QUANTIFYING THE BENEFITS OF CONSERVATION AUCTIONS: EVIDENCE FROM AN ECONOMIC EXPERIMENT

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Abstract

Building on available theory, this work uses controlled laboratory experiments to investigate the budgetary and the economic performance of competitive tenders for allocating conservation contracts to landholders. Experiments have been replicated in two different countries to check for robustness of results. We find that auctions outperform the more traditional fixed-price schemes only in the one-shot setting. With repetition, the auctions quickly lose their edge. Our results suggest that previous estimates of conservation auction performance are too optimistic.

Keywords

Conservation auctions, agri-environmental policy, experimental economics.

1 Introduction

Contracting with landholders for the provision of countryside benefits has become the dominant instrument of EU agri-environmental policy. This policy may be seen as a form of government procurement contracting whereby government purchases public-good type environmental benefits from private landholders. The increased importance of environmental contracting has, to date, not been reflected in innovative policy design or implementation. It remains the norm in EU conservation schemes to offer a single, fixed payment for compliance with a predetermined set of management prescriptions. One proposal that has been made to that effect is to put the conservation tasks up for tender: landholders are invited to bid competitively for a limited number of conservation contracts – a standard method in other areas of government procurement contracting. Producers facing competition are less likely to 'overbid' relative to their true compliance costs. Competitive bidding thus reduces over-compensation and increases cost-effectiveness. Bidding schemes have the added advantage of acting as a price discovery mechanism for environmental goods and services for which there are no well-established markets and thus no prices.

The diffusion of auctions into the practice of conservation management has been slow, but interest in auctions for purchasing conservation services from landholders has recently grown, especially after the BushTender trials in the state of Victoria, Australia (STONEHAM ET AL., 2003). In Europe, a conservation auction has been trialled in the state of North Rhine-Westphalia, Germany (HOLM-MÜLLER AND HILDEN, 2004). In the UK, the Challenge Fund Scheme relied on an auction mechanism to encourage further afforestation on private land.

There is, to date, very little evidence about the cost-effectiveness gains of auctions vis-à-vis fixed-payment schemes, and what little evidence exists appears contradictory. STONEHAM ET AL. (2003) argue that the amount of biodiversity benefits acquired through the first round of BushTender auctions would have cost the government agency about seven times as much if a fixed-price programme had been used instead. By contrast, LATACZ-LOHMANN AND VAN DER HAMSVOORT (1997) simulate farmers' bidding behaviour in a hypothetical conservation

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scheme and find cost-effectiveness gains ranging from 16 to 29%, depending on how the auction was implemented and how winners were selected. CJC CONSULTANTS (2004) report budgetary cost-effectiveness gains of 33 to 36% for the Scottish Challenge Fund Scheme.

This paper sets out to investigate the performance of conservation auctions vis-à-vis a benchmark of "equivalent fixed payments". The comparison was made with the use of economic experiments carried out both at the University of Kiel, Germany, and at the University of Western Australia, Perth, Australia. Because conservation auctions come in two possible formats, as budget-constrained (BC) or target-constrained (TC) auctions, we investigate whether this choice affects the relative performance of the auction. In addition, since conservation contracts are usually offered in multiple bidding rounds, we further examine whether auction performance is affected by repetition.

2 Measuring auction performance: some theory

Agri-environmental schemes usually have limited budgets, and applicants are accepted into the scheme until the budget is exhausted. We term this the "budget-constrained" (BC) auction. Alternatively, the regulator can specify the target to be achieved (in terms of the numbers of hectares to be enrolled or the units of environmental service to be bought), and applicants are accepted into the scheme until the target is achieved irrespective of the budget expenditure. This we call the target-constrained (TC) auction. Measuring the performance of BC conservation auctions requires one to define a budget equivalent fixed-rate scheme. This is the minimum uniform payment rate that would have resulted in the same total expenditure as the auction. The question then is: has the auction been able to buy more units of environmental service with the same budget and, if so, how much more? Measuring the performance of TC auctions requires one to define an outcome equivalent fixed-rate scheme. In this case, the corresponding uniform payment is computed as the minimum fixed-rate payment that would have been needed to achieve the same outcome (i.e. units of environmental service) as the auction.

Figure 1: A conceptual framework for assessing the performance of a budget-constrained conservation auction vis-à-vis an equivalent fixed-price scheme

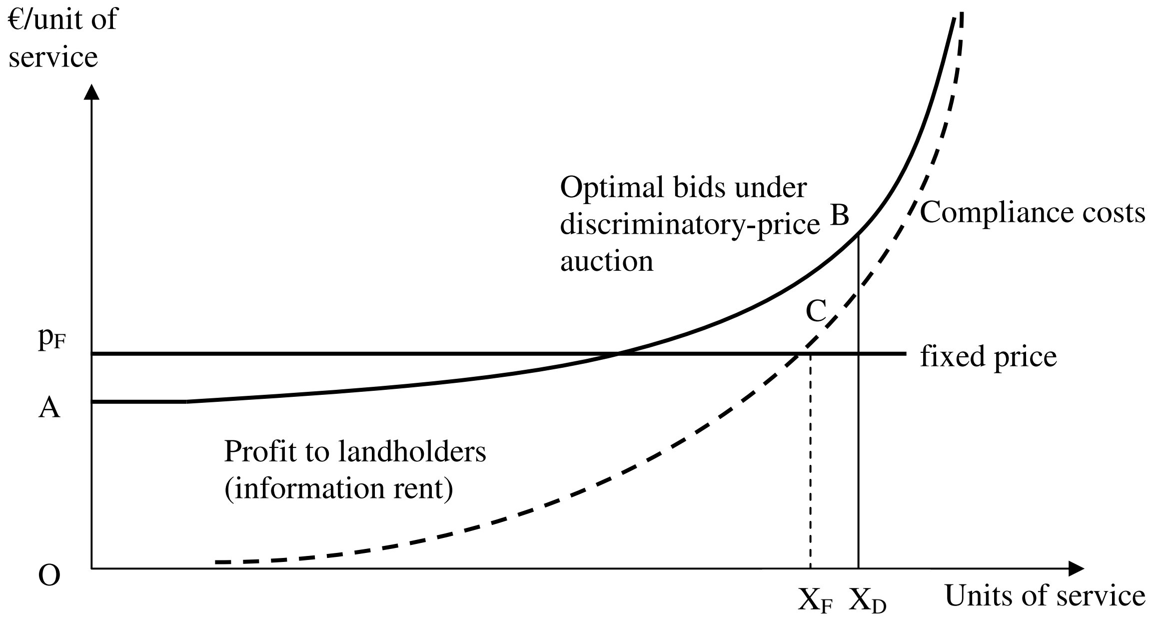

Figure 1 illustrates the conceptual framework for assessing the performance of BC auctions against the benchmark of a budget equivalent fixed-rate scheme. It is important to understand that the opportunity cost curve (representing the landholders' true costs of service provision) is the relevant supply curve when a fixed payment is offered. Then all landholders with opportunity costs below the fixed payment stand to gain from participation. The marginal participant is the one whose opportunity cost is equal to the payment rate offered. Thus, with a fixed payment rate p_F, X_F units of service will be traded. The total budget cost is represented by area $OECX_F$. Under a discriminatory-price auction, by contrast, the ordered bids (not the opportunity cost curve) represent the supply curve. The auction creates room for bidders to shade their bids above their true opportunity costs and thereby to secure themselves an information rent, as predicted by LATACZ-LOHMANN AND VAN DER HAMSVOORT'S (1997) model. Bidders are accepted in the order of their bids until the budget is exhausted. The total budget cost is represented by area $OABX_D$. Assuming the same budget as under the fixed-price programme (i.e. area $OABX_D$ = area $OECX_F$), X_D units of service can be bought – more than under the fixed-price programme.

3 The economic experiments

Economic experiments were carried out both at the University of Kiel, Germany, in January 2004 and at the University of Western Australia in Perth, Australia, in October 2004. The Perth experiment replicated the Kiel experiment, in order to check for the robustness of results. The Kiel experiment was carried out with 88 first-year students in agricultural sciences. They were divided into two groups, one for each of the two auction formats, BC and TC. The auction setup referred to reductions in nitrogen fertiliser on a wheat crop, in order to meet EU regulations regarding limits to nitrate concentration in groundwater (50 mg/litre). Participants were offered would-be contracts for committing themselves to reduce applications of nitrogen fertiliser from their currently most profitable level down to a predefined constrained level, equal to 80 kg per hectare. Each participant was given a different production function for nitrogen fertiliser in wheat production and thus faced a different opportunity cost resulting from the adoption of the nitrogen reduction programme. Opportunity (or participation) costs were spread uniformly between €5 (the lowest-cost farmer) and €264 (the highest-cost farmer). The cost range was not given, but bidders were told that costs were uniformly distributed. Bidders knew their own opportunity costs but not those of rival bidders. They were given a rough estimate of where he or she stood compared to rival bidders in terms of opportunity costs. This was done by informing bidders in which cost quartile they belonged: upper quarter, upper half, lower half, lower quarter. It was assumed that bidders could look around and estimate the number of competitors in their group: between 40 and 44 depending on sessions in the Kiel experiment, and 27 in the Perth experiment.

Participants were told that not all of them would be able to win contracts and that they were therefore competing against each other. To keep things very simple, each participant could put up just one land unit of wheat, the same area for all participants. They were told that if they won a contract, they would be paid the difference between their bid and their opportunity cost. For both groups, three rounds were held in order to investigate the performance of the auctions with repetition. That is, which of the two auction formats was better able to maintain a good performance as bidders get to "play the game" several times? In rounds two and three, exactly the same setup was used, except that bidders knew of their own result in the previous round(s), and successful bidders had been paid their net gains at the end of each round.

The two auction formats differed mainly with respect to the information given to, and asked of, the bidders. In the first round, the group playing the BC auction was informed of the available budget for the current session. A pre-announced budget has been common practice in the Australian conservation pilot auctions. The budget constraint announced (€3900) was clearly distinguished from the actual payments made at the end of the session. Actual bidder payments were proportional to their gains calculated as own bid minus participation cost. Bidders were then asked to state their bid. In the following two rounds, bidders also knew whether they had previously been successful or not, and if so, what their net gains were. No information regarding other bidders was given, as e.g. the number of winners.

To the TC auction group, instead of a budget constraint, the number of contracts to be allocated was announced. This number had to be worked out immediately after the BC auction had been held, because the target was set equal to the number of contracts allocated with the €3900 budget constraint. This was done in order to be able to compare the two auction formats on an equal footing. In the first round, the BC auction yielded 29 contracts. Thus the number 29 was announced to the TC auction group. The information treatment was identical to the BC auction. Importantly, during the first session, the two groups were not allowed to communicate. The TC group entered the experimental venue as the BC group exited by an opposite door. Tutors were present to make sure no communication happened. Participants were then asked to state the amount bid for a contract.

The Perth experiment was in all points identical to the Kiel experiment, save for the following logistical details. The number of participants was 53 in number, split about evenly between the BC and TC groups. To reflect the smaller number of participants in the Perth experiment, the budget constraint was lowered proportionately, compared to the Kiel experiment ($2300). A slight difference in the Perth experiment was the twist given to the story. Rather than nitrogen leaching into the groundwater, the government agency was buying back from horticulturalists in the Swan catchment (around Perth) a composite good made of nitrogen and phosphorus, and the problem was eutrophication in the Swan river following excess runoff of these two nutrients – a socially and politically sensitive issue in Perth.

4 Results and discussion

In evaluating auction performance, three criteria are standard: budgetary cost-effectiveness, information rents, and economic efficiency. The first is measured as the payment per kg of nitrogen (N) abated; it measures the value-for-money a government agency achieves with taxpayers' money. The second is measured as the payments made over and above participation costs. The third, economic efficiency, collapses in this case to forgone profits, that is, the participation or opportunity cost (OC) per kg of N abated, which measures the cost to society of achieving a unit of N abatement.

Table 1 presents the results. As highlighted in section 2, auction performance is measured against the benchmark of a budget-equivalent fixed-rate payment which appears as MUP in Table 1. This is the minimum uniform payment rate (MUP) that would have resulted in the same budgetary expenditure as the auction. It is important to understand that the MUP benchmark is defined as the fixed-rate payment to the lowest-cost participants up to the budget constraint. That is, landholders are accepted into the scheme starting from the lowest opportunity costs (OC) until the budget is exhausted. This provides a least-cost uniform pay rate, a theoretical but 'absolute' benchmark for comparison. Of course, it can only be used with controlled laboratory experiments where individual OC are known with certainty. In practice, policy makers will not have this information, and the MUP will thus not be a realistic benchmark for policy settings. It is more realistic to assume that policy makers and administrators will have some information about the average OC of participation as an anchoring point or benchmark for choosing the payment rate. This benchmark appears as ACP ('average cost payment') in Table 1.

Table 1: BC and TC auction performance relative to the two FRP benchmarks, 1st round
(See Table A1 in Appendix for underlying absolute values)

The Kiel experiment	Kiel BC 1 (Budget = €3900)			Kiel TC 1 (Target = 29 participants)		
	Auction	MUP	ACP	Auction	MUP	ACP
Applicants (or bidders)	100	59	70	100	67	70
Contracts awarded	100	90	72	100	100	100
Fixed pay rate (equivalent)	100	108	139	100	124	129
Total payment	100	97	101	100	124	129
Total opportunity cost	100	72	72	100	91	95
Total N abated	100	87	77	100	96	98
Budgetary cost-effectiveness = Payment / kg N abated	**100**	**111**	**131**	**100**	**129**	**131**
Information rent rate = Total payment / opp cost	**100**	**135**	**140**	**100**	**136**	**136**
Economic efficiency(*) = Opp cost / kg N abated	**100**	**82**	**94**	**100**	**94**	**97**

The Perth replicate	Perth BC 1 (Budget = $2300)			Perth TC 1 (Target = 19 participants)		
	Auction	MUP	ACP	Auction	MUP	ACP
Applicants (or bidders)	100	59	74	100	73	81
Contracts awarded	100	84	63	100	100	100
Fixed pay rate (equivalent)	100	114	152	100	116	126
Total payment	100	97	101	100	116	126
Total opportunity cost	100	64	65	100	90	98
Total N abated	100	75	64	100	88	92
Budgetary cost-effectiveness = Payment / kg N abated	**100**	**129**	**158**	**100**	**132**	**138**
Information rent rate = Total payment / opp cost	**100**	**151**	**157**	**100**	**129**	**130**
Economic efficiency(*) = Opp cost / kg N abated	**100**	**86**	**101**	**100**	**100**	**106**

BC1 and TC1 : budget- and target-constrained auctions, first round
MUP : Minimum Uniform Payment rate (absolute benchmark)
ACP : Average Cost Payment rate

Auction performance in Table 1 appears as 100% (or itself), while the MUP and ACP benchmarks are expressed in terms of the auction. The performance criteria appear in the three bottom rows in both the Kiel and the Perth tables, where a number greater than 100 means that the auction performs better than its equivalent fixed-rate scheme. The rows above provide the underlying values that help to interpret the results. Note that in the BC setting the budget is held constant when comparing the auction to the two fixed-price benchmarks, while in the TC setting the number of contracts awarded is held constant. The underlying raw data generated by the experiments is provided in Table A1 of the Appendix.

Starting with *budgetary cost-effectiveness* as measured by the payment per kg N abated, Table 1 shows that in all cases the auction outperforms fixed-price programmes, even the MUP. Relative to the MUP, this advantage ranges from 11 to 32 per cent, that is, one unit of abatement paid at a fixed rate would have cost 11 to 32 per cent more than the auction. Relative to the more policy relevant ACP benchmark, the range is, as one would expect, greater. This performance advantage of the auction also holds in terms of *information rents*, indicated in Table 1 by the ratio of total payments to opportunity costs. Again, the advantage of the auction is greater relative to the ACP than to the MUP. In a one-shot auction setting, discriminatory-price bidding thus achieves a unit of abatement at least cost and minimises the degree of overcompensation relative to the two fixed-price benchmarks.

In terms of *economic efficiency*, recall that the MUP by definition minimises the opportunity cost per kg N abated. This is because landholders are accepted into the programme starting from the lowest opportunity costs (OC) until the budget is exhausted or the target is achieved. Therefore, the best that an auction could do is to equal the MUP, which is the case in the Perth TC treatment. In the three other treatments, the MUP is up to 18 per cent more efficient than the auction; that is, the cost to society of a unit of N abatement is up to 18% higher. On the other hand, relative to the ACP benchmark, results are more mixed: in the Kiel experiment, the auction turns out to be slightly less efficient than the ACP, while the opposite holds for the Perth replicate. Relative to the ACP, the BC auction attracts a greater number of winners, namely those with higher OC, thus raising the *average* OC per kg of N abated. In the TC treatment, the explanation is less intuitive: the auction, through sufficient bid-shading, creates room for higher-cost participants to get selected. By contrast, in the ACP programme, only those participants whose OC is less than the ACP will be awarded a contract. When economic efficiency is the driving policy motivation, the advantage of the auction relative to an equivalent fixed-price programme based on [an estimate of] the average OC will be far less obvious than if budgetary cost-effectiveness was the main motivation.

Let us now proceed to consider the effect of repetition on auction performance. We are interested in two aspects: the advantage of the auction relative to its fixed-payment benchmark, and the advantage of one auction format relative to the other. If we contrast the outcomes of round 1 and 3 in Table 2 (round 2 mostly having values between rounds 1 and 3), we observe that except in the case of the Perth-BC 3 auction, both auction formats have lost their edge to the MUP. In the third round, the first-round results are mostly overturned. The TC auction has lost its advantage even to the ACP. This confirms and refines the results by HAILU AND SCHILIZZI (2004) who interpret this result in terms of bidder learning. Thus, with repetition, an auction loses its performance advantages over fixed-rate programmes; but the effect is only clear-cut in the TC case, where the auction clearly performs least well in terms of equivalent fixed-payment rates. In the BC case, this effect remains ambiguous, if at all present. While the BC auction clearly performs less well in round 3 than in round 1, it maintains its advantage over its fixed-price benchmarks. This suggests that the auction is more robust to repetition under the BC setting than under the TC setting, a result of potential relevance to policy.

While with repetition the TC loses relative advantage over the BC auction in terms of budgetary cost-effectiveness and information rents, this appears not to be the case when economic efficiency is considered: from Table 2, it appears that economic efficiency maintains the relative advantage of TC over BC, although the difference has been diminishing.

Table 2: Auction performance relative to MUP and ACP for different criteria (Auction = 100)

Relative auction performance	Kiel experiment		Perth replicate		Auction type and round
	MUP	ACP	MUP	ACP	
Payment / kg N abated	111	*131*	129	**158**	
Total paymt / Opp Cost	135	**140**	**151**	**157**	BC 1
Opp Cost / kg N abated	82	94	86	101	
Payment / kg N abated	129	*131*	132	**138**	
Total paymt / Opp Cost	136	**136**	**129**	**130**	TC 1
Opp Cost / kg N abated	94	97	100	106	
Payment / kg N abated	*98*	**116**	**106**	**133**	
Total paymt / Opp Cost	**107**	**115**	**114**	**124**	BC 3
Opp Cost / kg N abated	91	**101**	93	**107**	
Payment / kg N abated	*98*	**99**	**99**	**99**	
Total paymt / Opp Cost	**100**	**104**	**104**	**104**	TC 3
Opp Cost / kg N abated	98	**96**	95	**95**	

MUP: Minimum Uniform Payment rate (absolute benchmark)
ACP: Average Cost Payment rate
BC and TC: budget- and target-constrained auctions, rounds 1 and 3

In bold: values where BC > TC
In normal: values where BC < TC
In italic: values where BC = TC

Table 2 shows that the relative advantage of the auction relative to its corresponding fixed-rate schemes is slightly but systematically greater in the Perth replicate than in the Kiel experiment. This would have been a concern for the robustness of the results had the populations of bidders in both experiments been rigorously identical. Instead, the two populations differed in their risk attitudes, as measured by a standard certainty-equivalence test.[4] We hypothesise that a risk-aversion adjusted set of bids would reduce the differences between the two replicates and allow a meaningful comparison – a topic we leave for future work.

3 Conclusions

Some clear conclusions emerge from this study. The first is that conservation auctions perform better than any equivalent fixed-price scheme in a one-shot setting, where bidders have had no opportunity to learn from previous results. This holds for all three performance criteria, except when economic efficiency is measured relative to the minimum uniform fixed-payment programme (MUP) which, by construction, yields the lowest possible cost profile.

The second conclusion is that repetition erodes the advantage of auctions relative to fixed-price schemes, making it possible for an auction to be outperformed by an equivalent fixed-rate programme. Given that this effect was clearly visible in the third round in both replicates, we may conclude that auctions repeated identically and *ceteris paribus* erode their performance edge rather quickly.

The third issue was whether auction format matters. Results here are more subtle. In terms of economic efficiency, the TC format consistently outperforms BC in a one-shot auction. With respect to the other performance criteria, results are mixed and no clear picture emerges as to whether, in the one-shot setting, one format should be preferred to the other. With repetition, however, the BC auction appears to be more robust than the TC auction, which strictly lost all advantage over both its fixed-price benchmarks in the third round.

These conclusions seem to be robust, in that both Kiel and Perth replicates yield comparable outcomes, although the auction's advantages comes out slightly greater in the Perth replicate than in the Kiel experiment. We attribute this difference to different behavioural profiles of the two bidder populations.

The recent surge of interest in conservation auctions has been driven by evaluation results from pilots carried out across Australia since 2001. STONEHAM ET AL. (2003) reported cost savings of several hundred per cent for the first round of the BushTender pilots in Victoria. The results from the present study suggest that the gains from auctions relative to an equivalent fixed-price programme are not nearly as high. In a one-shot auction, gains are more likely to be in the range of 10 to 60 per cent than 200 to 700 per cent. With repetition, gains are quickly eroded to the extent that the auction may be outperformed by a fixed-price programme, as HAILU AND SCHILIZZI (2004) have already highlighted. Our performance figures compare well to the 33 to 36 per cent cost-effectiveness gains reported for the Scottish Challenge Funds (CJC CONSULTANTS, 2004), although these figures were not derived in comparison with equivalent fixed prices.

Our results confirm the experience gained from the US Conservation Reserve Program: when bidders have the opportunity to learn from preceding bidding rounds, they will use that information to update their bids and reap higher rents – at the detriment of auction performance (REICHELDERFER AND BOGGESS, 1988). A possible remedy might be to change one or more parameters of the auction; for example, by announcing different explicit reserve prices or changing the budget level. The extent to which this would be true, however, is the subject of current research by the authors.

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Appendix Table A1: Performance of BC and TC auctions and of the two FRP benchmarks, 1st round

The Kiel experiment	Kiel BC 1 (Budget = €3900)			Kiel TC 1 (Target = 29 participants)		
	Auction	MUP	ACP	Auction	MUP	ACP
Applicants (or bidders)	44	26	31	43	29	30
Contracts awarded	29	26	21	29	29	29
Fixed pay rate (equivalent), €/ha	133	144	185	147	182	189
Total payment, €	3861	3737	3900	4262	5269	5481
Total opportunity cost, €	2380	1704	1722	2573	2333	2435
Total N abated, kg	1422	1241	1092	1459	1402	1430
Budgetary cost-effectiveness = Payment / kg N abated, €/kg	**2.72**	**3.01**	**3.57**	**2.92**	**3.76**	**3.83**
Information rent rate = Total payment / opp cost, €/€	**1.62**	**2.19**	**2.27**	**1.66**	**2.26**	**2.25**
Economic efficiency(*) = Opp cost /kg N abated, €/kg	**1.67**	**1.37**	**1.58**	**1.76**	**1.66**	**1.70**

The Perth replicate	Perth BC 1 (Budget = $2300)			Perth TC 1 (Target = 19 participants)		
	Auction	MUP	ACP	Auction	MUP	ACP
Applicants (or bidders)	27	16	20	26	19	21
Contracts awarded	19	16	12	19	19	19
Fixed pay rate (equivalent), €/ha	120	137	183	175	203	221
Total payment, €	2274	2197	2300	3320	3857	4198
Total opportunity cost, €	1544	991	998	2404	2162	2346
Total N abated, kg	915	684	587	1229	1080	1128
Budgetary cost-effectiveness =Payment /kg N abated, €/kg	**2.49**	**3.21**	**3.92**	**2.70**	**3.57**	**3.72**
Information rent rate =Total payment / opp cost, €/€	**1.47**	**2.22**	**2.31**	**1.38**	**1.78**	**1.79**
Economic efficiency(*) =Opp cost /kg N abated, €/kg	**1.69**	**1.45**	**1.70**	**2.00**	**2.00**	**2.08**

FRP: Fixed Rate Payment
BC1 and TC1 : budget- and target-constrained auctions, first round
MUP : Minimum Uniform Payment rate (absolute benchmark)
ACP : Average Cost Payment rate