Tendering conservation contracts: Should information on environmental benefits be disclosed or concealed?

Thilo W. Glebe
Technische Universität München
Environmental Economics and Agricultural Policy Group
Alte Akademie 14, 85354 Freising, Germany
Phone: +49 (0)8161 715965
Fax: +49 (0)8161 713408

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1. Introduction

Auctioning of conservation contracts to farmers has attracted much attention in recent years. Prominent examples of auctioning conservation contracts are the US Conservation Reserve Program and the Australian BushTender and EcoTender (Reichelderfer and Boggess 1988, Stoneham *et al.*, 2003; Kirwan *et al.*, 2005; Eigenraam *et al.*, 2007). There have been also several examples of conservation auctions in Europe in the last decade (Latacz-Lohmann and Schilizzi, 2005). Moreover, tendering of conservation contracts has been explicitly recommended in Article 39 of the EU Council Regulation (EC) No. 1698/2005.

The attention paid to conservation auctions is based on the widely held belief that competitive bidding can enhance the cost-effectiveness of public spending (Gerowitt *et al.*, 2003). Since landholders possess private information about site-specific opportunity costs of conservation measures, governments cannot tailor payment rates to each field plot's cost level (Fraser, 1995). On the other hand, offering uniform payments allows landholders with low compliance costs to realise information rents. The cost-revelation mechanism of a bidding process has the advantage to reduce such rents, though the scale of public cost-savings depends on the specific auction design (Stoneham *et al.*, 2003; Latacz-Lohmann and Schilizzi, 2007; Connor *et al.*, 2008).

An important element in the design of conservation auctions is the selection of an optimal information policy. As environmental benefits of conservation measures are usually heterogeneous, the government can enhance auction performance if it obtains information on site-specific environmental scores. However, if the government evaluates site-specific environmental benefits, landholders will have an informational disadvantage (Cason and Gangadharan, 2004). Disclosing or concealing such information to landholders will affect bidding behaviour and will thereby have an influence on auction performance.

The results of a laboratory experiment undertaken by Cason *et al.* (2003) suggest that government expenses can be saved if information on the environmental scoring is withheld. However, an important question is whether these results are specific to the authors' *experimental* set-up or a finding generally applicable to conservation auctions. To the knowledge of the authors, there has been no *theoretical* study analysing whether either the withdrawal or the disclosure of information on conservation benefits is superior. The objective of the present study is therefore to extend economic theory for conservation auctions to elaborate conditions for efficient information policies.

The remainder of the article is structured as follows: after presenting the modelling framework, section 3 analyses the performance of an auction in which bids are ranked merely based on farmers' proposed compensation payments. Section 4 considers an auction in which environmental programme benefits are included in the bid ranking system while farmers are not being informed about their land's environmental score. Section 5 analyses how revealing information on the environmental score may affect bidding, when it does not affect participation. The influence of information policy on bidders' entry decisions is then investigated in section 6. To provide a numerical example of how the optimal information policy depends on participation and acceptance rate, section 7 applies the modelling framework to a hypothetical conservation programme. The article ends with a discussion of the predominant findings.

2. Modelling conservation payment schemes

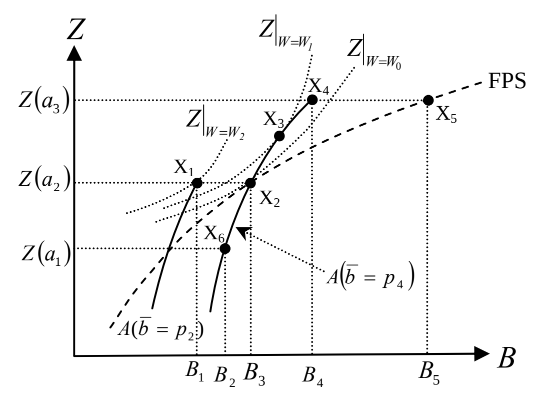
Consider a government designing a voluntary conservation programme in order to buy environmental services from farmers. An optimal policy mix will maximise a government's welfare (W) with respect to the overall environmental programme contribution (Z) and the budgetary outlay (B) of programme payments offered to farmers:

(1) $\max_{Z,B} W(Z,B)$

Note that equation (1) represents a rather general objective function. It reflects the common practise of environmental agencies aiming for the maximisation of environmental quality improvement with a given budget (Hajkowicz *et al.*, 2007; Connor *et al.*, 2008; Schilizzi and Latacz-Lohmann, 2009). It also covers the alternative approach of a government aiming for an environmental target with least budgetary outlays.

Government's welfare may decrease as payments to farmers are raised ($\partial W/\partial B<0$), but increase with the overall environmental improvement linked to the programme ($\partial W/\partial Z>0$). We further assume diminishing marginal rates of substitution between environmental improvement (Z) and budget savings ($-B$), so that the government's preferences can be depicted by indifference curves ($Z|_{W=constant}$) (figure 1). The government's welfare will subsequently increase as indifference curves are shifted north-westwards ($W_2>W_1>W_0$).

Figure 1: Transformation curves of a fixed payment scheme (FPS) and an auction (A)



Assume that farmers have full information on their own land's conservation costs, whereas the government is not able to estimate site-specific per acre costs. Opportunity costs involved with participating in a programme are usually heterogeneous since they depend on natural conditions and farmers' management skills. Naturally, farmers do therefore have an informational advantage over the government with regard to the compliance costs of their own land.

Information asymmetry may also arise in the context of environmental programme benefits, which do usually depend on location-specific factors and thereby vary across field plots. In the absence of reliable valuation studies, environmental benefits can often not be expressed in monetary terms. Per acre environmental benefits (z) may therefore be represented by a dimensionless index composed of several environmental attributes such as water, biodiversity, soil or atmospheric quality. A dimensionless aggregate measure of environmental quality has been applied in numerous conservation auctions in practice (Stoneham *et al.*, 2003; Kirwan *et al.*, 2005; Connor *et al.*, 2008; Rolfe and Windle, 2006). Even if farmers are able to estimate the relative performance of land participating in the programme with regard to some of those attributes, the government can keep an informational advantage since it determines their relative weight. We consider a simplified asymmetric informational structure of a government being able to obtain *full* information on environmental quality changes, whereas farmers cannot obtain *any* a-priori information on site-specific environmental scores.

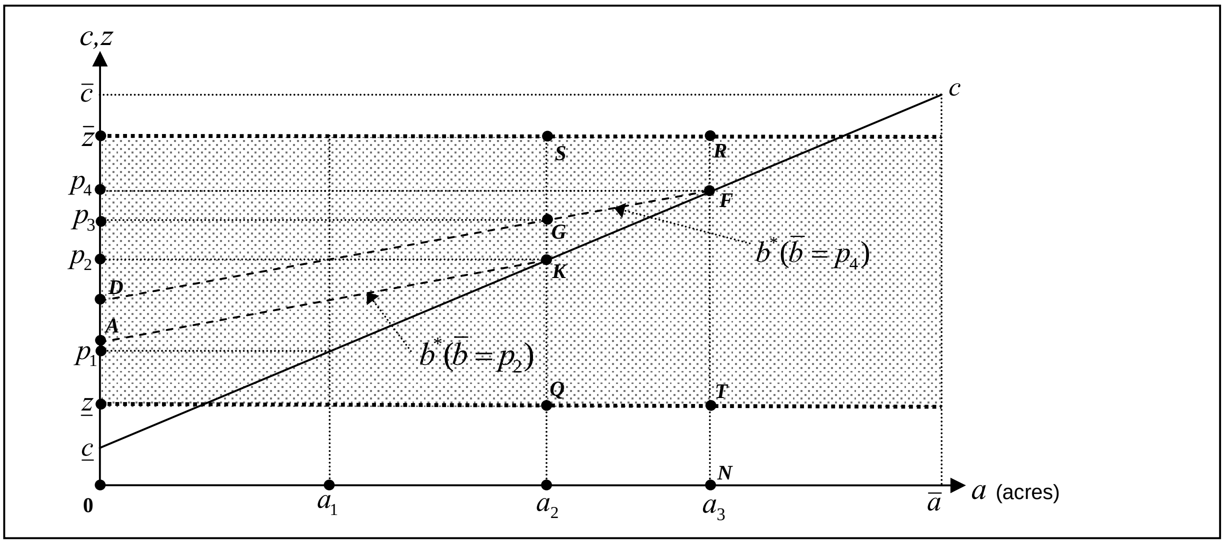
We choose a fixed payment scheme (FPS) as a benchmark for analysing the relative economic performance of conservation auctions. The analysis of an optimal environmental payment scheme will be based on the diagrammatic modelling framework of figure 1 and 2. The eligible area for programme participation is given by $\bar{a}$, while the per acre compliance costs (c) of programme participation, ranging between $\underline{c}$ and $\bar{c}$, are given by the solid line (figure 2). Site-specific environmental scores, ranging between $\underline{z}$ and $\bar{z}$, are not correlated with per acre conservation costs and indicated by the dotted area.[1]

Since programme participation is voluntary, the total area participating in a FPS will be determined by the land quantity at which the per acre payment s equals farmers' compliance costs ($s = c$). For example, if the government offers a per acre payment of p_2, area a_2 will be subscribed to the programme (figure 2). The relevant budget outlay for the government is characterised by area $0a_2Kp_2$, whereas the overall environmental benefit can be obtained by aggregating the environmental scores of each acre (z) participating in the programme, illustrated by the rectangle $\underline{z}QS\bar{z}$. Note that the aggregated environmental score is not identical to the size of that rectangle. The dots within that rectangle do merely indicate the environmental scores that need to be aggregated in order to obtain the overall environmental score:

$$(2) \qquad Z(a_2) = \sum_{i=1}^{n} z_i m_i$$

The total number (i) of field plots participating in the conservation programme is characterised by n, while m_i represents each field plot's size.

Figure 2: Distribution of per acre environmental benefits (*z*) and compliance costs (*c*)



Let the combination of programme outlay (area $0a_2Kp_2$, figure 2) and environmental improvement (area $\underline{z}QS\bar{z}$, figure 2) correspond with B_3 and $Z(a_2)$ (point X_2 in figure 1). If the government offers a higher payment rate (p_4), and thereby raises the programme outlay to B_5 (area $0a_3Fp_4$), it will be able to reach a higher environmental quality level $Z(a_3)$, as indicated by the dots within area $\underline{z}TR\bar{z}$ (figure 2). The combination of B_5 and $Z(a_3)$ corresponds with point X_5 in figure 1. Given that total budget expenditures will increase relatively stronger than environmental quality if per acre payment rates are raised, the relationship between Z and B resulting from a FPS must follow a concave transformation curve (dashed curve in figure 1).

[1] Note that the information asymmetry would no longer exist if c and z were strongly correlated, which would make the analysis of an optimal environmental policy redundant.

Given that point X_2 (figure 1) coincides with the tangency of the transformation and indifference curve, p_2 represents the welfare maximising per acre payment rate the government may offer when implementing a FPS.

3. Auctioning conservation contracts

Next, we will analyse how auctioning of conservation contracts may enhance the economic performance of the conservation policy. We consider a discriminatory sealed bid auction in which each farmer can submit a financial bid (b), a proposed per acre compensation payment for land subscribed to the conservation programme. While the government aims for low bids to reduce budgetary costs (B), farmers face the trade-off that the submission of low bids will enhance the chance of bid acceptance, but also decrease their potential net pay-off from programme participation. Farmers' perceived probability of bid acceptance can be derived from their expectations on the ex-post chosen bid cap $\tilde{b}$, the maximal per acre payment the government is willing to make. For simplicity, we assume symmetry so that all bidders have the same expectation of the bid cap. Building upon Latacz-Lohmann and Van der Hamsvoort's (1997) analysis, the optimal bid (b^*) of risk-neutral farmers can be written as:

(3) $$b^* = (1 - H(b))/h(b) + c$$

where $h(b) = \partial H(b)/\partial b$ denotes the density function of the expected bid cap. Equation (3) suggests that optimal bids generally exceed per acre compliance costs (c) to ensure a positive expected net pay-off from programme participation. Bids will be larger the higher farmers' compliance costs, but will not exceed the expected maximum bid cap $\bar{b}$ at which the probability of bid acceptance is zero (hence $c \le b^* \le \bar{b}$).

Consider that bidders' expected maximum bid cap is given at a rather high level ($\bar{b} = p_4$), so that the optimal bid curve $b^*(\bar{b} = p_4)$ is located between the expected maximum bid cap (p_4) and farmers compliance costs c (figure 2). If the government fixes the ex-post chosen maximal acceptable bid at $\tilde{b} = p_4$, all submitted bids will be accepted, leading to a total conservation area of a_3. The associated combination of environmental quality $Z(a_3)$ and budget expenditures of B_4 (area $0a_3FD$) corresponds with point X_4 (figure 1). Hence, an auction will be superior to a FPS because the environmental output $Z(a_3)$ can be reached with lower costs (B_4 rather B_5).

Nevertheless, an auction will not necessarily perform better than a FPS. If the government aims for a less ambitious environmental target ($Z(a_2)$) it may choose an ex-post bid cap of $\tilde{b} = p_3$ (figure 2). As a result, the programme outlay (area $0a_2GD$) may coincide with that linked to a fixed per acre payment of p_2 (point X_2 in figure 1). An auction will perform worse than a FPS if the government tries to reach an environmental quality improvement of only $Z(a_1)$ (point X_6 in figure 1). The relevant ex-post bid cap of an auction will be given at $\tilde{b} = p_2$ (figure 2), whereas a payment of $s = p_1$ will be sufficient to reach $Z(a_1)$ within a FPS (figure 2). We conclude that the transformation frontier of an auction approach (for given farmers' expectations) does intersect that of a FPS (figure 1). The transformation curve of an auction is concave since programme expenditures (B) increase more than proportionally as environmental output (Z) is raised.

Notice further that the relative performance of an auction is determined by farmers' expectations about the bid-cap. The diagrammatic model (figure 1 and 2) illustrates that lower expectations of the maximum bid cap will enhance the performance of an auction, since an environmental quality target can be achieved with a lower programme outlay. Lower expectations are illustrated by a south-west shift of an auction's transformation curve (figure 1). For instance, if bidders' expected maximum bid cap is $\bar{b} = p_2$, the environmental quality of $Z(a_2)$ can be reached by choosing an ex-post bid cap of $\tilde{b} = p_2$. The associated budget expenditures (area $0a_2KA$ in figure 2) will be lower than that of the relevant FPS (comparison between X_1 and X_2 in figure 1).

Low expectations will also lead to lower participation rates since farmers will only participate in an auction if per acre costs are not higher than the expected maximum bid cap ($c \leq \bar{b}$). Subsequently, given an expected maximum bid cap of $\bar{b} = p_2$, the government will not be able to enhance environmental quality beyond $Z(a_2)$. Hence, while an auction has the potential to enhance the economic performance of agri-environmental payments, a FPS may turn out to be superior if farmers' expectations are either too high or too low.

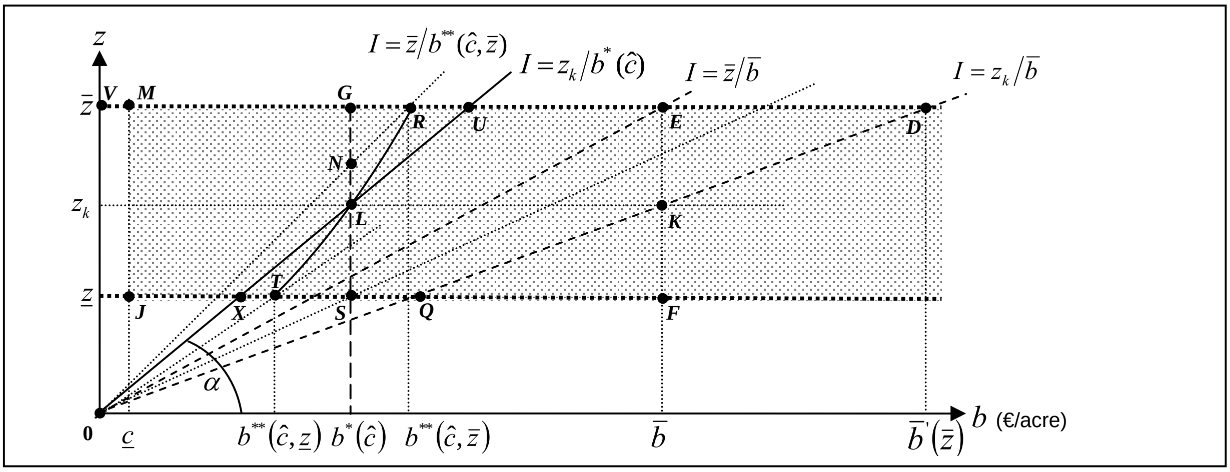
4. Obtaining information on site-specific environmental benefits

The previous section considered that accepted bids are selected merely on the basis of proposed payments (*b*). This is relevant, if the government has no knowledge of site-specific environmental benefits of programme participation. We will now extend Latacz-Lohmann and Van der Hamsvoort's (1997) analysis by demonstrating that gathering of information on site-specific environmental benefits may enhance the economic performance of auctions.

Obtaining information on site-specific environmental scores allows the government to apply a two-dimensional ($I(z,b)$) rather than a one-dimensional scoring index (*b*). A widespread approach in conservation auctions has been to use a scoring system which relates environmental benefits to programme outlays (Stoneham *et al.*, 2003; Eigenraam *et al.*, 2007; Greenhalgh *et al.*, 2008; Windle and Rolfe, 2008; Connor *et al.*, 2008). A scoring system $I=z/b$ involves that the probability of bid acceptance increases with a higher bid index. Bids will only be accepted if they *exceed* an ex-post chosen critical index $\tilde{I}$.

Analysing the influence of information on bidding behaviour requires a modified modelling framework. Let us therefore depict combinations of financial bid (*b*) and environmental score (dotted area between $\underline{z}$ and $\bar{z}$ in figure 3):

Figure 3: Influence of a two-dimensional scoring index on auction performance

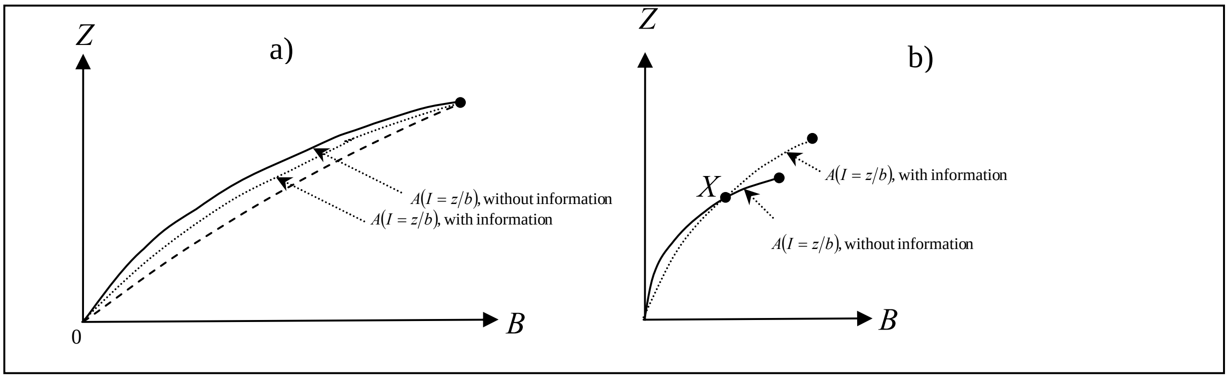


Assume that, in the scenario without information on *z* (one-dimensional scoring system), a bid cap will be chosen which coincides with the optimal bid linked to the cost level $\hat{c}$, hence $\tilde{b} = b^*(\hat{c})$ (line *SG* in figure 3). The auctioneer will thereby accept all combinations of *b* and *z* within rectangle *JSGM* (figure 3) leading to total budget expenditures of:

(4) $$\overline{B} = \sum_{i=1}^{n} b_i^* m_i$$

Consider now that the government has obtained information on *z* and applies a two-dimensional scoring index (*I=z/b*). Given the same budget constraint $\overline{B}$, the iso-score curve representing the critical scoring index below which bids will be rejected (line 0*U*) must lie between points *S* and *G*, hence $\tilde{I} = \tan\alpha = z_k / b^*(\hat{c})$ where $\underline{z} < z_k < \overline{z}$ (figure 3). An auctioneer applying a two-dimensional bid scoring system would thereby accept all combinations of *b* and *z* within area *JXUM* (figure 3). Hence, when taking the one-dimensional bid scoring system as a comparison, bidders with relative high *z/b* ratios will be included (area *LUG*), while those with relative low *z/b* ratios (area *SLX*) will be excluded. We infer that the government can reach a higher aggregate environmental quality with the same budget (or alternatively the same environmental target with least public expenditures), which is illustrated as a leftward shift from the dashed to the solid transformation curve (figure 4a):

Figure 4: Auctioning with and without information on the environmental score



5. Bidding with and without information on the environmental score

Let us now turn to the question of how bidding will be affected by different information policies. By neglecting the relevance of participation decisions, we provide a theoretical explanation for Cason *et al.*'s experimental finding that withholding information on site-specific environmental benefits may enhance auction performance. Later, in the following section, we demonstrate how auction performance is affected if an information policy's impact on entry decisions is considered.

If farmers' bids are accepted, their net pay-off per acre is given by the difference between proposed per acre payments (*b*) and costs (*c*). When applying a two-dimensional scoring index, the probability of bid acceptance (*p*) becomes a function of *b* and *z*:

(5) $$p = P\left(I(b,z) \geq \tilde{I}\right) = \int_{\underline{I}}^{I(z,b)} f\left(I(b,z)\right) dI = F\left(I(b,z)\right)$$

where $\tilde{I}$ characterizes the ex-post chosen critical bid index below which bids will be rejected and $f(I) = \partial F(I)/\partial I$ the expected density function of $\tilde{I}$. The expected net-gain of bidders not being informed on site-specific *z*-values can thereby be formulated as follows:

(6) $$E[\pi] = \int_{\underline{z}}^{\overline{z}} \left[g(z) F\left(I(b,z)\right)(b-c) \right] dz$$

When specifying farmers' expected density function of the environmental score ($g(z)$) and the critical scoring index ($f(I)$), the optimal bids $b^*(c)$ of risk-neutral uninformed bidders can be derived from equation (6).[2] For example, let us consider uniform distribution functions for the scoring index ($F(I)=(I-\underline{I})(\bar{I}-\underline{I})^{-1}$) and the environmental quality index ($G(z)=(z-\underline{z})(\bar{z}-\underline{z})^{-1}$). Equation (6) can then be rewritten as:

$$(7) \qquad E[\pi]=\frac{E(z)}{(\bar{I}-\underline{I})}-\frac{E(z)c}{b(\bar{I}-\underline{I})}-\frac{\underline{I}(b-c)}{(\bar{I}-\underline{I})}$$

By maximizing (7) for b we get the optimal bid of uninformed bidders:

$$(8) \qquad b^*=\sqrt{E(z)c/\underline{I}}$$

Let us now analyse how the optimal bid will change when bidders are being informed on their land's environmental score. We consider that bidders are aware of the two-dimensional scoring index $I=z/b$. The expected net pay-off from auction participation is then given by:

$$(9) \qquad E[\pi]=F(I(b,z))(b-c)$$

Applying the first-order conditions of a local maximum ($\partial E[\pi]/\partial b=0$), the optimal bid of a risk-neutral informed bidder can be written as:

$$(10) \qquad b^{**}(c,z)=c-\frac{F(I(b,z))}{f(I(b,z))I_b}$$

If we assume the same uniform distribution for b and z as above, the optimal bid of an informed bidder (b^{**}) becomes:[6]

$$(11) \qquad b^{**}(c,z)=\sqrt{cz/\underline{I}}$$

A comparison between equations (11) and (8) demonstrates that bidders being aware that they have an average environmental score ($E[z]$) would submit the same bid as if they were uninformed. However, since the optimal bid of informed bidders will increase as z increases ($\partial b^{**}/\partial z>0$), landholders with more than average z-values will increase their proposed payments, while those with lower than average z-value will reduce bids.

Optimal bids for uninformed (b^*) and informed bidders (b^{**}) linked to the cost level $\hat{c}$ are illustrated by line *SG* and *TR*, respectively (figure 3). The positive slope of the bid curve b^{**} (line *TR*) indicates that farmers who get to know the environmental scores of their land will increase their bid if $z>z_k$ and lower it if $z<z_k$. Let z_k denote the environmental score at which proposed payments of informed and uninformed are identical ($b^*(\hat{c})=b^{**}(\hat{c},z_k)$). Notice that z_k may not necessarily coincide with $E[z]$ if we assume other than uniform distributions of $F(I)$ and $G(z)$.

We can now demonstrate that an auctioneer will usually be better off by concealing information on site-specific environmental benefits, when maintaining the assumption of a fixed participation rate. The reason is that bids with the highest z/b ratios will be accepted first whereas low z/b ratio bids will only be accepted if the budget is sufficiently large. To illustrate the superiority of information concealment, let us focus on bidders with the compliance cost level $\hat{c}$ (figure 3). Assume that bidders not being informed about their land's environmental score submit the bid $b^*(\hat{c})$, indicated by line *SG* (figure 3). If the auctioneer chose a critical scoring index of

[2] Note that farmers' *expected* distribution may not necessarily correspond with actual distributions of z and I.

$\tilde{I} = \bar{z}/b^{**}(\hat{c},\bar{z})$ below which bids are rejected, only *z/b* combinations along line *GN* would be accepted (figure 3). Revealing information on site specific values of *z* would shift the bidding curve from *SG* to *TR*. Hence, when applying the same critical scoring index $\tilde{I} = \bar{z}/b^{**}(\hat{c},\bar{z})$, no bids could be accepted. The auctioneer would therefore need to lower the critical scoring index $\tilde{I}$ and thus accept bids with a worse *z/b* ratio. Hence, we conclude that the revelation of information on *z*-values would lead to a right-ward shift of an auctions' transformation curve (from the solid to the dotted line in figure 4a).

As the programme outlay is gradually increased so that more and more bids will be accepted, the relative advantage of information concealment becomes smaller, indicated by the converging of the transformation curves (figure 4a). A higher acceptance rate involves that more bidders with low z/*b* ratios ($z < z_k$) will be accepted. However, these are the bidders who will reduce their proposed payments and thereby raise the z/*b* ratios as a result of information revelation. Hence, if all bids are accepted ($\tilde{I} \le \underline{z}/b^*(\hat{c})$), both information policies may lead to similar budget expenditures.[3]

Note that the superiority of information concealment is only guaranteed if the bidding curve for informed bidders (line *TR*) is generally steeper sloped than any iso-index line (*I*=constant) intersecting it. This implies that disclosing information on site specific *z*-values will induce *z/b* ratios of bids associated with low environmental benefits ($z < z_k$) (line *TL* in figure 3) not to increase beyond the bid score of *non*-informed bidders' land that is associated with high environmental benefits ($z > z_k$) (line *GL* in figure 3). Let us therefore provide the following proof:

May *b*(*p,z*) denote the inverse of the probability of bid acceptance $p(b,z) = P(I(b,z) > \tilde{I})$. As long as that combinations of financial bid (*b*) and environmental score (z_i, z_j) lead to the same bid score, the associated probability of bid acceptance must be the same. We can therefore derive the following relationships:

(12) $$b(p,z_i) = \frac{z_i}{z_j} b(p,z_j)$$

(13) $$\frac{\partial b(p,z_i)}{\partial p} = \frac{z_i}{z_j} \frac{\partial b(p,z_j)}{\partial p}$$

Maximising a bidder's expected net pay-off ($\pi = p(b(p,z) - c)$) with respect to the probability of bid acceptance (*p*) requires the first-order condition:

(14) $$\frac{\partial b(p,z_i)}{\partial p} = \frac{b(p,z_i) - c}{p^*(z_i)}$$

where p^* may represent the probability which maximises a bidder's expected net pay-off. By inserting (12) and (13) into (14) and resolving for *p*, we derive:

(15) $$\frac{p^*(z_i)}{p^*(z_j)} = 1 + \frac{c(z_i - z_j)}{z_i(b(p,z_j) - c)}$$

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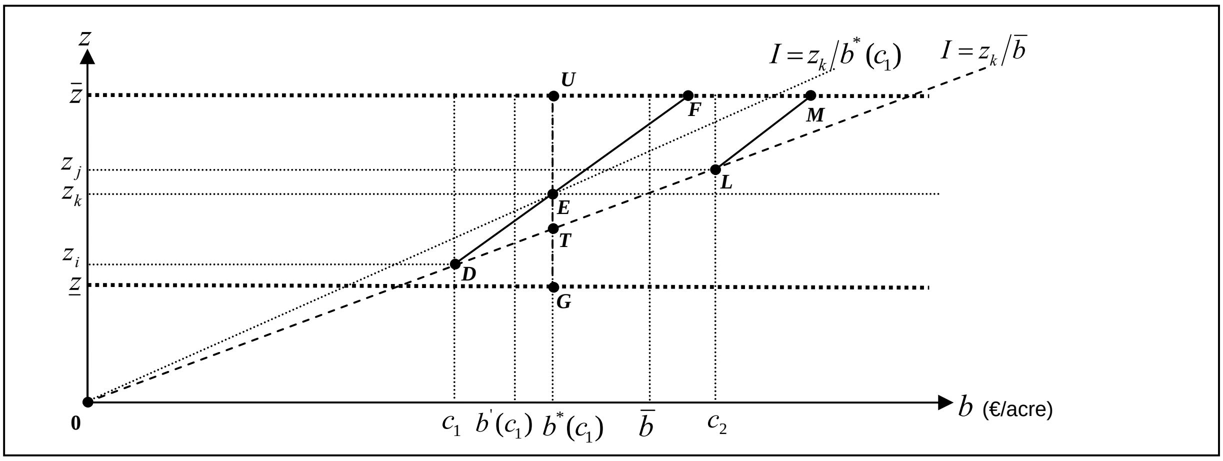
[3] When assuming uniform distribution functions for *I* and z, the average bid of an informed bidder will be lower than that of an uninformed bidder. This is because the optimal bid will increase less than proportionally as the environmental score is raised, given that the second derivative of (11) with respect to *z* is negative: $\partial^2 b/\partial z^2 = -\sqrt{c/(4\underline{I}z^3)} < 0$. The reverse might be given if alternative distribution functions of *I* and *z* are considered.

Rational bidders will propose compensation payments larger than compliance costs ($b>c$). Hence, equation (15) must take a value greater than one for $z_i > z_j$. The probability of bid acceptance linked to a risk neutral farmer's optimal bid will therefore increase with the z-value, provided that $c > 0$. Since a higher probability of bid acceptance is associated with a higher scoring index I, the bidding curve for informed bidders (line TR) must consequently be steeper sloped than any iso-index line intersecting it.

6. Influence of entry decision on auction performance

Next, we analyse how auction performance is affected if changes in information policy influence the participation rate. For simplicity, we focus on farmers facing per acre cost levels of either c_1 or c_2 (figure 5). May both groups of farmers expect the bid cap to be not higher than $\bar{b}$ and the ex-post chosen critical scoring index to be not below $\underline{I} = z_k/\bar{b}$, when information on environmental scores is concealed. As a consequence, farmers facing cost level c_1 may choose the bid $b^*(c_1)$ (line UG), whereas farmers with c_2 will not participate in the auction. The reason is that rational farmers will only submit bids, if their expected maximal bid cap is higher than compliance costs of project participation ($c < \bar{b}$).

Figure 5: Influence of information policy on auction participation



If farmers are informed on site-specific z-values, the bid curve linked to the cost level c_1 will shift from UG to DF (figure 5). If farmers' environmental score is below z_i, they will not be able to reach the expected minimal scoring index $\underline{I} = z_k/\bar{b}$ and thereby abstain from the auction. On the other hand, the disclosure of information on z may convince landholders with high environmental scores to participate in the tender, who would not do so if information were concealed. For example, farmers with cost level c_2 and site-specific environmental benefits of $z > z_j$ would now offer bids characterised by line LM. The associated z/b ratios are higher than that of the iso-index line $\underline{I} = z_k/\bar{b}$ and thereby also higher than many offers (along line TG) that would be otherwise submitted by uninformed farmers facing the cost level c_1 (figure 5).

Several insights can be derived from this analysis. If a small budget is spent, withdrawing information on z-values will still be more efficient than information revelation. This is because more bids will be included by moving from point U to E rather than by moving from F to E (figure 5). However, if budget expenditures are rather large, so that bids linked to cost level c_2

will be accepted, providing information on z-values can enhance auction performance. The transformation curve corresponding with the revelation of information on z (dotted line, figure 4b) will thus intersect with the transformation curve linked to information concealment (solid line, figure 4b).

We conclude that the provision of information on site-specific conservation benefits can enhance an auctions' economic performance. It may occur when landholders' expectations of the bid cap are so low that not all eligible plots will be offered, and when a rather large share of the submitted bids is accepted. In other words, the lower landholders' expectations of the bid cap (i.e. the fewer eligible field plots participate in the auction) and the larger the proportion of submitted bids that will be accepted, the more likely it is that disclosing information is superior to concealing it. The break-even line indicating combinations of acceptance and participation rates at which both information policies yield the same results, must therefore reach from south-west to north-east, when plotting participation rates against acceptance rates (figure 6a).

7. Numerical analysis: Monte Carlo simulation

To assess the relevance of the theoretical findings discussed in the previous section, we analyse the optimal information policy within a hypothetical conservation auction. A Monte Carlo simulation of a conservation auction is conducted with 1000 potential bidders. Per acre opportunity costs linked to conservation measures vary between zero and 400€, while site-specific environmental scores are assumed to range between $\underline{z} = 10$ and $\bar{z} = 400$. Opportunity costs for each of the landholders are randomly chosen from an approximated normal probability distribution[4], while environmental scores are considered to be uniformly distributed. By assuming also a uniform distribution for the expected critical bid score ($\tilde{I}$), farmers' optimal bids for the different information policies can be derived from equations (8) and (11).

By ranking bids according to the relevant scoring system, we can derive transformation functions for the policies "information withdrawal" and "information disclosure" (figure 4b). For each run we calculate the acceptance rate at which both information policies lead to the same combination of budget expenditures (B) and environmental benefit (Z) (point X in figure 4b). The simulation is replicated 4,000 times. Since farmers' expectations on the expected minimal critical bid score $\underline{I}$ are varied between different runs, each simulation may lead to a different participation rate.

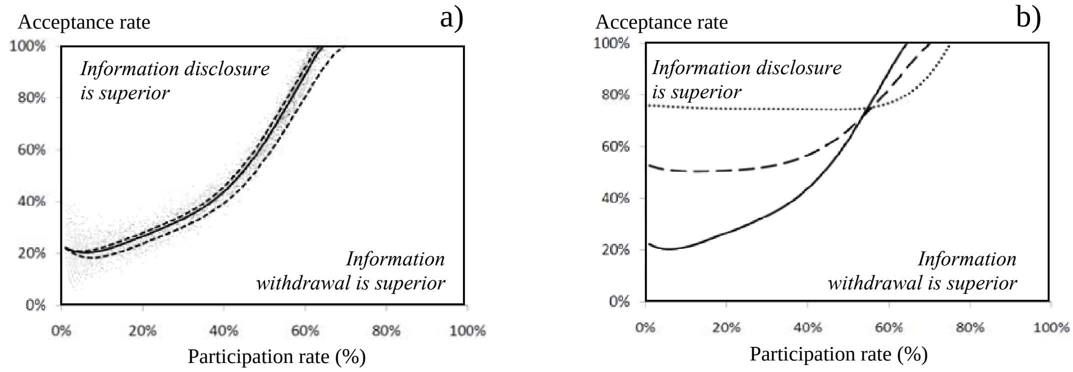
Results are presented in figure 6. Each dot (figure 6a) corresponds to an acceptance rate at which both information policies perform equally (point X in figure 4b). Each observation in figure 6a does thereby represent a break-even combination of participation and acceptance rate. The trend of all observation is given by the solid line (figure 6a). The area below the trend line can therefore be interpreted such that it characterises combinations for which information concealment is expected to be the superior policy (figure 6a). For participation/ acceptance rate combinations above the trend line, the government should be better-off by making site-specific environmental benefits public.

To analyse the robustness of the results, we conduct a sensitivity analysis. Participation/acceptance rate combinations are calculated at which information concealment either decreases or increases budgetary costs by 10% (dashed lines in figure 6a). The results indicate that relatively small deviations from the break-even line may already lead to significant budgetary costs savings when selecting the optimal rather than the sub-optimal policy.

[4] A normal distribution is approximated by adding four uniformly distributed random variables.

Next, we alter the distribution functions for the opportunity costs of programme participation. The break-even trend line linked to normally distributed costs is depicted by the solid line in figure 6b. When farmers' costs follow a triangle distribution, the break-even trend line shifts to the dashed line, whereas uniform distributed compliance costs lead to the dotted break-even trend line (figure 6b). The results suggest that the distribution of bidders' opportunity costs has a strong influence on the selection of an optimal information policy.

Figure 6: Monte Carlo simulation: Comparison of different information policies



8. Conclusions

The present study analyses optimal information policies based on a conservation auction model for two-dimensional bid-scoring. Conditions under which either concealing or revealing of information on site-specific conservation benefits maximises an auctioneer's welfare are elaborated. The analysis demonstrates that information concealment will usually be preferable if entry decisions are not relevant. The study does thereby provide a theoretical explanation for Cason *et al.'s* (2003) experimental result. However, we demonstrate that information concealment is not generally superior to information revelation. An auctioneer can be better-off by revealing information because it may motivate farmers to participate in the auction who would not do so otherwise. Low participation rates do therefore increase the probability that information revelation will be superior to information concealment.

The analysis of optimal bids is based on the assumption that landholders behave risk-neutral. Risk-neutrality was considered to be appropriate in the context of a theoretical study, given that the specification of an optimal bid of risk-averse bidders would need to rely on rather restrictive assumptions. When considering risk-aversion rather than risk-neutrality, optimal proposed payments would tend to be lower for both information policies. Because concealment of information on environmental benefits introduces a further element of uncertainty in the bidding process, one may speculate that considering risk-aversion rather than risk-neutrality might improve the relative performance of information concealment. The break-even line might therefore shift north-westwards (figure 6). However, it is questionable whether risk-aversion may lead to a situation where information withdrawal will be generally superior. We suggest laboratory experiments with risk-averse probands to test the influence of risk attitude on auction performance. Such experiments may also incorporate the different kinds of transaction costs which may influence landholder's decision to abstain or participate in a conservation auction.

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