 1$ and this is the point the harvester then chooses.

3 Model Simulations

To gain better understanding of how performance bonds work in practice, we use a simulation model built on the analytical framework laid out in the above discussion. Holmes et al. (2001) and Medjibe and Putz (2012) list RIL related costs by each component and each task has a differing cost. Opportunity cost of RIL compliance may become even higher than the actual technical costs. To keep the analysis tractable, we propose the following functional forms the RIL cost function and harvester participation:

$$c(x) = Kx^2$$
$$F(B) = d_1 B + d_2$$

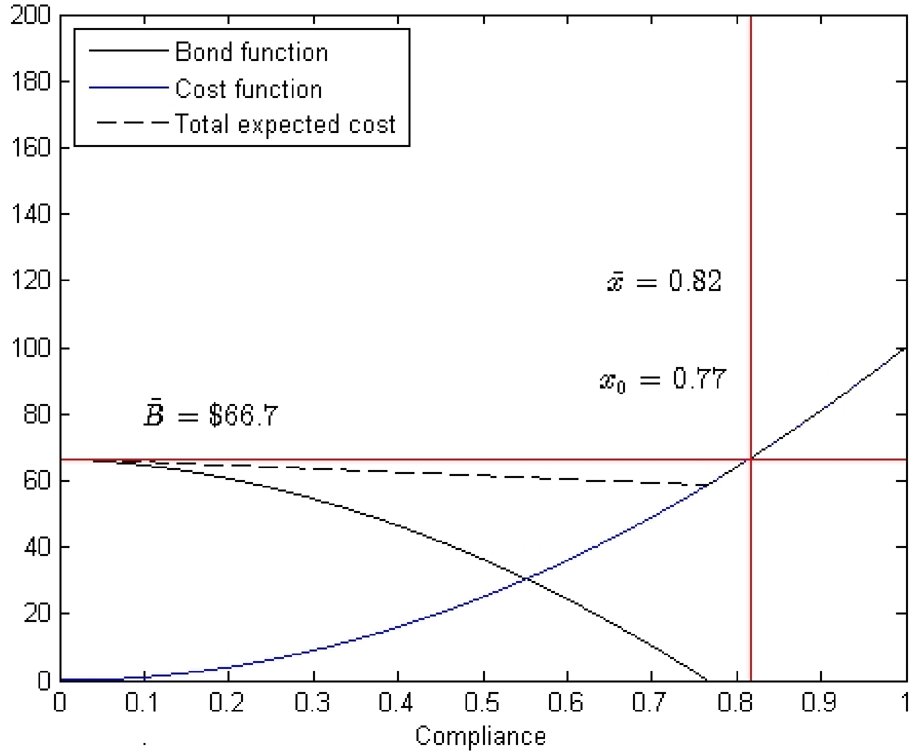

Fig. 3. a second-best RIL compliance scenario

where k, d_1, d_2 are parameters that we choose to calibrate the model to fit real world data. The RIL cost function takes a simple quadratic form to capture the increasing costs implementation and the participation cost function is simply a linear function in bond size. Parameters d_1 and d_2 can be thought of as the interest rate and fixed borrowing cost, respectively. Table 1 lists the parameter values we have chosen for the simulation study. We assume in this study that full implementation of RIL costs an additional \$ 100 per hectare and use this value to pin down the parameter k by using the condition $c(1) = k$ from our cost function specification.[8]

Table 1. Parameter values used in simulation.

Parameter	Value	Description
K	100	Cost function parameter
d_1	0.15	Participation cost function
d_2	5	Participation cost function
$c(1)$	\$100	Cost of full RIL per hectare
$\bar{F}$	\$15	Maximum bond cost per hectare

[8] See Kuusela et al. (2012) for further discussion. There we develop a more nuanced bond-subsidy scheme.

Figure 3 presents a second-best RIL compliance scenario. The participation constraint, $\bar{F}$, is set at \$15 and the maximum target level and maximum bond payment are therefore $\bar{x} = 0.82$ and $\bar{B} = 66.7$, respectively. We assume that the government sets a RIL target level of $x_0 = 0.77$. In the figure, this and bond payment are both encircled with red dashed line. Notice that the RIL target level is also the resulting compliance level since it is the point that minimizes the total cost of compliance, $T(x) = c(x) + B(x; B_0)$, given the bond function in Proposition 1. In order to move this concession bond outcome to the first best, the government would need to devise a bond-subsidy scheme given by function

$$B(x; \bar{B}) = \bar{B} - c(x) - a/\bar{x}\; x$$

where negative values signify a subsidy payment to the harvester. Using the above parameter values, we compute the total required subsidy to be \$43. Alternatively, the government can also directly subsidize the harvester's bond related costs.[9]

4 Conclusions

Application of environmentally sensitive logging practices in tropical concessions continues to pose a policy challenge. Despite the evidence that RIL may actually reduce operational costs in some instances, harvesters have remained reluctant to invest in RIL capacity. Performance bonds have been suggested as an additional policy instrument in enforcing concession management practices. They have not, however, gained much traction for various reasons as outlined in the above discussion. In this paper, we highlighted the role of binding credit constraints using a simple model of RIL compliance, and showed potential for government subsidies or REDD+ payments in improving the bonding outcomes. In a closely related work (Kuusela et al. 2012), we extend this model to incorporate repayment risk and imperfect enforcement, and find new and interesting results. These more realistic concession features enable us to derive concession bond function properties and required subsidies that are more aligned with the realities facing many tropical countries.

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