Liquidity Constraints and Deforestation: The Limitations of Payments for Ecosystem Services

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Deforestation is responsible for 20 percent of anthropogenic carbon emissions, and today most of it occurs in developing countries (Gullison et al., 2007). Curbing deforestation in poor countries is potentially one of the most cost-effective ways to reduce carbon emissions and to address climate change (Stern, 2006).

One popular policy approach to reducing deforestation is to pay forest owners for avoiding deforestation on their land. This type of policy is called "payments for ecosystem services" (PES); payments are made conditional on voluntary pro-environment behaviors (Ferraro and Simpson, 2002; Engel, Pagiola and Wunder, 2008).

This paper considers how the effectiveness of such incentive payments depends on the time profile of forest owners' opportunity costs. The time profile of opportunity costs theoretically becomes important to the success of a PES program when credit markets are imperfect. The analysis uses data from a survey of private forest owners in western Uganda, plus administrative data on whether they signed up for a deforestation PES program offered to them.

Incentive payments for conservation have a particular time profile: The participant receives a flow of payments that continues for as long as he performs the conservation activity. For example, in the program studied, if a forest owner keeps his forest land intact for a year, he receives a specified amount of money; then the next year, if he continues to keep the forest intact, he again receives a payment. The reason for this time profile of payment—rather than, say, an upfront payment in exchange for a promise not to degrade the forest for two or ten years—is that a fundamental (and realistic) assumption in many developing countries is that the government would not have the enforcement power to fine the individual if he violated the contract.

Thus, the incentive payments will not always match the time profile of the forest owner's opportunity costs. One common reason for clearing forests is to use the land for cultivation. Here, the income derived from deforesting is a steady stream of payments, and the PES payments and opportunity costs have a similar time pattern. Another common reason for deforestation is that the trees themselves are valuable, and the forest owner receives a large one-time payment for selling the timber. The opportunity costs are more front-loaded than the PES payments in this case.

In the absence of credit constraints, an incentive payment scheme can be equally effective at deterring deforestation whether or not the opportunity costs are front-loaded.[1] All that is required is that the net present value (NPV) of the incentive payments exceeds the NPV of the opportunity costs. However, when a landowner is credit constrained, the two NPV-equivalent streams of income are no longer equivalent to him. If a credit-constrained forest owner

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[1] Alix-Garcia, Shapiro and Sims (2012) discuss a different link between credit constraints and PES. If agriculture requires upfront investments and a PES program allows an individual to enroll some but not all of his land, then PES income he receives from his enrolled land relaxes liquidity constraints and could increase land-clearing on the individual's unenrolled land.

wants to, say, pay for emergency health care for a family member, then a steady stream of payments from the incentive program may not be as attractive as the lump-sum income from selling timber.[2]

I. Theoretical predictions

Consider a two period model in which a forest owner has the following utility function:

$$u = u(c_0) + \beta u(c_1).$$

He consumes c_0 in period 0 and c_1 in period 1, and $u()$ is the period utility function. The discount rate is β. Individuals can borrow or save at gross interest rate R. For simplicity, set $\beta = 1/R = 1$. With this simplification, the individual will set the consumption level to be equal in the two periods, if possible.

The individual has no income in period 0 and income $y > 0$ in period 1. With this assumption, we are focusing on the case where the individual wishes to move lifetime income forward. The individual also owns forest land, and if he clears the forest in period 0, he earns $f_0 \geq 0$ in period 0 and $f_1 \geq 0$ in period 1. We will consider two profiles of the revenue stream from deforestation. In the *steady revenue* case, $f_0 = f_1 = f$. This stream would arise if the forest owner used the cleared land to grow crops and f represented the per period profits from cultivation. In the *front-loaded revenue* case, $f_0 = F$ and $f_1 = 0$. This stream would arise if the cut-down trees are valuable and the forest owner earned money by selling them. We consider the case where the NPV of the revenue is the same, or $F = 2f$.

Denote as d the amount borrowed in period 0. Then $c_0 = d + f_0$ and $c_1 = y + f_1 - d$. With perfect credit markets, in the steady revenue case, $d = y/2$. In the front-loaded revenue case, $d = y/2 - f$. In both cases, consumption (and thus marginal utility) is equated across periods, with $c_0 = c_1 = y/2 + f$.

Now consider a PES contract that offers the forest owner a payment X in each period if he does not cut down his forest. If he takes up and complies with the contract, his income stream will be X in period 0 and $X + y$ in period 1.

With perfect credit markets, only the NPV of the PES payments compared to the foregone revenue matters. This holds either for the steady revenue or the front-loaded revenue case. Thus, the contract is more attractive than the status quo if the payments exceed the foregone income, or $X > f$.

Henceforth, assume $X > f$ so that everyone takes up the program in the absence of credit constraints. Now consider the case where the individual faces a credit constraint. We model this constraint as a cap on the amount of borrowing, $\overline{d} \geq 0$.

Now the individual takes up the PES contract if

$$u(X+\overline{d})+u(X+y-\overline{d}) > u(f_0+\overline{d})+u(f_1+y-\overline{d}).$$

For the steady revenue case, with $f_0 = f_1 < X$, the inequality holds and the individual will still take up the program. However, with the front-loaded revenue case, for a sufficiently low credit limit $\overline{d}$, the individual will not take up the program. For example, for $u(c) = log(c)$, the condition for take-up is $\overline{d} > y - X(X + y)/(2f)$.

More generally, the likelihood of taking up the PES program is increasing in access to credit $\overline{d}$ and is decreasing in f_0 holding the total payments $f_0 + f_1$ fixed, that is, in the degree to which the revenue stream from deforestation is front-loaded. Take-up is more strongly increasing in $\overline{d}$ the more front-loaded the revenue stream from deforestation is. This stands in contrast to the case of perfect credit markets, where take-up of the PES program depends on the NPV of the foregone income stream, but not its time profile.

RESULT 1: *Credit constraints are more likely to reduce take-up of the PES program when the foregone income stream is more front-loaded.*

[2] The same reasoning applies to other conditional cash transfers where the costs of compliance are more front-loaded than the payments. An example is financial incentives to delay marriage of adolescent daughters, if one motivation for early marriage is a bride price paid to the bride's family.

II. Description of setting

The data used in the analysis are from an ongoing project in Hoima and Kibaale districts in western Uganda. As in much of Africa, the main drivers of deforestation in this area are subsistence agriculture and domestic demand for timber and charcoal, rather than the export market for cash crops or timber (Fisher, 2010).

We conducted a survey of 1,245 private forest owners in 136 villages in 2010. The survey asked about characteristics of the forest owner's land, his past tree-cutting behavior, attitudes toward the environment, access to finance, and other topics.

The survey was the baseline survey for a randomized experiment of a PES program. After the baseline survey, 65 of the villages were randomly selected to be in the treatment group. Among the forest owners surveyed, 610 were assigned to the treatment group.

In the treatment villages, forest owners were offered a PES contract by the local non-governmental organization (NGO) implementing the program. The NGO held meetings to explain the program and to distribute the contract forms. For forest owners who chose to participate, the NGO measured their forest area, and the forest owner signed and submitted the contract to the NGO. The contract specifies that the forest owner will conserve his entire existing forest, plus has the option to dedicate additional land to reforestation. Under the program, individuals may not cut down medium-sized trees and may only cut selected mature trees, determined by the number of mature trees per species in a given forest patch. Participants are allowed to cut small trees for home use and to gather firewood from fallen trees.

Compliance with the contract is monitored by the NGO staff via spot checks of forest owners' land. Those who comply receive 33 dollars per hectare annually for two years. The median amount of forest area owned is 2 hectares, yielding a payment of 66 dollars a year for compliance, equivalent to roughly 10 to 15 percent of annual household income. For comparison, one large timber tree sells for 20 to 40 dollars, and a typical forest owner might sell one to four trees every couple of years. While most households consume all of the crops that they grow, among households that sell crops for cash, income is in the range of 30 to 100 dollars per hectare of cultivated land; if a forest owner clears new land, he usually clears one or two 40 square meter (0.16 hectare) plots.

Most of the households in the sample have limited access to credit. The majority of survey respondents say it would be difficult or very difficult for them to obtain a 50 dollar loan from a moneylender or a bank, and two thirds say that if they had an emergency expense of 50 dollars, they would be able to cover less than half the amount from savings.

The program is ongoing and information on compliance with the contract (and the environmental and economic impacts) are not yet available. Therefore the analysis will examine take-up of the program, that is, whether the individual signed the PES contract. If there are costs of signing up for the program (e.g., hassle costs), then take-up should be positively correlated with compliance since only those individuals with a high enough expectation that they will comply will choose to sign up.

III. Empirical results

We examine whether recent tree-cutting behavior is associated with take-up. The baseline survey asked the individual about his tree-cutting in the past three years, including the purpose. The most common reasons for cutting trees were to sell them for money and to clear the land for agriculture. Fifty-nine percent of respondents cut trees to sell them. Many cited health care costs or other emergency expenditures as the precipitating event. In addition, forty-eight percent of forest owners cut trees to clear land for cultivation or other uses. Take-up of the program was 33 percent.

We start by estimating the following re-

gression:

$$TakeUp_i = \alpha + \beta CutTreesToSell_i + \gamma CutTreesForLand_i + \varepsilon_i \quad (1)$$

The variable $CutTreesToSell_i$ is a dummy for whether individual i cut down trees in the past three years to sell the tree products for cash, that is, in exchange for a front-loaded revenue stream. The prediction is in terms of expected tree-cutting during the PES contract period, but the available data describe past tree-cutting. The assumption is that past tree-cutting is positively correlated with future tree-cutting because it reflects both the availability of valuable trees on the individual's land and the need to sell trees to cover financial needs. Tree-cutting reduces one's stock of trees that are available to cut in the future, so tree-cutting could be negatively serially correlated instead. The analysis assumes that this source of within-person negative serial correlation is outweighed by the large degree of between-person variation in the propensity to cut down trees.

The variable $CutTreesForLand$ is a dummy for cutting down trees in the past three years to clear the land for agriculture or other uses, which generates a steady revenue stream. Again, past behavior is used as a proxy for the forest owner's expectations about his future tree-cutting. The prediction is that $\beta < \gamma$, or that individuals who will cut trees to sell the timber products, providing them with upfront cash, will find the PES contract less attractive and will hence be less likely to take it up.

The results are presented in Table 1. The first column shows that forest owners who cut trees to sell them are less likely to sign up for the PES program, while the second column shows that, in contrast, cutting trees to clear the land does not deter take-up and in fact increases take-up. As seen in the third column, this pattern persists when the two effects are estimated jointly. The equality of the two coefficients can be rejected with a p-value of 0.01.

While the results in Table 1 are suggestive that the attractiveness of the PES program depends on the time profile of the would-be participant's opportunity costs, the main prediction is about the interaction of the income stream from deforestation and credit constraints. Hence we estimate a model similar to equation (1) except that it includes the interaction of credit constraints with the two forms of tree-cutting (as well as the main effect of credit constraints).

The measure of credit constraints is the absence of a savings and credit cooperative society (SACCO) nearby the village. SACCOs are the dominant type of financial institution in rural Uganda. The credit-constraint measure is a dummy for whether the walking distance, as reported by the respondent, is more than the sample median distance of one hour. Having no SACCO nearby is negatively correlated with household savings and self-assessed ability to obtain loans. Note that this proxy for credit constraints could be correlated with other factors besides access to credit so the results should be interpreted as suggestive evidence.

The predictions are that if the SACCO is far away, PES program take-up should be lower especially when the individual has a propensity to clear trees for cash. Financial access should not have the same predictive power when tree-cutting is done to clear land for agriculture, which does not produce a front-loaded income stream.

The results are presented in Table 2 and are consistent with the predictions. The distance to a SACCO (credit constraints) has no average effect on program take-up, but it decreases take-up among forest owners who, in the past, have cut down trees to sell them for money. The main effect of $CutTreesToSell$ is indistinguishable from zero; when there is a SACCO nearby, whether the forest owner sold trees for money in the past is not predictive of take-up. In other words, with access to credit, the differing time profiles between the PES payments and opportunity costs does not affect the attractiveness of the program to a forest owner. In contrast, the interaction of $CutTreesToSell$ with the SACCO being far away is negative and significant at the 10 percent level. Those who

sold trees for money and are more credit-constrained—that is, those most likely to be using trees as a source of emergency liquidity—are less likely to take up the PES program. As predicted, these patterns are not seen for those who cut trees to clear land. The p-value on the test of equality of the two interaction coefficients is 0.20.

Note that we find similar results if instead of contrasting tree-cutting for money to tree-cutting to clear land, we use whether the individual cut large trees versus small trees. Large trees are typically the more valuable ones, so the purpose in cutting them is more likely to be to sell them for money. Again, cutting large trees is a negative predictor of take-up whereas cutting small trees is not, and this pattern is more true with limited access to credit.

IV. Conclusion

A main approach to forest conservation in developed countries is to place legal restrictions on forest clearing and then fine or otherwise punish violators. This approach is less effective in developing countries for two reasons. First, due to weak governance, regulations may be poorly enforced. Second, because people are very poor, it may not be possible (or desirable) to impose financial penalties on violators. Hence, using "carrots" rather than "sticks" has gained popularity in poor countries: Forest owners are offered financial rewards for forest-preserving behaviors.

However, these same two features of poor countries place limitations on the design of PES programs. Suppose the government paid individuals upfront in exchange for pro-environment behavior over the next, say, ten years (e.g., keeping a forest intact over this time period). Enforcement problems and limited liability would make it unlikely that the money could be reclaimed if the individuals violated the contract. Hence, PES programs typically offer a steady flow of payments in exchange for a flow of pro-environment behaviors.

But it is often the case that forests are cleared because the timber products are valuable and the owner wants to liquidate these assets. The opportunity costs of participating in the PES program are then more front-loaded than the PES payments. Many forest owners in developing countries are credit constrained and sell trees to pay for emergency expenses such as hospital bills. In this case, PES programs may be considerably less effective than hoped for at deterring deforestation. The effectiveness of PES programs could be enhanced by combining them with improved access to credit.

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Table 1—Tree-cutting as a determinant of PES program take-up

	Take-up	Take-up	Take-up
CutTreesToSell	-0.066		-0.049
	[0.039]*		[0.040]
CutTreesForLand		0.085	0.074
		[0.038]**	[0.040]*

Note: ** indicates p < 0.05; * indicates p <0.1. Each observation is a forest owner in a treatment village (N=610). Regressions control for district fixed effects and the log of the individual's forest area.

Table 2—Liquidity constraints as a determinant of PES program take-up

	Take-up	Take-up
SaccoFarAway	-0.003	0.085
	[0.043]	[0.083]
CutTreesToSell		0.048
		[0.069]
SaccoFarAway * CutTreesToSell		-0.148
		[0.088]*
CutTreesForLand		0.083
		[0.070]
SaccoFarAway * CutTreesForLand		-0.010
		[0.088]

Note: ** indicates p < 0.05; * indicates p <0.1. Each observation is a forest owner in a treatment village (N=610). Regressions control for district fixed effects and the log of the individual's forest area.