Auctioning Conservation Contracts:

An Application to the Flemish Afforestation Policy

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Abstract

This paper studies the possibility of using auctions as a policy instrument in conservation programs. In particular, it provides insight into the main concerns that need to be dealt with when implementing conservation auctions. To show the cost saving potential of this policy instrument, we also calculate the social welfare improvement that can be obtained for an afforestation project in Flanders.

Keywords: Auctions; Conservation contracts; Afforestation

1. Introduction

Over recent years agro-environmental policy issues have become increasingly important. As mentioned by Latacz-Lohmann and Hodge (2003), on the one hand, this is due to the increase of the marginal value of environmental goods compared with the marginal value of food and fibre. Consumers and governments put progressively more emphasis on the environmental characteristics of agricultural production, such as landscape values and carbon sequestration. As a result, they are more and more willing to pay for environmental quality improvements on farmland. On the other hand, general environmental quality has simultaneously declined and the supply of environmental goods, for instance biodiversity, has become scarcer.

Currently the European Union employs fixed-price, or uniform subsidy, schemes to promote biodiversity conservation, such as the afforestation of agricultural land (EU Council regulation n° 1257/99). However, auctions are a noteworthy alternative. They can and have been used to address several different land-related management problems, such as soil erosion, dryland salinity, flood management and afforestation.

Auctions are a method frequently used in procuring commodities for which there are no well-established markets. As Latacz-Lohmann and Van der Hamsvoort (1997) put it *'auctions are the main quasi-market institution used to arrange the provision of public-type goods by private enterprises'*. Auctions are of particular interest to conservation contracting for at least two reasons. First, the item being traded, the provision of environmental services, is a public-type non-market good which has no standard value. For this reason there can be substantial uncertainty about the value, benefits and importance of the environmental characteristics associated with a particular type of land use. Second, land conservation issues typically concern private land and informational asymmetries are visibly present. Landowners know the costs associated with afforestation or other conservation measures and their impact on profits and production, whereas the government often has a higher knowledge of the ecological benefits associated with the environmental assets that exist on farmland. The government can indeed employ experts in several scientific fields (such as auction design), has greater data availability and can include interactions and externalities in its policy judgments.

Auctions in this respect enable the participants to deal with the uncertainty about the object being sold or purchased. Latacz-Lohmann and Van der Hamsvoort (1997) show in their study that the benefits of using auctions as an environmental policy instrument increase if there is less information available to the regulator. However, the less information the government possesses, the higher the information rents that are assigned to farmers.

This paper studies the possibility of using auctions as a policy instrument in conservation programs. In particular, it provides insight into the main concerns that need to be dealt with when implementing conservation auctions. To show the cost saving potential of this policy instrument, we also calculate the social welfare improvement that can be obtained for an afforestation project in Flanders (Belgium).

2. Theoretical insights

An auction is a market-based mechanism that provides buyers and sellers with a forum for the trade of goods and services within a predefined framework of guidelines. If these auction rules are well designed, the allocation of the traded good can be efficient. Auctions attain allocative efficiency under the following two conditions: resources are allocated to bidders with the highest valuations and bidders' valuations reflect the social values of resources (that is, their returns when used for production in competitive end markets). Auctions are generally used by the seller or auctioneer to sell one or more goods (e.g. paintings or tulip bulbs) to the bidder who values the good most.

In this section we provide a background to basic auction theory, with particular attention to the use of auctions in conservation programs.

2.1 Auctions

Four types of auctions are widely used and analysed (Klemperer, 1999). Firstly, in the ascending auction (the open, oral or English auction), the price is successively raised until only one bidder remains and that bidder wins the object at the final, highest, price. Secondly, the descending auction (Dutch auction) works in exactly the opposite way: the auctioneer starts at a very high price and then gradually lowers the price. The first bidder who calls that he will accept the current price wins the object at that price. Thirdly, in the first-price, sealed-bid auction each bidder independently submits a single bid, without seeing others' bids, and the object is sold to the bidder who makes the highest bid. The winner pays his bid. Finally, in the second-price sealed-bid auction (Vickrey auction), also, each bidder independently submits a single bid, without seeing others' bids, and the object is sold to the bidder who makes the highest bid. However, the price he pays is the second-highest bidder's bid, or 'second price'.

It can be shown that under the same set of basic assumptions each auction form, on average, yields the same revenue to the auctioneer. This is known as the Revenue Equivalence Theorem (Vickrey, 1961, Myerson, 1981 and Riley and Samuelson, 1981). This theorem depends on five crucial assumptions, which we will discuss more thoroughly in section 2.2.1.

Early work on auctions stems from the seminal papers of Friedman (1956) for the case of a single strategic bidder, and Vickrey (1961) for the equilibrium game theoretical approach. Survey articles that offer an insight in the theoretical literature on auctions are, for example, McAfee and McMillan (1987) and Klemperer (1999 and 2002).

2.2 Conservation auctions

Auctions can also be used to allocate conservation contracts. However, in this setting, the roles of bidders and auctioneers are quite different from their parts in 'classic' auctions. The bidders now offer to change their land use and management practices and their bids indicate the minimal amount (subsidy) they require as compensation for this alteration. It is important to note that the winning bidders, i.e. the participants in the program, remain the sole owners of their land. The objective of the auctioneers is now either to minimise the amount spent in order to reach a specified conservation objective or to maximise the conservation value of the awarded contracts within a given budget.

Auctions designed to grant contracts for conservation typically involve multiple identical contracts. Land ownership is, after all, often in private hands and fragmented. This is called a multiple item auction, as opposed to a single-unit one. For multiple contracts a discriminatory first-price sealed-bid auction can be used. This implies that bidders are not judged solely on the level of their bid but also on the quality of the conservation contract they propose. After correcting for the conservation value offered, the *n* lowest bidders are rewarded and receive the payment stated in their bids. In the case with no budget constraints, optimal auction design requires the use of a reserve price (i.e. a maximum acceptable bid or bid cap) to induce farmers to reveal their bids truthfully (Myerson, 1981).

Subsequently we discuss whether the revenue equivalence theorem is applicable to conservation auctions, what the optimal bidding rules might look like and what the implications of repeated conservation auctions are.

2.2.1 Revenue equivalence theorem

The revenue equivalence theorem states that each auction form, on average, yields the same revenue to the auctioneer under the set of the following five crucial assumptions (McAfee and McMillan, 1987):

i) bidders are risk neutral,

ii) bidders have independent private values,

iii) bidders are symmetric,

iv) payment is a function of bids alone and

v) zero transaction costs associated with bidding and participating in the auction.

As Latacz-Lohmann and Van der Hamsvoort (1997) note, the revenue equivalence theorem is not likely to hold for conservation contracts and we comment briefly on the five assumptions. Firstly, in general, farmers are assumed to be risk averse and to prefer certain outcomes to uncertain ones with the same expected payoff. However, according to Latacz-Lohmann and Van der Hamsvoort (1997) empirical studies assessing farmers' conservation attitudes in this respect do not arrive at a unanimous judgment. Still, the assumption of risk aversion has its implications on the selection of the auction format. With risk averse bidders, the first-price sealed-bid auction produces higher revenues to the auctioneer than the English auction (Riley and Samuelson, 1981). In the case of conservation contracting, risk aversion therefore leads to a higher level of cost effectiveness. Risk averse bidders will require a lower compensation payment from the program than risk neutral bidders, since the conservation payment provides them with a unchanging element in their income. After all, farmers' uncertainty decreases with the inclusion of a nonstochastic income component and thus this induces them to marginally decrease their bids in order to increase the probability of acceptance.

Next, in a conservation setting one can assume that bidders have independent private values, i.e. farmers know how the contract would affect their profits. The bid they submit is independent of the value other farmers place on their land. However, practical applications have shown that a common-value element can arise when the conservation contracts are sold in sequential auctions (Latacz-Lohmann and Van der Hamsvoort, 1997).

Thirdly, since the quality of the land and thus the environmental services can differ between farmers, we have an asymmetric bidding situation. Each farmer draws their bid from different probability functions. Practically this can be solved by discriminating between bids or by using eligibility criteria. Bidders will be judged both by their monetary bid and by the quality of the environmental services they will provide.

Further, the conservation payment may be a function of bids alone. Alternatively, part of the payments can be made when the contracts are assigned and the rest can be paid at the end of the program depending on the environmental outcomes.

Finally, since information costs can be important for the bidders and influence their bidding behaviour, it is important to promote the clarity and simplicity of contracts and bidding process. Farmers will, after all, need to collect information about which conservation actions are possible on their land and the costs associated with them, about the workings of the auction and about the administrative requirements for the contract.

2.2.2 Optimal bidding

When analysing auction schemes, it is important to know which factors influence the bidding behaviour of the participants. Two studies are particularly worth mentioning here: Latacz-Lohmann and Van der Hamsvoort (1997) investigate the optimal bid for a uniform distribution of the farmers' beliefs on program acceptance and Vukina et al. (2003) look at more general distributions. The optimal bidding contract is investigated when farmers are risk neutral and there are two criteria to determine winners: a monetary bid and an environmental score.

According to Latacz-Lohmann and Van der Hamsvoort (1997) and Vukina et al. (2003) the optimal bid b_i^* for farmer *i* is the one that maximises the expected benefit of participation over and above the benefits from farming, and is found by maximising $\pi\left(b_i\right)=\left(b_i+Y_i^{con}-Y_i^{agr}\right)\left[1-F\left(b_i\right)\right]$ with respect to the submitted bid b_i. Net income from agriculture for farmer *i* is represented by Y_i^{agr} and net income from the conservation project is Y_i^{con}. An interior solution is given by:

$$b_i^* = \frac{1-F\left(b_i^*\right)}{f\left(b_i^*\right)} + (Y_i^{agr} - Y_i^{con}) \qquad (1)$$

with $Y_i^{agr} - Y_i^{con}$ = net farmer's cost of the land use change (including both current costs and future benefits)

$f(b_i)$ = continuously differentiable probability 'density' about β_i, which is the unknown largest possible bid farmer *i* can submit and still win acceptance into the program with a full support on $\left[0,\bar{\beta}\right]$ where $\bar{\beta}$ is the bid cap.

$F\left(b_i\right)=\int_0^{b_i} f(u)du$ = cumulative density function of f.

Here f summarises the entire farmer's uncertainty, which includes ignorance of the rules judging the environmental services provided by the offered contract, the lack of knowledge on the evaluation rules combining scores and bids, as well as other bidders' strategies and scores.

The formula for the optimal bid indicates that bidders increase their bids above the net cost of the land-use change by a positive factor $\frac{1-F\left(b_i^*\right)}{f\left(b_i^*\right)}$. This mark-up can be thought of as the farmers' information rent earned as a result of their private information about the opportunity cost of program participation. Bidders balance their net payoffs with the probability of acceptance.

2.2.3 Dynamic setting

In reality conservation auctions often involve multiple rounds, in each of which several conservation contracts are awarded. This adds a dynamic dimension to the study of auction schemes. Hailu et al. (2004), for example, examine repeated procurement auctions that are target-constrained and that aim to reach a particular conservation target rather than to spend a predefined budget. They show that for a single-unit discriminatory sealed-bid auction, the optimal bidding strategy is one of overbidding and that this overbidding declines when the number of bidders increases. The more general result for a multiple item auction shows that the level of overbidding is high for low-value bidders. Overbidding decreases as the value increases, with the bids from high-value bidders asymptotically approaching their respective private values. This implies that the extraction of rents under auctions can be similar to that under fixed-price schemes. It also implies that the current expectations about the performance of auctions relative to fixed-price schemes need to be reassessed.

3. Implementation issues and guidelines

The theoretical and empirical research on the potential of auction schemes for nature conservation allows us to identify policy objectives and to formulate guidelines that warrant consideration when designing and implementing conservation auctions. We have singled out for discussion eight relevant topics concerning the design and realisation of nature conservation auctions.

3.1 Program objectives

The correct specification of the objectives targeted by the program's directors is critical (Reichelderfer and Bogges, 1988). It is also important to consider the interaction with other programs or regulations; see, for example, the European Common Agricultural Policy (CAP). As Latacz-Lohmann and Hodge (2003) note, cross compliance is an interesting notion in this respect. Farmers who do not comply with environmental guidelines could risk foregoing payments from EU income support schemes. They specifically propose the use of competitive bidding in the development of a green-CAP.

3.2 Single round versus repeated auctions

A single auction round is better if landowners have independent private values (Stoneham et al., 2002). Repeated auctions can, after all, endanger the efficiency properties of conservation auctions (Hailu et al., 2004 and Hailu and Schilizzi, 2003). The farmers' learning process can increase their information rents and, as Shoemaker (1989) has pointed out, bids can approach the bid cap if farmers are risk averse and if they obtain more information over time.

3.3 Sealed-bid

Klemperer (2002) notes that a sealed-bid approach is less susceptible to collusion between bidders than repeated open, ascending and uniform-price auctions. Sealed-bid auctions are also preferable if bidders are risk-averse. A first-price sealed-bid auction will facilitate lower bids because landholders can reduce their own commodity and weather related income variability by adding a regular income stream from conservation payments.

3.4 Reserve price

As Riley and Samuelson (1981) and Myerson (1981) have noted reserve prices are less important when the budget is constrained. If the government envisions only a single auction round with a budget constraint, it is not necessary to set a reserve price, i.e. a maximum allowable bid or bid cap. If the program consists of several auctions rounds over different regions or periods, it is important to include a reserve price. The reserve price allows transfers between auctions in order to maximise total biodiversity outcomes (Stoneham et al, 2003).

Shoemaker (1989) has argued that asymmetric information about farmer risk aversion and the possibility of farmers learning the bid cap can cause bids to approach the bid cap. The maximum allowable bid (cap) for the US Conservation Reserve Program (CRP) is, for example, equal to the average land rental rate for each soil type in the county where the proposed CRP land is located, plus a $5 per acre maintenance allowance (Vukina et al., 2003). In order to deter farmers from learning the bid cap, it might be advisable to use a more complicated definition of the bid cap or one that is altered annually rather than the land rental rate. Moreover, while this bid cap is meant to measure the opportunity cost of land, in fact it simply sets an upper bound for land values among farmers who participate in the auction.

3.5 Discriminatory price versus fixed-price auctions

One of the first studies about the efficiency of auctions is Latacz-Lohmann and Van der Hamsvoort's (1997). In a simulation exercise they show that auction schemes are more efficient than a fixed-rate offer (i.e. a uniform subsidy scheme). Under all bidding scenarios considered, more of the program goals were achieved with the same amount of money. The reasons for these efficiency gains are twofold. First, the difference between payments and costs accruing to farmers who enrol land with lower-than-average opportunity costs are reduced. Second, producers with opportunity costs above the level of the fixed-rate payment are encouraged to tender cost-covering bids. These farmers would not participate under the offer or subsidy system.

Discriminatory price auctions involve lower costs for the same outcome as fixed-price policies if they are truth revealing. Cason and Gangadharan (2004) show in an experiment that a discriminatory pricing scheme is superior to a uniform scheme since its overall market performance is better.

Hailu and Schilizzi (2004), on the other hand, caution against too much optimism in the setting of repeated auctions. They use simulation results to show that, in a dynamic setting where bidders can learn, the auction mechanism is not superior to fixed-price schemes except when the latter involve the use of high uniform subsidy levels.

3.6 Collusion

Bidders collude in an auction if they coordinate their bids and allow one bidder to win the traded good at a price substantially below what other colluding bidders are willing to pay (Chan et al., 2003). Bidders can collude in an implicit or explicit way. Collusion does not have to imply an illegal arrangement. It is more likely to arise in repeated auctions than in one-off, single-bid auctions. Recurrent interaction between bidders adds to the attractiveness and feasibility of collusive strategies. McAfee and McMillan

(1992) have investigated the possibility for all bidders to collude in a first-price sealed-bid auction.

In order to prevent possible collusion, the seller should set specific auction rules to avert bid coordination between bidders. Auction rules should be devised to enable individual bidders to gain from non-cooperative bidding strategies (i.e. cheating on the agreement to collude) without being detected or sanctioned by the other bidders. Chan et al. (2003) suggest the following design features to reduce collusive bidding.

- The higher the reserve price, the larger the number of potentially colluding bidders. Also, a high reserve price limits the potential gain from collusion. In repeated auctions the mere threat of a high reserve price can already deter collusion.
- Keep the reserve price a secret. Potential colluders need to know the reserve price in order to determine their collusive bids.
- Announce only the identity of the winner, not the winning bid or losing bids and adopt a secret allocation rule that does not depend on the highest bid. This reduces the colluders' ability to detect deviating behaviour.
- Choose a sealed-bid auction over an open auction. This postpones the punishment of cheaters to the future.

3.7 Contract design

Since the conservation benefits differ from site to site, it is best to use individual management agreements. It is also interesting to incorporate progress payments (Stoneham et al., 2002), since this provides the government with an easy sanction in case of non-performance, i.e. funds can be withdrawn.

In conservation programs the relation between actions and outcomes does not always exist, is site-specific and depends on non-measurable factors (Reichelfelder and Bogges, 1988). Biodiversity is difficult to measure, so the resulting environmental services are hard to assess. This forces the government to base the contracts on inputs rather than outputs, e.g. the type of tree planted or the presence of undergrowth. This has its implications for risk bearing: the risk of not obtaining the desired outcome due to unforeseen circumstances is shifted from landowners to government.

Vukina et al. (2003) show that including the farmers' own environmental benefits into the evaluation formula can distort bidders' incentives. Including these benefits compensates farmers for actions they would have taken anyway. Moreover, farmers can have a hold-up position if they know that the environmental score associated with their plot is high and that the environmental services provided are highly desirable or even unique. Stoneham et al. (2002) and Cason and Gangadharan (2004) argue that if landowners do not know the exact value of the environmental benefits associated with their land, the auction's cost effectiveness is improved. For this reason, it may be desirable to change the weighting of multiple objectives each year. This will reduce the information leakage. Latacz-Lohmann and Van der Hamsvoort (1997) also suggest concealing the functional form of the bid acceptance mechanism while at the same time providing new bidders with guidelines as to the range of realistic payment levels.

3.8 Implementation

To attract as many bidders as possible, it is important to make sure that there is enough publicity about the conservation program. Possible strategies are the distribution of brochures, development of websites, designating a fixed contact person, organising local information meetings and site visits. In BushTender (Australia), for example, field officers visited the different sites and helped landowners to fill in the forms and discuss the different management options.

4. Real-life applications

Conservation auctions take place across the world. This section provides an overview of these programs per continent, with a discussion of the most important ones.

4.1 United States of America

A real-life example is the above-mentioned US Conservation Reserve Program (CRP) that pays farmers to remove land from production and put it to a conservation use (www.fsa.usda.gov/dapf/cepd/crp.htm). Since its start in 1985, there has been 29 sign-up periods and the US CRP's main aims are to protect the topsoil from erosion and to safeguard natural resources. According to the program, a farmer can, if his bid is accepted, receive annual rental payments equal to the value of the submitted bid in exchange for removing the land from agricultural production and putting it to a conservation use. In addition to an annual per-acre rental payment, the farmer may request a one-time cost-share payment. A typical contract period is generally 10 to 15 years. In order to rank bidders, an environmental benefit index (EBI), which measures the potential environmental benefit of an offered parcel, is combined with the cost factor, which is a function of the bid placed. The algorithm, which translates the bid into the cost factor, is unknown to farmers. From 1996 onwards, bidders were informed about their EBI, which was previously not communicated to them, and an upper limit on acceptable bids was installed.

Several papers have investigated the Conservation Reserve Program. Firstly, Reichelderfer and Bogges (1988) have described the actual and potential cost savings of the program in 1986. They conclude that CRP's performance is highly sensitive to the choice of eligibility criteria, the bid solicitation and selection process. Next, Shoemaker (1989) has argued that, for the CRP, asymmetric information about farmer risk aversion and farmers learning the bid cap caused bids to approach the maximum acceptable bid. Finally, Vukina et al. (2003) have used data from the CRP auctions to elicit farmers' attitudes toward the environment. By analysing their bids, they found that farmers condition their bids on their environmental score, as predicted by theory. Farmers appear to value those environmental benefits that directly affect productivity of their land (e.g. reduced soil erosion) but do not value those benefits that resemble public goods (e.g. biodiversity).

Another application of auctions to conservation problems is the Swine Buyout Program in North Carolina (www.enr.state.nc.us/DSWC/). This voluntary program removes high-risk swine production operations from the 100-year floodplain and reduces potential hazard from future floods while keeping the land in agricultural use. The program's first phase started in 1999 and elicited 85 bids from which 22 were accepted. Later auctions took place in 2002 and in 2004.

A further example is the Flint River Drought Protection Irrigation Auction in Georgia (www.state.ga.us/dnr/environ/), which pays farmers not to irrigate their cropland for one year. Through a voluntary auction, eligible farmers could submit bids via computer for the state to purchase their irrigation permits. The need for auctions arose in 2001 and 2002. The program was able to enlist 33000 and 40300 acres respectively (approx. 13350 and 16300 ha) by paying on average 136 USD (2001) and 128 USD (2002) per acre for the accepted offers. Weather conditions improved in subsequent years and further auctions were unnecessary.

4.2 Australia

BushTender is an auction-based program developed in Australia (www.dse.vic.gov.au/dse/). Its main goal is to allocate biodiversity contracts to private landholders. Under this system, landholders competitively tender for contracts to improve their native vegetation. Successful bids are those that offer best value for money. A survey of landholders in the trial areas has indicated that participants and successful bidders are reasonably typical of all landholders living in the trial areas. The BushTender approach was also able to support landowners already undertaking some management of native vegetation as well as those landowners that did not previously participate in other government incentive schemes.

Two trial auctions were executed at the beginning of the BushTender program: the North East/ North Central trial (2001) and the BushTender trial Gippsland (2002). These were single-round, discriminatory, sealed-bid auctions. As a result, 3200 ha and 1684 ha of farmland respectively were enlisted in the program at acceptance rates of 65.5% (2001) and 45% (2002). Currently several projects, such as PlainsTender and EcoTender, are implemented under BushTender program.

Stoneham et al. (2003) focus on the implementation and the key design features of the BushTender trial auctions. The authors have analysed the bids submitted by landholders and have calculated that a price discriminating auction would reduce the cost of achieving the same biodiversity improvement using a fixed-price approach by seven times. Moreover, when truthful revelation of the farmers' opportunity costs is assumed, the price discriminatory auction and the fixed-price or uniform subsidy scheme have the same efficiency properties.

Besides the BushTender program, several other Australian conservation programs have included auctions as a policy instrument. The Land Management Tender in Liverpool

Plains (NSW) was a joint trial with WWF Australia. Landscape auctions were used to establish landscape corridors in Burdekin-Fitzroy (Queensland) and to counter degradation of biodiversity and dryland salinity. A multiple-outcome auction of land-use change in Gouldburn-Broken Catchment (Victoria) is being implemented.

4.3 European Union

In the United Kingdom, the Conservation Sensitive Stewardship Scheme and the Nitrate Sensitive Areas Scheme offer a fixed payment to landowners for specified environmental actions (www.defra.gov.uk/erdp/). The administration then chooses the bidders that offer the best quality management plan.

In Germany a trial auction took place in Northeim as a co-operation between academic researchers and local authorities (Groth, 2005 and Bertke et al., 2004). Every farmer had to deliver an individual offer for each plot of grassland. This offer included the choice of the ecological good (grassland I, II or III) and the price per hectare. Offered bids ranged from 10 to 350 Euro per hectare, and a total of 289 hectares of grassland participated in the program. In his study, Groth (2005) determines and evaluates the farmers' transaction costs associated with participation in the grassland auction in Northeim. His follow-up survey suggests that the whole process of offer submission took farmers on average four hours.

4.4 General comments on existing auction programs

All existing programs are fairly recent, with the notable exception of the US Conservation Reserve Program. Especially in Australia, bidding schemes are a popular instrument in conservation policy and the number of auction schemes is rapidly expanding. Apparently, the first impressions of the policy programs are favourable and the regulators are willing to increase their use. However, since conservation programs are so recent, a thorough analysis of the programs' results has not yet been performed. Quantifying the efficiency benefits of using auction schemes rather than subsidy schemes would be very interesting for further research.

The high acceptance rate of bids in the existing programs is also noteworthy. On average 55.9 percent of submitted bids is accepted, with a minimum of 23 percent (US CRP, 1986) and a maximum of 83.2 percent (Grassland trial auction, Germany). This might imply that only farmers with a high probability of acceptance are submitting bids.

The theoretical and empirical results discussed previously show that design issues are very important when implementing conservation auctions. In practice we see that long established programs, such as CRP, tend to change and adapt the auction rules over the years in order to deal with observed problems. Typically, regulators also tend to finance a trial auction with a limited budget in order to gain some familiarity with the impact and working of auctions for nature conservation.

5. Exercise: afforestation in Flanders

To show the potential of auctions, we will perform an exercise for an afforestation project in Flanders and calculate the gain from using a bidding mechanism in an ideal setting. For this purpose we assume that the auction is truth revealing and that there is complete participation of the targeted landowners. The exercise will therefore provide an upper limit on the possible gains from using auctions rather than the actual achievable gain.

5.1 Description of the case study

The area studied is Wetteren-Aalst, a suburban region in Flanders (Belgium), which currently has a low forest index. Ten agricultural sites are marked as potential locations for new forests. We assume that the ten sites are each owned by one single farmer and that decisions on land use change apply to the site in its entirety. Site characteristics are obviously heterogeneous: different types of soil, diverse agricultural uses and different distances to existing forests and city centres are considered. More site information can be found in Moons and Rousseau (2005).

The processing of farm manure is included in the model, which implies that the farmers' afforestation decisions cannot be examined independently of each other. For example, if crop farmers decide to plant trees on their land, there will be less land available to spread pig manure and pig farmers will have to dispose of their manure in another, more costly, way. Since crop farmers do not consider this externality when deciding on land use, their decisions are not always socially optimal.

Agrarian land and forests produce not only agricultural products but also benefits such as recreation, hunting, carbon sequestration, non-use and ecological values. Recreation values are combination dependent since they depend on the number of substitutes in the neighbourhood. Appendix A summarises the estimates of the benefits under consideration.

5.2 Auction scheme

In our exercise, we consider a discriminatory first-price sealed-bid auction in which farmers can ask the amount of subsidies (=bid) they would like to receive to convert their farmland into a multifunctional forest. The regulator will not need to set a reserve price since we face an area constraint; only combinations with a total surface area between 150 and 200 hectare are considered. When all bids are made, the regulator will calculate the optimal cluster of new forests using the methodology developed in Moons et al. (2005) and accept the bids of all landowners that belong to that optimal combination. The farmers do not know in advance the outcome of this optimisation exercise and assume, for this reason, that the probability distribution of winning the auction is equal for all participants. Calculating the optimal location of new forests implies that the government knows the costs and benefits of forestry and agriculture for the different farmers.

The optimal combination of new forests, which maximises the total net social benefits of the afforestation project, consists of sites 1, 2, 9 and 10. The methodology, explained in detail in Moons et al. (2005) and Moons and Rousseau (2005), takes the social benefit for all possible combinations of the potential forest sites into account, with a total surface area between 150 and 200 ha. Sites 1, 9 and 10 are currently used for crop farming, whereas site 2 is used for grazing (see table 1). Site 2 is the largest in terms of surface area (64 ha), while site 9 measures only 22 ha. Population density around sites 1 and 2 is higher than the average for Flanders (approx. 400 inhabitants per km^2), sites 9 and 10 are situated in far less densely populated areas.

PLEASE INSERT TABLE 1

5.3 Comparison of policy scenarios

Let us now compare the current Flemish afforestation policy with the optimal command-and-control (CAC) policy and an auction scheme. First we apply the current Flemish uniform subsidy scheme to our benchmark and observe which farmers will participate. If the current subsidy scheme with an annualised subsidy of 765 Euro/ha for planting a multifunctional forest is imposed, then farmers 1, 9 and 10 decide to plant forests. Social welfare increases by 881 968 Euro compared to a situation without afforestation policy (see figure 1). The optimal CAC policy and the auction scheme, which both ensure that the new cluster of forests is planted at its optimal location, additionally increase social welfare by 220 102 Euro, i.e. 25 percent. However, in a democratic country the dictatorial CAC solution, i.e. forcing the landowners of the optimal sites to plant forest, is not a realistic option. Therefore, it is interesting to look at the potential advantage of using auctions.

PLEASE INSERT FIGURE 1

In order to identify the differences between the different policy scenarios, the components of social welfare are studied more closely in table 2. The current subsidy amount induces only three (out of ten) farmers to plant forests while the auction policy involves four landowners. Surprisingly the optimal location of forests has a slightly lower recreational value to Flemish consumers than the present policy. However, the increase in non-use, ecological and carbon sequestration benefits compensates for the loss in recreational value under the optimal policy. Total net farmers' income is always negative due to the externalities caused by the manure disposition. Government income is positive under the auction scheme since the budget spent on afforestation projects is compensated by the decrease in agricultural subsidies that have to be paid.

PLEASE INSERT TABLE 2

In this illustration, the auction could be designed perfectly and all necessary information could be obtained without costs by the government. For this reason, the comparison between the different policy schemes has taken place in an ideal setting and was not entirely realistic. Nonetheless, the gains from using an auction scheme rather than the existing uniform subsidy are obvious. Auctions, as an environmental policy instrument, allow the regulator to obtain the optimal solution, whereas a uniform subsidy could not if there are no objective criteria to condition the subsidy on (Moons and Rousseau, 2005).

6. Conclusions

When developing conservation policies, it is worthwhile to consider auctions as an alternative to fixed-offer (uniform subsidy) schemes. The potential cost savings can be considerable even though the auction's design characteristics and specifications are not straightforward and should be tailored to each individual program. The expanding use of auctions in conservation programs over recent years indicates regulators' growing interest in this policy instrument as well as its potential as a cost saving device.

Several design issues need to be addressed before implementing a conservation auction. The attitude towards sharing information on environmental benefits with participants should be determined, since this has important implications on the level and range of bids offered as well as on the possibility of collusion between bidders. The necessity and the level of a reserve price depend on the constraints embedded in the program and on the number of auction rounds planned. As was demonstrated in the BushTender auctions in Australia and the grassland auction in Germany, the collaboration of scientific experts on auction theory and administrations can be helpful and should be considered.

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Appendix A: Estimates of costs and benefits

The amounts are expressed in Euro per hectare per year (Moons and Rousseau, 2005).

PLEASE INSERT TABLE A1

Table 1: characteristics of the optimal combination

Site Number	**(Surface) Area**	**Soil Type**	**Population Density in 15 km zone**	**Number of substitute forests within _km distance (surface area in ha)**				**Current Land Use**
				2	**2-5**	**5-10**	**10-15**	
1	47	Sand	476.47	1 (70)	0	3 (648)	5 (799)	Crop farm
2	64	Sand	504.82	1 (60)	0	5 (949)	3 (498)	Grazer farm (excl. milch cows)
9	22	Sand-Loam	154.97	0	2 (137)	3 (175)	1 (62)	Crop farm
10	49	Sand-Loam	263.66	0	3 (175)	3 (157)	1 (119)	Crop farm

Table 2: Comparison between current subsidy and optimal CAC policy

	Current subsidy policy	Optimal CAC policy	Auction scheme
Forested area (in ha)	118	182	182
Number of forests	3 (1, 9 and 10)	4 (1,2,9 and 10)	4 (1,2,9 and 10)
Type of forests	Multifunctional	Multifunctional	Multifunctional
Net farmers' income (euro)	-13 716	-162 209	-26 167
Government revenue (euro)	-47 267	67 118	68 924
Net recreational value (euro)	473 221	472 663	472 663
Net non-use value + net ecological value + net carbon sequestration (euro)	469 729	724 498	724 498

Table A1: Estimates of costs and benefits

	Agriculture	**Multifunctional forest**
Benefits		
Net agricultural income	Crop farms: 646 Pig farms: 549 Grazer farms: 473	**Combination dependent** Crop farms: $[-364, 646]$ Pig farms: $[-4738, 549]$ Grazer farms: $[-1259, 473]$
Timber	0	5
Hunting	7.69	15.38
Carbon uptake	0	68.8
Recreation value	193.14	**Combination dependent** Average value per site belongs to $[314, 2268]$
Non-use value		3860
Ecological value		51.96
Costs		
Planting and management	0	24.16

Figure 1: Comparison between policy scenarios