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Targeting REDD+: An Empirical Analysis of Carbon Sequestration in Indonesia

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Summary. — The implementation of REDD+ requires knowledge of the willingness to accept land use change contracts and its application over large areas. This paper uses primary data from Indonesia to contrast two approaches to the elicitation of the supply curve for carbon: an auction and an analysis of opportunity costs. The analysis shows that there are important differences between the two approaches for a wide range of prices. An analysis of bidding behavior shows that location and individual preferences (time and risk preferences), but not opportunity costs, play a significant role in this decision. The implications for targeting are discussed.

Key words — REDD+, targeting, auction, opportunity costs, Southeast Asia, Indonesia

1. INTRODUCTION

The economic consequences of climate change, and the possible mitigation and adaptation policies, are the focus of a wide debate, that was recently summarized in World Bank (2009). From this debate, there is a growing consensus to include Reducing Emissions from Deforestation and Degradation (REDD+) as a mitigation strategy, both due to the perceived low cost of using forests to sequester carbon (Stern, 2006; Eliasch, 2008) and the relative importance of deforestation as a major source of greenhouse gas emission, accounting for approximately 12% of global emissions (Corbera, Estrada, & Brown, 2010).

This emerging consensus fuels an increased interest in the definition of the actions that can be funded under this program, in particular the possibility of inclusion of afforestation and reforestation activities (the "+" in REDD+).[1] As evidence of the interest in these type of actions, it is worth mentioning that they are proposed as eligible for funding in most of the proposals put forward by both governments and NGOs regarding REDD+ (see, for example Parker, Mitchell, & Mardas, 2009).[2]

Because reforestation or afforestation projects are to be established on cleared land with some recognized property rights, their inclusion as part of REDD+ would address one difficulty with the practical implementation of this program: the fact that, in many forests throughout the developing world, there are conflicting local and governmental claims over the same forest with the consequent difficulty in clearly defining and enforcing carbon sequestration contracts (Wunder, Engel, & Pagiola, 2008).[3] The clarification of who should be paid for carbon sequestration (the landowner) under such actions comes at the cost of raising the potential importance of asymmetric information in determining how much should be paid. Landowners will have a private valuation of the reforestation project, known solely by him/her, and no incentive to reveal it to a potential buyer of such goods. Instead they will be interested in maximizing the amount of information rents that can be extracted from the uniformed buyer (Ferraro, 2008; Salanie, 1997). Problems of asymmetric information are not exclusive of REDD+ and generally plague any program that relies on the voluntary participation of beneficiaries, as shown by the extensive literature on targeting (see, for example Coady, Grosh, & Hoddinott, 2004; Ravallion, 2009).[4]

The targeting of REDD+, that is, the identification of how much should be paid to whom in order to encourage program participation while minimizing the costs of carbon sequestration, has been addressed in two ways. Most of the early work estimates the opportunity cost of land use change.[5] In essence, this approach assumes that reservation prices are highly correlated with observable behavior, which can then be used to target the program—or, in other words, that asymmetric information is not important. Estimates of opportunity costs rely on important conceptual assumptions (chiefly among them, the assumption of complete markets), that may not be easily met in developing countries where most of the deforestation occurs (see, for example, White & Minang, 2011; Gregersen *et al.*, 2010, for a discussion).

One alternative is to use mechanisms that create the incentive for individuals to reveal their private information (or reserve price), such as auctions. Vickrey (1961) showed that in a second price auction, truth-telling is a dominant strategy: in the context of a reverse (procurement) auction, the lowest bidder wins the contract but is paid the value submitted by the second-lowest bidder. Any bidder will then have to weigh the value of the payment requested (a positive function of the bid), against the probability of winning the contract (a decreasing function of the bid). Conversely, the auction also acts as an incentive to not underbid, as this would have negative implications on expected future profits. Additionally, a budget constraint combined with a sealed bid mechanism makes undercutting other bidders (while bidding at least the reserve price) the (weakly) dominant strategy, eliminating the possibility of strategic collusion. See Lusk and Shogren (2007) for a lengthier discussion.

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In developing countries, auctions have been used in the design and implementation of afforestation contracts in Vietnam (The & Ngoc, 2008) and Malawi (Jack, 2013) and of contracts for soil conservation in Sumatra, Indonesia (Jack, Leimona, & Ferraro, 2009). Ajayi, Jack, and Leimona (2012) provides a discussion of some of the lessons learned with these experiences. [6]

Despite their theoretical advantages and the growing experience with their use in the field, auctions are time consuming and expensive to implement, raising questions about the feasibility of basing the implementation of REDD+ on its generalized use. If the willingness to accept such contracts, as elicited through an auction, does not differ significantly from the values obtained through simpler approaches, such as those based on the estimation of opportunity costs (in particular if they can be approximated by easily available secondary data, as in the "minimum data" approach suggested by Antle & Valdivia (2006) and Antle, Diagana, Stoorvogel, & Valdivia (2010)), the use of the latter could be justified by their relatively lower cost.

We contribute to this discussion by comparing these two approaches using data from two locations in Central Sumatra. Through a detailed household survey, that paid special attention to the collection of information on the costs and returns associated with current land use (namely, rubber monoculture), we are able to estimate the opportunity costs of any change in land use, which can be compared with household decisions in an experimental auction that was designed to directly elicit willingness to accept land use change contracts. The remaining sections of this paper proceed as follows. The next section presents the data we use and is followed, in Section 3 by an analysis of the supply curve elicited through the different approaches. Although average values of bids and estimates opportunity costs are not statistically different, the supply curves associated with each approach differ for a wide range of prices.

In Section 4 we analyze the determinants of bidding behavior. This analysis further confirms the lack of relation between the estimates of opportunity costs and bids, and suggests that only spatial heterogeneity and behavioral preferences toward risk and time play a significant role in explaining these decisions. We conclude in Section 5 with a discussion of the implications of this work for the targeting of the REDD+ program. In particular, we suggest that, if the importance of unobservable preferences is confirmed in other settings, auctions may be cost-effective ways of implementing REDD+, given that they are a mechanism that accounts directly for such preferences (through bids), providing a way for low-cost bidders to self-select into the program.

2. CONTEXT AND DATA

The data used in this article were collected by the first author in Senamat Ulu and Tebing Tinggi, two villages in the Province of Jambi, Central Sumatra, Indonesia. The two villages were chosen due to their location in areas where local farmers have been encroaching into the native forest, with large and small tracts of forest replaced by palm oil, coffee and, particularly, monoculture rubber plantation. The reduction in carbon storage due to these changes in land use is important: native forest is estimated to store approximately 300 tonnes of carbon per hectare, more than six times the amount stored by rubber plantations (Swallow *et al.*, 2007). [7] However, there are differences between the two sites, with one of them (Tebing Tinggi) located 50 km closer to the regional center (Muara Bungo) than the other. We expected that difference, in a context of high transportation costs such as Central Sumatra, to have profound consequences for livelihood choices and, consequently, for the potential interest in a REDD+ scheme.

The data, collected with the objective of understanding the willingness to accept contracts that promote reforestation, fall into three categories: socioeconomic variables (collected through a survey of household heads), preferences toward risk and time (collected through artefactual field experiments, in the classification of Harrison & List (2004)), and willingness to accept for reforestation contracts (collected through an experimental auction).

Table 1 presents some descriptive statistics of the variables for which we collected information, both with respect to household and household heads (namely assets and economic activities, but also behavioral preferences) and the rubber plots that were brought to the auction (paying particular attention to costs and returns, but also including the bid submitted at the auction). Given the likely differences between the two sites, these data are presented first for the entire sample and then by village. As shown in the last two columns, there are not many statistically significant differences between the two villages—the exception being the higher prevalence of formal rights to land in Tebing Tinggi (p-value = 0.03). This is confirmed by a Hotelling T^2 tests of equality of joint distribution of the variables in each panel (Household variables: T^2=15.81, $p > F_{(11,49)}$ = 0.32; Auctioned plots (excluding bids): T^2=22.61, $p > F_{(13,48)} = 0.20$). It seems then that, with the exception of distance from the closest regional center, there are not many important differences between these two locations.

It is possible, with the information collected through the household survey, to estimate the profits of rubber monoculture (as this is the use of the plots brought to the experimental auction). Profits were calculated by subtracting all intermediate input costs (seedlings, fertilizer, and pesticides) and labor costs (including costs with both hired and household labor, valued at the local wage rate of 30,000 IDR/day) from revenues. The distribution of the estimated profits of rubber monoculture (in US$/ha) is presented in Figure 1. [8] As shown in Table 1, there are differences between the two villages, with profits in Tebing Tinggi being 38% higher than in Senamat Ulu, but this difference is not statistically significant (p-value = 0.45).

Household heads were also asked to participate in an artefactual field experiment designed to elicit time and risk preferences. The risk preference experiment involved a choice between lotteries with different expected payoffs and different variances, as in the approach pioneered by Holt and Laury (2002). Varying numbers of red and blue tickets were combined in a lottery, and associated with different payoffs depending on which option the individual selected for that round, as shown in Table 2. These combinations were designed so that risk neutral individuals would switch between option A and option B at the fifth choice. In order to minimize the possibility that the choices would not correspond to their preferences, each participant was informed that one of the choices would be randomly selected *ex post* to determine the amount of winnings each individual would receive from the game. The expected payoff was IDR 20,000 (or 2/3 of the local daily rural wage).

The degree of risk aversion was then estimated by observing when (if ever) did the respondents change their selection from option A to option B and counting the associated number of safe choices, where a safe choice is defined as one in which the expected value of the option chosen was greater than the expected value of the alternative option. The distribution of