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Surveys

Buying spatially-coordinated ecosystem services: An experiment on the role of auction format and communication

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ABSTRACT

Procurement auctions are one of several policy tools available to incentivise the provision of ecosystem services and biodiversity conservation. Successful biodiversity conservation often requires a landscape-scale approach and the spatial coordination of participation, for example in the creation of wildlife corridors. In this paper, we use a laboratory experiment to explore two features of procurement auctions in a forest landscape: the pricing mechanism (uniform vs. discriminatory) and availability of communication (chat) between potential sellers. We modify the experimental design developed by Reeson et al. (2011) by introducing uncertainty (and hence heterogeneity) in the production value of forest sites as well as an automated, endogenous stopping rule. We find that discriminatory pricing yields to greater environmental benefits per government dollar spent, chiefly because it is easier to construct long corridors. Chat also facilitates such coordination but also seems to encourage collusion in sustaining high prices for the most environmentally attractive plots. These two effects offset each other, making chat neutral from the viewpoint of maximizing environmental effect per dollar spent.

1. Introduction

Procurement or reverse auctions are one of several Payment for Ecosystem Service (PES) design options available to incentivise the provision of ecosystem services and biodiversity conservation on privately-owned land (Hanley et al., 2012). In this setting, they are often referred to as "conservation auctions". Such auctions offer the potential to deliver a cost-efficient allocation of limited government funds for conservation (Latacz-Lohmann and van der Hamsvoort, 1997; Schilizzi and Latacz-Lohmann, 2007) and to reduce information asymmetries concerning private owners' costs of supplying an ecosystem service or of conserving biodiversity (Ferraro, 2008; Reeson et al., 2011; Reeson and Whitten, 2014). They involve multiple potential sellers, each typically endowed with multiple units of a "good" for sale – here, plots of land offered to be managed in a specific way – and a single bidder interested in purchasing multiple units. Conservation auctions have attracted limited attention in the theoretical literature so far, but have been extensively studied using lab experiments and simulation modelling (Hailu and Thoyer, 2010).

However, little research has been conducted to date on the ability of conservation auctions to deliver environmental improvements in a spatially-coordinated manner. This is important since the ecological benefits delivered by PES schemes often depend on the spatial configuration of enrolled sites. For example, if the goal of such a scheme is to improve water quality in catchments subject to diffuse pollution from agriculture, then the location of farms who are awarded contacts is crucial to determining the change in water quality resulting from the scheme. An interesting specific case is that of *spatial agglomeration*, where awarding contacts to adjoining parcels of land (adjoining farms) is more effective in attaining conservation outcomes than a random spatial pattern of sign-ups (Parkhurst and Shogren, 2007; Banerjee et al., 2012, 2014a). Such spatial coordination can be beneficial if a species requires access to several habitat types, if wildlife corridors are being created, or if a minimum viable area of land contiguously enrolled in the scheme is necessary to allow a species to thrive. In such cases, spatial agglomeration delivers higher environmental benefits for a given total area of hectares enrolled.

One study where authors have looked at the potential of conservation auctions to achieve desired spatial patterns of sign-ups in a landscape is Windle et al. (2009). The authors investigate the use of auctions to encourage the creation of landscape corridors in Queensland, Australia. They found that the auction mechanism succeeded in producing connected corridors of enrolled land, with 70% of successful bidders being spatially connected. Banerjee et al. (2014b) also use an experimental approach to investigate spatial coordination in auctions. Participants in their experiment are informed of a spatial rule which was used to allocate a score to bids in conjunction with the amount offered. The authors included a

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treatment whereby the treated group of participants were told about the targeted spatial outcome of the auction. They find that the treatment had an effect on rent-seeking but no impact on auction efficiency. In the key reference paper for our study, Reeson et al. (2011) investigate the effects of promoting connectivity between sites in a de-contextualized setting. In their lab experiment, they considered a homogeneous landscape of 400 plots divided among 10 owners/bidders, and investigate the effects of having multiple rounds of the auction with different stopping rules for when the process ended. Other authors such as Bamière et al. (2013) and Iftekhar and Tisdell (2015) use simulation, rather than lab experiments, to investigate spatial coordination in PES design.

The main objectives of the present paper are to explore the impacts of auction format (Discriminatory Price vs. Uniform Price) and the opportunity for communication between participants on environmental benefit maximization and the efficiency of providing ecosystem services by forest owners. We do this in the context where the spatial location of successful bidders matters for the delivery of overall environmental benefit and where there is variation in the supply price of conservation across landowners.

We build upon the experimental design developed by Reeson et al. (2011), introducing four principal modifications which seem potentially important in improving cost-effective spatial coordination in conservation auctions. First, we account for heterogeneity in the production value of plots, both between and within land owners. The rationale behind this is that forests differ in terms of tree species, age and planting density, and thus deliver different production values. The opportunity costs of conservation can thus vary considerably over space. Second, we use an automated, endogenous stopping rule in a multiple-round auction, which means participants do not know which round of bidding will be the last. If subjects do know which round is going to be the last, they have limited incentives to bid in an economically-rational manner in all previous rounds, and can signal their collusive intentions in a costless manner through cheap talk (Cason et al., 2003).

Third, we analyse two different auction formats: Discriminatory Pricing and Uniform Pricing. Both of them have their merits in practical applications, and these merits have been compared in many previous experiments (Cason and Gangadharan, 2005). In Discriminatory Price auctions, transaction prices are determined in a straightforward manner—they are identical to accepted offers—and this simplicity is a major virtue in these otherwise complicated markets. However, they create incentives for landowners to bid higher than their true minimum willingness to accept. Uniform Price auctions place less burden on the participants as far as the determination of their bidding strategy is concerned, since the bidder can focus on their minimum acceptable price level. Participants may consider the uniform price format as being fairer (Kahneman et al., 1986; Cong and Wei, 2010).

In familiar single-object auctions, the analogue of the Discriminatory Price auction is the first-price sealed-bid auction, while the second-price (Vickrey, 1961) auction is the analogue of the Uniform Price auction. The properties of these two variants are well understood. It is tempting to extend this reasoning to multiple-object auctions (in which buyers submit a number of bids for the first, second, … and n-th units — that is, a demand schedule), but this is an oversimplification. In the case of multiple bids, any buyer's lower bid can affect the price paid to a (successful) higher bid so that some shading pays off. This holds for the case of multiple potential sellers and a single buyer. If sellers are only interested in selling one unit, then under the uniform rule they should bid their reservation price. However, it pays to add some mark-up on all but the first unit if they submit an entire demand scheme.

In our case of a Uniform price auction with a spatial aspect, finding a theoretical prediction for the relative performance of the two formats is difficult. Nevertheless, by analogy with the situations sketched above, we generally expect offers in the Discriminatory Price treatment to be higher than reservation prices in the Uniform Price treatment. It also seems natural that horizontal corridors of adjacent plots purchased will be more common under Discriminatory Pricing. This is because in such a corridor there will typically contain at least one highly-productive plot. To contract for this highly-productive plot under a Uniform price format would mean that the buyer has to pay a very high price for all other connected plots too, which will not be cost-effective.

The last of our modifications examines the effect of communication between subjects in the course of the auction. From a practical viewpoint, this is an important consideration because the owners of different forests or farms will typically know each other and might indeed want to coordinate their strategies. Moreover, multi-round auctions will often give participants multiple opportunities to communicate. On one hand, we expect communication to facilitate collusion, thereby decreasing the auction's cost-effectiveness. One the other hand, since environmental benefits depend on participants' abilities to coordinate strategies with their neighbors such that larger contiguous areas of wildlife protection are created, communication may improve an auction environmental performance (Balliet, 2010; Vogt et al., 2013). The overall effect is thus hard to predict.

In what follows, the remainder of the paper is organized as follows. Section 2 contains the experimental design, treatments, information provided to subjects and the applied procedures. Section 3 describes and discusses the obtained results, followed by Conclusions which are presented in Section 4.

2. Methods

The experiment is framed in the context of forest biodiversity protection. Specifically, we consider a national park (NP) surrounded by hitherto un-protected privately-owned land. Such a situation is quite typical in the European context. Spatial coordination is implemented in the auction by building in additional rewards based on the *proximity* of individual forest plots to the NP: ecological benefits per enrolled plot are assumed to be higher if that plot is adjacent to the NP. Second, additional rewards are also associated with enrolled plot *connectivity*, since the creation of enrolled corridors is assumed to facilitate the movement and migration of wild animals. Both proximity and connectivity increase the score given to a bid by increasing the value of an *environmental metric*. A forest-related (rather than a neutral) framing is used to make the situation more realistic for the subjects, and to help them understand this relatively complex design.

2.1. Design

Participants of the experiment were divided into groups of 6 (typically, there were 18 subjects in each session). Each of these participants was assigned a “property” consisting of 16 *plots* (see Fig. 1 showing the initial information displayed to subject owning plots A3–D6, the white lines delineating each player's property). Each property was a 4×4 square, except for the subject holding A1–D2 and A11–D12 squares, although this makes no strategic difference. Each plot had a specific *production value* (PV) in experimental dollars (ED), drawn independently from a uniform distribution on (50, 150) that could be realized if that particular plot was retained by the owner at the end of the experiment. Each owner could also offer any subset of his plots at any plot-specific prices expressed in ED he wished at a single multi-round auction run by an automated *government* (with total rounds determined by the stopping rule).

In each round, the government would “provisionally purchase” a combination of plots offered by some or all the sellers that would maximize *environmental value* (EV) per experimental dollar spent on purchases, subject to the constraint that at least 80% of the government