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AUCTIONING OUTCOME-BASED CONSERVATION CONTRACTS

Uwe Latacz-Lohmann[1], Steven Schilizzi[2], Gunnar Breustedt[3]

Abstract

This paper explores two ideas to enhance the performance of agri-environmental contracting schemes: linking contract payments to environmental outcomes and putting the contracts up for tender. This paper investigates whether there are any gains to be had by combining the benefits of both approaches. Controlled lab experiments were run in two countries, systematically varying the rate at which payments are linked to environmental outcomes. This paper clarifies the conditions under which the benefits from combining tenders with incentive payments outweigh the costs.

Keywords

Conservation tenders, auctions, incentive contracts, agricultural policy, environmental policy, market-based instruments, experimental economics

1 Introduction

In the last three decades, governments around the globe have developed market-based policy instruments to procure environmental services from private landholders. Conservation contracting represents the most commonly used policy instrument in this respect. The increased importance of environmental contracting has, to date, hardly been reflected in innovative policy design. It remains the norm in most conservation programs to offer a uniform payment for compliance with a uniform set of management prescriptions. This paper sets out to explore two proposals that have been made to enhance the effectiveness of conservation contracting: linking contract payments to environmental outcomes (rather than management prescriptions) and putting the contracts up for tender (rather than paying landholders uniform prices). Whereas the two aspects have been studied in isolation in the literature, the focus of the present paper is on exploring the combined effect of outcome-based payments and tendering on conservation behavior and the resultant performance of agri-environmental contracting. In the interest of clarity, we will however explore the two aspects consecutively. We will first investigate the impact of linking payments to environmental outcomes in a non-tendered setting. Subsequently, we will study the additional impact on conservation behavior and policy performance of putting such incentive contracts up for tender.

Theoretical predictions are far from clear. Outcome-based payments harness the self-interest of their recipients to act in the interest of the conservation agency by optimizing their stewardship effort. At the same time, they create previously absent risks for landowners, some or many of which are beyond their control. It can happen that, due to factors such as disease, pest invasions, fire, drought, or natural fluctuations in wildlife populations, the environmental outcome is much diminished or even nil – in spite of the fact that costly on-ground actions have been carried out. This is likely to reduce participation in the scheme and thereby its environmental effectiveness. There is thus a tradeoff to be studied between an incentive effect on the one hand and a participation effect on the other. If the latter outweighs the incentive effect, linking payments to uncertain outcomes is likely to be unproductive.

[1] Institut für Agrarökonomie der Universität Kiel, ulatacz@agric-econ.uni-kiel.de
[2] School of Agricultural and Resource Economics, University of Western Australia
[3] Department für Agrarökonomie und Rurale Entwicklung der Universität Göttingen

The motivation for studying the impact of tendering lies with the property of auctions of creating competition among potential providers of environmental benefits. Properly designed, auctions create scarcity amongst landholders in that the total payments on offer are set to be (much) less than the potential demand for them. Putting incentive contracts up for tender thus has the potential further to enhance the performance of conservation programs.

The present paper aims to further current knowledge in the field of conservation contracting by clarifying key aspects of tendering contracts with payments linked to uncertain outcomes. In order to examine the effect of the two opposing forces, the incentive effect and the participation effect, we shall study several points on the continuum between no payments linked to uncertain outcomes and the totality of payments thus linked. The analysis is based on controlled economic experiments which were carried out in two locations: at the University of Kiel, Germany, and the University of Western Australia in Perth, Australia.

2 Previous work

This study builds on three strands of previous work: the problem of efficiently allocating conservation contracts; the theory of auctioning incentive contracts; and the design and implementation of conservation auctions. These represent a logical progression from how to get landholders to provide conservation services efficiently, to the idea of tendering incentive contracts and finally to investigating how far this idea can be made to work for conservation policy. The problem of optimally selecting conservation actions and sites includes investigations by VAN TEEFELEN and MOILANEN (2008) and by COSTELLO and POLASKY (2004). Casting the solution of this problem into an appropriate analytical economic framework includes work by MOXEY ET AL. (1995) and DAVIS ET AL. (2006). This framework highlighted the key issue, that of moral hazard in a principal-agent relationship (FRASER, 2002; HART and LATACZ-LOHMANN, 2005). Accordingly, the problem of how to design contracts in such a way as to address this problem was studied by authors like MOXEY ET AL. (1999), OZANNE and WHITE (2007) and FERRARO (2008); WHITE (2005) also analyzed the correlative issue of contract monitoring.

Getting the contracted parties to provide the necessary effort to deliver the contracted goods to quality specifications was a problem first clearly formulated by GREEN in 1979. This problem was cast into the analytical framework of the principal-agent relationship by MCAFEE and MCMILLAN (1986), LAFFONT and MARTIMORT (2002) and LAFFONT and TIROLE (1987, 1988). LEITZEL and TIROLE (1993) applied this framework to the procurement setting. This idea had also been pursued by LAFFONT and TIROLE (1993) by combining and integrating the linking of contractual payments to outcomes and the auctioning of the contracts in a competitive setting; BRANCO (1995) generalized some of the results obtained by LAFFONT and TIROLE in 1987. The static setting was also expanded to the dynamic setting by LAFFONT and TIROLE (1988), with a follow-up by SUN CHING-JEN in 2007. This work provided the theoretical bedrock on which applications to environmental policy could be formulated.

The key problem in the present study was how to optimally select contracts for conservation works that are to be carried out by landholders (HAJKOVICZ ET AL., 2007). LATACZ-LOHMANN and SCHILIZZI (2005) review the literature on how ideas from auction design and implementation have been applied to conservation contracting, and LATACZ-LOHMANN and VAN DER HAMSVOORT (1997) propose a specific model for doing so when budgets are constrained (which is normally the case). A number of policy implementations were reviewed, mainly in the USA and Australia (REICHELDERFER and BOGGESS, 1988). Evaluation of this experience by GRAFTON (2005), GOLE ET AL. (2005) and CONNOR ET AL. (2008) highlighted the problematic nature of paying landholders uniquely on actions or inputs, e.g. fencing, weeding or planting trees, without specific reference to the actual environmental outcomes, such as streamwater quality, a measure of biodiversity or the rate of soil erosion. At this juncture, the idea of tendering contracts to landholders and that of linking contract payments to environmental outcomes were brought together, linking the two previous strands of literature. This integration has now begun to be investigated both theoretically (GODDARD ET AL., 2008) and practically, with The Australian Auction for Landscape Recovery Under Uncertainty (ALRUU) leading the way (WHITE ET AL. 2009), and some explorations also carried out in Europe, e.g. in Germany (GROTH, 2009; KLIMEK ET AL., 2007) and Sweden (ZABEL and HOLM-MÜLLER, 2008). This latter work, as well as that by Goldman et al., has also highlighted the importance of landholder cooperation in achieving the contracted environmental outcome: the effects of individual landholder actions extend beyond the boundaries of their private properties, especially when mobile species and synergistic ecological effects are involved.

3 Experimental design

The experiments did not aim to study the effort response to performance payments *per se*, but rather whether any efficiency gains, both in terms of effort provision and in terms of expected environmental outcome, could be obtained by combining performance payments and tendering. To disentangle these two effects, it was necessary to compare the tendered and non-tendered contracts. The non-tendered case was thus implemented primarily as a benchmark for the tendered case.

In addition, the level of environmental outcome is directly related to effort; more specifically, it reflects total effort *obtained* rather than individual *supply* of effort. Total effort obtained is also a function of the participation rate: individual effort of those who have 'opted in' may be high, but if their number is small relative to those who have 'opted out' due to the participation effect, the total level of effort obtained will be small, as will the corresponding environmental outcome. These considerations can all be brought together and summarized as shown in Table 1.

Table 1: Study of incentives involved

	Individual incentive effect	**Total incentive effect**
Contract: performance payment effect	**1** Basic incentive (effort level)	**2** = (1) × participation rate
Auction: competition effect (bidding through effort level)	**3** Extra incentive over and above (1)	**4** = (3) × participation rate × selection rate

The *performance payment effect* in Table 1 is linked to the achievement of an uncertain environmental outcome; the *competition effect* is linked to selection by the tendering mechanism. Each introduces a certain degree of uncertainty. Cell (1) represents the individual incentive effect, for those who have 'opted in', of linking (at least part of) the payment to uncertain environmental outcomes. Cell (2) represents the total incentive effect of performance payments and is the combined effect of individual effort and participation rate. Cell (3) is the extra incentive, if any, over and above (1) created by putting the contracts up for tender. Cell (4) represents the total incentive effect when incentive contracts are tendered. Not only, like in (2), does it depend on the participation rate but also on the selection rate, as decided by the tendering authority. Table 2 gives an overview of the experimental design aimed at disentangling the various effects. The core idea underlying Table 2 is to examine how increasing the *proportion* of the uncertain performance payment relative to the sure fixed payment affects the supply of individual effort, and to replicate this under both non-tendered and tendered scenarios.

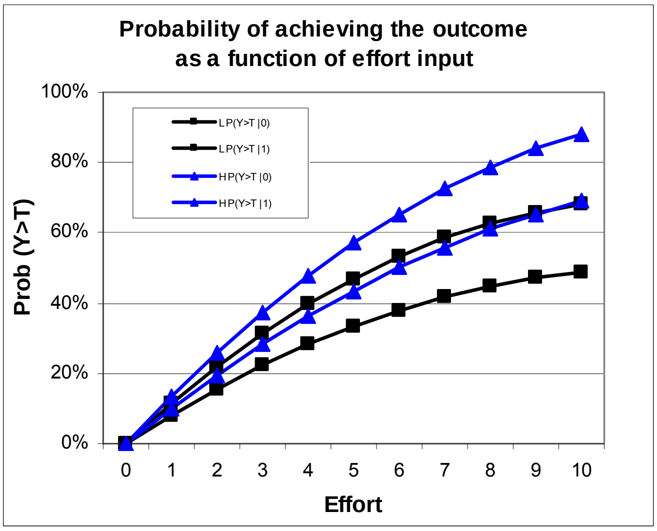
Effort could vary between 0 and a maximum of 10 units. Whenever a non-zero fixed payment was offered, a minimum of three units of effort was required. Effort was costly, with a linear cost function of 10 ECUs (Experimental Currency Units) per unit of effort. An 'environmental production function' defined the probability of achieving an environmental 'biodiversity value' threshold (BV) as an increasing function of effort. This probability had two possible values for any given level of effort: a higher and a lower value, representing, respectively, a favorable and an unfavorable states of nature (disease, drought, fire, etc.), thereby defining a state-contingent production function (CHAMBERS and QUIGGIN, 2000) (see Figure 1). Each of these two states was equiprobable.

Table 2: Experimental research plan

SESSIONS	Effort (0 to 10)	Fixed Payment	Performance Payment
Non-tendered incentive contracts		Benchmark computed for PP = 0	
1) C150	✓; min 3	150	150
2) C200	✓; min 3	100	200
3) C300	✓	0	300
Tendered incentive contracts		Benchmark computed for PP = 0	
4) E150	✓; min 3	150	150
5) E200	✓; min 3	100	200
6) E300	✓	0	300

Legend: ✓ = bidder's decision (There was no minimum effort when no fixed payment was offered.) Payment amounts in ECUs (experimental currency units)

Figure 1: Environmental state-contingent production functions for two types of nature



Since the results were likely to be affected by risk attitudes, we submitted all participants with a simple lottery, which asked them to consider a lottery ticket that had a 50% chance of earning them $1000. They were then asked the minimum amount they were willing to accept to sell the ticket to the experimenter. A number below $500 was a measure of risk aversion, while a number above $500 was a measure of risk taking. As the results below suggest, the data, however crude, proved sufficient to shed some light on the role of risk attitudes. This was all done prior to, and independently of, the core part of the experiment, albeit in the same session and with the same participants.

The experiments were carried out in two different locations, in Kiel, at the University of Kiel, and in Perth, at the University of Western Australia, to control for robustness of the results. The Kiel experiment was carried out with first-year agriculture students. Participants in the Perth experiment were mostly second-year students – all in the area of agriculture or natural resource management. The number of participants in each session varied somewhat but averaged 20. The resolution of the state of the environment (favorable or not) was done by tossing a coin at the end of a session (the two states being equiprobable). This determined for each participant whether they had achieved the BV threshold or not. The risk spread between these two states of the environment was held constant in this study. The tender type was of the target-constrained rather than of the budget-constrained type and selected two-thirds of the bidders with the highest effort supply. So as not to distract from the main focus of the experiments, participation costs were equal for all, and consisted of a fixed transaction cost of 50 ECUs and a variable cost of 10 ECUs per unit effort. Initial wealth endowments, which were added to net gains at the end, were calibrated so as to avoid the possibility of net losses in real dollars for participants. Landholders' decisions involved participating versus opting out and, if opting in, choosing their level of effort. The payment mix (of fixed and performance payments) was given in each scenario, but different scenarios varied the mix, as per Table 2. An overview of the experimental parameters and their values is given in Box 1.

Box 1: Experimental parameters

- Two locations (Kiel and Perth): to control for robustness of results
- Number of groups (2 x 2) and group size (≈ 20)
- States of nature, uncertain (0 and 1: unfavorable & favorable by ex-post coin toss)
- Risk spread between 0 and 1: probability of achieving the BV threshold, g(x), held constant in this study
- Incentive contracts: 50%, 67% and 100% PP (The 0% case was computed)
- Tender type: target-constrained (as opposed to budget-constrained)
- Type of bid: through supply of effort; effort could be chosen on a scale from 0 to 10 units, with a minimum of 3 units for contracts involving a fixed payment
- Selection (under tender): 2/3 of those who do not 'opt out' (freedom not to participate) by effort level; no selection in the non-tendered case
- Decision variables: participation; individual effort supply
- Policy parameters: fixed payment; performance payment
- Participation costs: equal for all = fixed transaction cost + cost per unit effort
- Initial wealth: 0; 50; 100 ECUs: to avoid net real final losses
- Information given after each round: none, to simulate one-off bid only and no learning

PP = Performance Payment, linked to achievement of outcome: it constitutes the incentive payment
BV = Biodiversity Value threshold, which defines the achievement target

4 Experimental results

Examining the impact of performance payments on participant effort carries its own value in terms of research results; however, the main focus of this study was to assess the value of tendering the contracts and therefore also how to disentangle the two aspects when combined. In the non-tendered treatment, we focus on the effects of increasing the proportion of performance (i.e. incentive) payments relative to fixed (input) payments, while in the tendered treatment, we focus on how tendering the contracts modifies the NT results. Accordingly, we present the non-tendered treatment (henceforth NT) results separately from the tendered treatment (henceforth T) results.

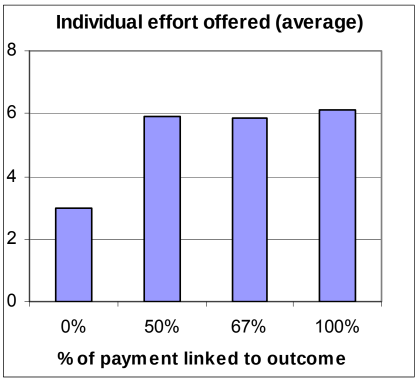
We investigate two aspects, individual behavior and policy performance. Individual behavior focuses on 1) the individual effort supplied by participants (NT treatment) or bidders (T treatment); 2) the participation rate (or whether subjects choose to opt out and not participate); and 3) the impact of risk attitudes on effort provision and participation. Policy performance is measured by 1) the total effort obtained, which directly determines the expected environmental outcome; and 2) 'value for money' in the form of budgetary cost-effectiveness, whether in terms of dollar outlay per unit of total effort or per unit of expected outcome obtained.

4.1 Individual behavior: effort and participation

4.1.1 Non-tendered treatment (NT): impact of increasing performance payments

Supply of individual effort. Hypothesis: the supply of individual effort increases with the proportion of the total payment, kept constant, that is linked to the environmental outcome (henceforth %PP). Experimental results confirm this on average and consistently across all four subject groups (Figure 3): effort doubles when moving from the 0%PP to the 50%PP scenario. In 0%PP, the total payment is made up front, requiring only the minimum of 3 effort units. However, this is true only up to a point. As Figure 4 shows, at fairly moderate rates of %PP (around 50% in our case), individual effort levels off and remains constant in spite of further increases in %PP. This result adds new information to the theoretical analysis, since it was not predicted by it. One reason why this is happening might be that participants' risk aversion to uncertain payments ends up outweighing the incentive effect. Is this the case?

Figure 3: Individual effort offered as a function of the share of payment linked to outcome



Effect of risk attitudes on supply of effort. Hypothesis: all other things held equal, a higher degree of risk aversion should increase optimal effort. Our experimental results vary somewhat from this prediction, as Table 4 shows. Read vertically (to keep the treatment parameter constant), risk attitudes appear to have no effect on the supply of individual effort whatsoever, except at the highest %PP level, when, indeed, risk-averse individuals do increase their supply of effort. To understand this discrepancy, we need to know what happens to the participation rate which, we may recall, reflects participants' individual rationality constraint.

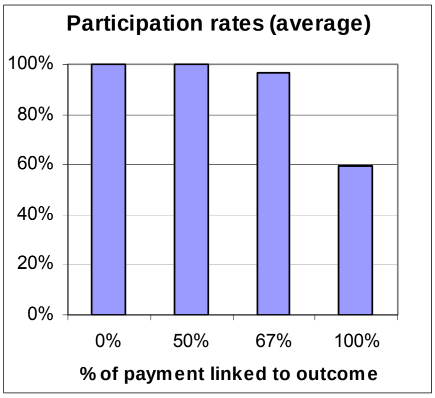
Participation rate. Hypothesis as %PP increases, participation should fall. This prediction is borne out by our results, on average and consistently across all four experimental groups (Figure 4). In our experiments participation started dropping at around 67% PP, but only became substantial at 100% PP, where the participation rate fell to 60%. For the remaining subjects the risk of a net loss was not worth the minimal effort required for receiving the fixed payment; they decide to 'opt out' and not sign a contract.

Table 4: Risk aversion and individual effort provision (all four groups, N = 76)

NT	50%PP	67%PP	100%PP
RA	5.9	5.9	7.2
RN	5.7	5.6	5.8
RP	6.1	5.8	5.9

Legend: RA = risk averse; RN = risk neutral; RP = risk prone

Figure 4: Participation rates as a function of the share of payment linked to outcome



4.1.2 Tendered treatment (T): impact of tendering the contracts

Supply of individual effort. Hypothesis: tendering increases the supply of individual effort of those who have decided to put in a bid. Indeed, tendering adds a second layer of uncertainty, that of not being selected, over and above the risk of not achieving the BV threshold. A higher level of effort thus reduces the risk of not being selected as well as that of not achieving the threshold.

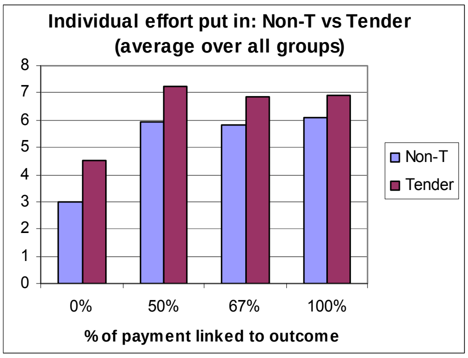
This extra individual effort obtained by tendering is visible over the whole range of performance payments, from 0%PP to 100%PP (Figure 5a). However, as Figure 5b shows, a second-order effect also emerged from our experiments: consistently across all four groups, the rate at which tendering extracts additional effort falls as %PP rises[4]. For non-incentive 0%PP contracts, tendering extracts about 50% more effort, but this figure drops to 20% for 50%PP and further to 15% for 100%PP. This is a result that theoretical analysis was not powerful enough to predict. If the transaction costs of organizing and running a tender are taken into account, then a compromise must again be struck between performance payments and tendering the contracts. From Figure 5a, it is clear that, on average, tendering does extract more effort, but there is no advantage in increasing %PP beyond 50%. Thus, what was true in the NT case remains true under tender.

Participation rate. Theory suggests that tendering should not modify the participation rates obtained in the non-tendered case. Figure 6 shows however this not to be entirely true, at least for high values of %PP. Although the 1% lower participation rate at the 67%PP level is negligible, the 7% average drop at the 100%PP level, from 59% to 53%, is significant and consistent across all four experimental groups. This drop in participation may be related to two possible causes, though these are only hypotheses at this stage. One is the extra mental loading of having to also include the uncertainty of being selected, a form of transaction cost. The other is the possible role of ambiguity aversion, as opposed to risk aversion, in Ellsberg's sense:

[4] A negative logarithmic function fits the aggregate data well (R2=90%), where dE = – 0.26 Ln(%PP) + 0.47. However, when looking at individual bids, the data is much noisier.

total uncertainty is greater under the combined tender and incentive scheme than in the NT case alone.

Figures 5a,b: Impact of tendering on individual effort offered



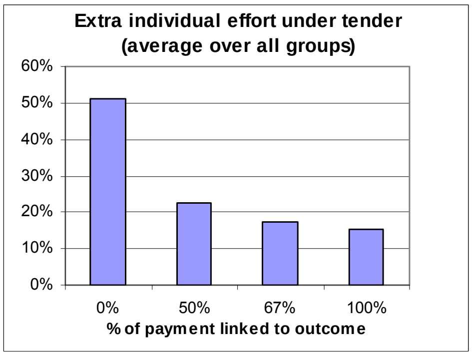
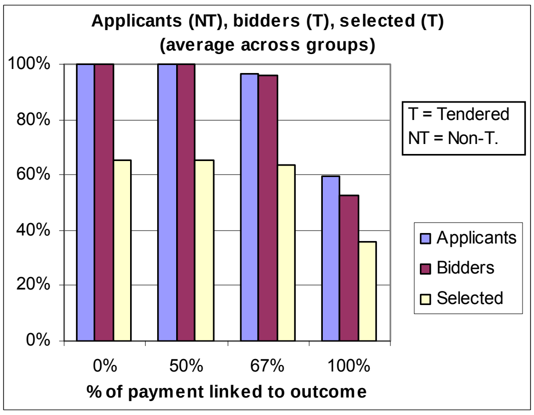


Figure 6: Impact of tendering on participation rates



4.2 Policy performance: environmental outcomes and cost-effectiveness

4.2.1 Non-tendered (NT) treatment

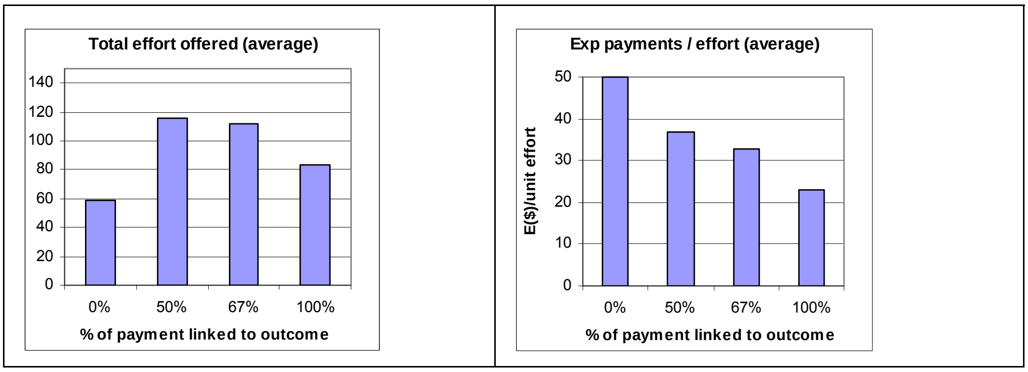
Total effort and expected outcome. Total effort results from the combination of individual effort and participation (Table 1, cell 2). Since increases in %PP were shown to increase effort but reduce participation, it is not surprising that total effort exhibits an inverse U curve, as per Figure 7a. There thus exists an optimum level of %PP. In our experiments, it ranged between 50%PP and 67%PP. Since total effort also determines expected outcome, as per Figure 1, this result extends to expected level of environmental outcome.

Cost-effectiveness. Defining cost-effectiveness by the payment outlay per unit of total effort, the story changes: in this case, the higher the %PP, the lower the payout per unit of effort, and so the higher the cost-effectiveness, as shown in Figure 7b. From a policy perspective, when deciding what %PP rate is best, one must make trade-offs between the two objectives of outcome level and cost-effectiveness.

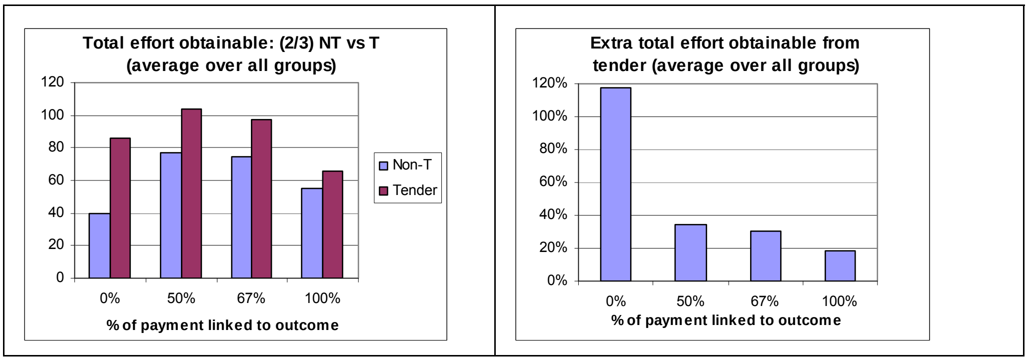
4.2.2 Tendered (T) treatment

Total effort and outcome obtained. Participation rates and individual supply of effort combine with the selection rate (see cell 4 in Table 3) to yield total effort obtained, and so too the expected level of environmental outcome. Here, one needs to distinguish between two aspects, a theoretical and a pragmatic one. For the NT and T scenarios to be directly comparable, one must apply the same selection ratio to both. In practice, however, the NT setup will accept all participants whereas in T a selection criterion will apply. Figures 8a and 8b present the theoretical comparison and Figures 8c and 8d present the pragmatic one, assuming a tendering selection ratio of 2/3 of bidders.

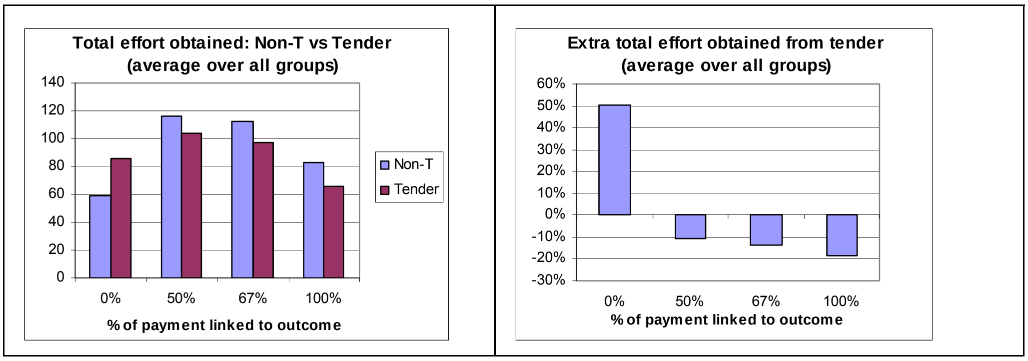
Figure 7a,b: Total effort and budgetary cost-effectiveness as a function of the share of payment linked to outcome (averages across all four groups)



Figures 8a,b: Impact of tendering on total effort obtained with identical selection ratios



Figures 8c,d: Impact of tendering on total effort obtained with a 2/3 selection ratio only in tender

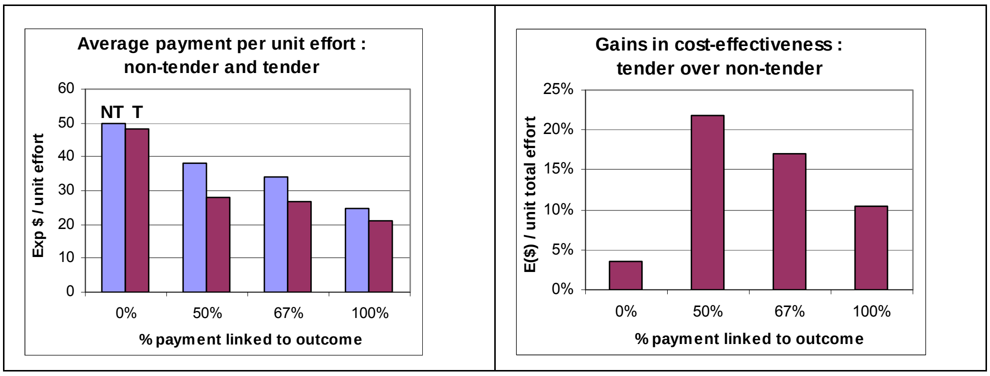


Figures 8a and 8c show that tendering does not modify the pattern observed in the NT case, namely, that there exists an optimal %PP, between 50% and 67%, which yields maximum effort and outcome. However, the incremental second-order effects from tendering now depend on one's perspective. If one artificially neutralizes the policy-dependent selection ratio by applying the same ratio to both NT and T scenarios, the result, as shown in Figure 8b, appears similar to the individual effort case of Figure 5b, but with different increments. In both cases, the advantage of tendering the contracts falls rapidly as payments linked to uncertain outcomes are introduced (see decrease between 0%PP and 50%PP).

From the pragmatic point of view, NT and T setups will always differ by the fact that a selection criterion operates in the latter but not in the former. A selection criterion of 2/3 of bidders is a reasonable ratio and close to what has been often chosen by policy-makers using conservation tenders (e.g. BushTender in Australia). The incremental effects of the tender now appear different to those observed in Figures 5b and 8b: as Figure 8d shows, not only does the increment in total effort fall very rapidly with the rate of performance payments, but it actually goes negative before even reaching 50%PP. That is, tendering the contracts with a 2/3 selection ratio actually *reduces* the expected level of environmental outcome. Of course, the difference between Figures 8b and 8d will be smaller if the selection criterion is greater than 2/3 and tends towards 1 and greater if it is less than 2/3 and tends towards 0. Thus in practice, tendering and incentive payments counter-act each other in terms of total effort and expected outcome, reflecting the opposite forces of incentive provision and risk bearing. With too much risk, as is the case when cumulating outcome and selection uncertainty, the risk effect ends up outweighing the incentive effect. Our experiments consistently showed that this happens rather early on the incentive scale; that is, before 50%PP is reached.

Cost-effectiveness. If we now change perspective and focus on 'value for money', or budgetary cost-effectiveness, the picture again changes, in a similar way it did in the NT scenario. Figure 9a shows that the higher the %PP, the better the cost-effectiveness; that is, the smaller the budgetary outlay per unit of total effort or expected environmental outcome. The marginal value of running a tender is however greatest in cost-effectiveness terms for contracts with only moderate payments linked to outcomes (50%PP), as Figure 9b suggests.

Figures 8a,b: Impact of tendering on total and marginal cost-effectiveness



5 Conclusions

Based on a general theoretical analysis, controlled laboratory experiments were carried out with four different groups of university students in two countries to investigate the effects of tendering incentive contracts on effort supplied and participation, as well as their implications in terms of expected environmental outcome and budgetary cost-effectiveness.

Experimental results for the non-tendered contracts confirmed the theoretical predictions, but also added new insights in the form of second-order effects. As the proportion of the outcome-linked payment increases at the expense of the fixed payment, the total expected payment remaining constant, the participation rate falls, and the supply of individual effort increases, but only up to a point, after which it levels off. This results in a trade-off between maximizing the expected level of environmental outcome and maximizing budgetary cost-effectiveness. Maximizing environmental outcome requires one to limit incentive payments to moderate levels, whereas cost-effectiveness is maximized when 100% of the payment is outcome-based.

Taking the previous results as benchmarks, tendering contracts which are subject to varying rates of performance payments has the following impacts: with only a slight fall in participation at high rates of performance payments, it further increases the supply of individual effort, but at a decreasing rate as the proportion of performance payments increases. It thus further exacerbates the trade-off between maximizing environmental outcome and maximizing cost-effectiveness. Except for very low rates of performance payments, when most of the payment is made up front, and taking into account the policy-determined selection ratio, tendering actually reduces the expected level of environmental outcome. However, tendering raises even further the cost-effectiveness of the scheme for all values of performance payments; but the marginal value of the tender peaks at moderate performance payment rates of around 50%.

The foregoing results carry clear implications for the design of conservation contracts when both tendering and performance payments are available as options. Based on our theoretical analysis, confirmed but also qualified by our experimental results, we can derive the following implications from the policy maker's perspective:

Implication 1: The provision of individual effort is maximized by tendering contracts with payments only moderately linked to outcomes.

Implication 2: For maximizing the expected level of environmental outcome, contracts should not be tendered but payments should be made partially dependent on achieving outcomes.

Implication 3: If value for money (budgetary cost-effectiveness) is to be maximized, payments should be totally dependent on outcomes and contracts should be tendered.

To the above three propositions, we can add this fourth one:

Implication 4: For a purely risk-averse population, the main difference with the more general results above is that it is always preferable to put the contracts up for tender.

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