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How Cost Effective are Conservation Auctions?

Abstract

Several trials have recently taken place in Australia of sealed bid discriminant price auctions for conservation contracts. The trials encourage landholders to competitively tender for funds to provide conservation actions on private land. In these auctions, environmental benefits of offers are evaluated using an environmental benefits index and bids are selected based on estimated environmental benefits per dollar cost. Such auctions represent a departure from past practice in Australian payment schemes to encourage private landholder conservation in two significant ways: 1) a new way of assessing benefits using an environmental benefits index is introduced and used in project selection, 2) a new way of setting price using a competitive tender process is introduced.

In this paper we evaluate the cost effectiveness of the Catchment Care conservation contract auction trial in the Onkaparinga catchment in South Australia. This evaluation differs from past Australian conservation contract auction evaluations by offering a disaggregate assessment of saving attributable to two sources: 1) use of an EBI to assess benefits and target high environmental value projects and 2) use of an auction mechanism to set prices.

In addition, this article reconsiders the assumption in many evaluations of efficiency benefits of auctions (and other market based policies) that the appropriate comparison benchmarks are rather naïve uniformly applied polices. In reality, conservation payment (and other environmental) policies in place prior to auction trials (or other market based instruments) often include mechanisms to differentiate

among projects based on environmental value and to elicit truthful revelation of landholder opportunity cost. For example, the program in place prior to the auction evaluated in this article included bi-lateral negotiation of in-kind labour contributions as mechanism to reduce rent payments to landholders.

One key conclusion is that credible estimates of cost saving achievable with discriminant price auctions requires comparison of discriminant price auction outcomes to outcomes of realistic policy alternatives. In this case study a naïve interpretation of the alternative as an input payment program with no effort to reduce rent seeking or select projects based on environmental cost effectiveness lead to a relatively large 80% estimated cost saving from discriminant price auction implementation. A 56% saving was estimated from the implementation of the discriminant price auction compared to the extant negotiated input payment price setting mechanism (without an EBI).

No savings from the auction were estimated when the comparison was comprised of a hypothetical strategic input payment policy including bi-lateral negotiation of payment rates and use of an environmental benefits index to develop a $/EB threshold for project selection. In fact the strategic input payment comparison policy was estimated to be negligibly (0.5%) more environmentally cost effective than the actual Catchment Care auction.

The finding for this case study that the estimated value of cost savings potential is critically sensitive to assumptions about the policy to which the discriminant price auction is compared, suggests that it may to desirable to re-estimate cost savings to other conservation auctions that have taken place in Australia.

1 Introduction

Market-based Instruments (MBI) are policy approaches designed to encourage behaviour through market signals rather than through explicit directives. The potential advantage of MBI approaches is that they can achieve environmental goals at a more affordable cost to agencies implementing policy than alternative policies (Stavins, 2000; Sterner, 2003; Harrington *et al*, 2004).

To advance understanding of potential for MBI to deal with diffuse source water quality issues, the Australian Government initiated the National Action Plan (NAP) for Salinity and Water Quality Market-Based Instrument Pilot Program in 2002 (MBI working group, 2002). The MBI Pilot program is unique in that it involves testing hypotheses related to how MBI can be effectively and equitably implemented for environmental issues involving diffuse source emissions like salinity with real world limited scope and duration policy trials. Eleven trials were initiated in the first round with completion of most in mid 2005 (Grafton, 2005).

Four of the eleven trials in the NAP MBI Pilot Program involved sealed bid discriminant price auctions. The approach involves program officers working with landholders to develop land management proposals. Landholders offer sealed bids describing actions they are willing to take and the payment that they would require to undertake the action. Agencies then rank bids based on an environmental benefits index and fund bids in order of cost effectiveness until a fixed budget is exhausted (Bryan *et al*. 2005a; Bryan *et al*. 2005b).

The cited economic rationale for use of sealed bid discriminant price auctions has been the capacity of the instrument to provide truthful revelation of the cost of conservation provision (e.g. Latacz-Lohman and van der Hamsvoort 1997, 1998). In typical auction settings, landholders possess information about their own opportunity cost of offering environmental services that is hidden to agencies. Agencies, in contrast, possess information that is hidden to landholders about benefits of heterogenous environmental service offers across sites of varying inherent ecological value, though this requires monitoring and metrics for quantifying environmental benefits.

An additional advantage claimed by proponents of auctions for conservation contracts in Australia, is that savings may result from improved capacity to target locations and types of actions with greatest environmental benefits. All of the auction trials sponsored by the Commonwealth MBI program began with development of significant environmental benefits assessment capacity in the form of environmental benefits indices (EBI). In short two things are introduced with the implementation of discriminant price auctions:

- The more objective measurement of benefits is used in project selection which allows all hectares of native vegetation to no longer be considered equal, and

- The use of a tender process to attempt to persuade potential auction participants to offer to do the contractual work at a lower price than otherwise would have been the case.

2 Objectives

In this paper we evaluate the cost effectiveness of one of the conservation contract auctions conducted as a MBI Pilot Program trial, the Catchment Care auction in the Onkaparinga catchment in South Australia (Bryan, *et al*, 2005a; Bryan, *et al*, 2005b). Prior to implementation of the auction the policy for conservation services purchase was an input payment scheme. As is the case with standard input payment schemes, landholders received rates of payment for purchased inputs according to a schedule. In contrast to standard practice, rates for in-kind labour contribution were determined through bilateral negotiation between agency officers and landholders. Any landholder willing to accept the price terms offered had their offer accepted until the annual budget was exhausted. Thus bids were considered individually and independently as offers arose without first gathering all offers then using a systematic selection process based on an EBI to choose a subset of all bids. In contrast, the trial tender process involved systematically selecting a subset of the most environmentally cost effective bids using an EBI.

Two previous studies have evaluated actual conservation contract outcomes in Australia (Stoneham *et al*., 2003; White and Burton, 2004). Both of these studies evaluate the cost-effectiveness of an actual discriminant price auction in comparison to the cost of a uniform price per unit environmental benefit payment policy. Both studies are comparisons of payment mechanisms, a uniform versus a discriminant price. But neither study compares sample selection treatment differences. For both the discriminant price auction and the comparison uniform price metric, the same bid sample is assumed, the sample that was chosen for the actual discriminant price auction through the systematic ranking of the population of all bids using an EBI.

One objective of this article is to expand the conservation auction cost effectiveness evaluation literature by offering a disaggregate assessment of saving attributable to two sources: 1) use of an EBI to assess benefits and select projects in a way that targets high environmental value projects and 2) use of an auction mechanism to set prices. Another objective is to reconsider the typically assumption in many evaluations of efficiency benefits of market based policies that the comparison benchmarks are rather naïve uniformly applied policies. In reality, conservation policies often include mechanisms to differentiate among projects based on environmental value and mechanisms to elicit truthful revelation of landholder opportunity cost; though the mechanisms used often differ from those prescribed in environmental economics textbooks (Randall, 2003; Sterner, 2003).

To assess the cost effectiveness of the actual Catchment Care discriminant price auction the outcomes are compared to estimated outcomes of several policies. Three of the comparisons are input payment policies, each with different assumptions about the approaches to price setting, benefits assessment and project selection.

- A naive input payment policy evaluation estimates the cost of an input payment policy assumed to involve no mechanism to reduce rent seeking by landholders. In addition No EBI (or other mechanism) to assess environmental benefits or select projects with greater environmental value preferentially is assumed. Projects are assumed to be selected in the order they arise with no regard for environmental value in this evaluation.

- A negotiated input payment policy evaluation represents a lower bound estimate of the cost of the program in place prior to the Catchment

Care auction. It included bilaterally negotiated input payment rates as a mechanism to reduce rent seeking by participants but no use of an EBI to assess project benefits or select highest environmental benefit projects.

- A strategic input payment policy is modelled assuming negotiated input payment price to reduce rent seeking as well as use of the EBI to set a $/EBI threshold criteria on acceptance of project offers to select highest environmental value projects.

In addition, outcomes of the Catchment Care Auction are assessed relative to a comparison metric used in two previous conservation contract auction evaluations Stoneham, *et al*, (2003); and White and Burton, 2005. One comparison policy used in both of these studies assumes a price setting mechanism that involves payment of a uniform price per unit environmental benefit. This uniform price comparison metric involves the implicit assumption that the same set of cost effective projects selected with the discriminant price auction would also have been selected with the uniform price comparison policy. The difference measured is assumed to be in prices paid with discriminant price auction versus a uniform price payment for the same selection of projects.

3 The conceptual basis for measures of auction cost effectiveness

The problem of bid selection faced by an agency implementing a conservation contract auction is to choose a subset from a population of potential bids (I_i), each with environmental benefits (e_i) and dollar value (b_i) in order to maximise the sum of environmental benefits obtainable for a total budget of M dollars. The most straightforward way to solve the bid selection problem is to: compute the environmental cost effectiveness of each bid, b_i/e_i; rank all bids in order of this environmental cost effectiveness measure; and select bids in order of cost effectiveness until funding any further bids would result in a violation of the total budget for conservation contracts.

Figure 1 about here

Figure 1 is a conceptual depiction of the cost of such an auction where bids are sorted from most to least cost effective. The cost to the agency can be represented as the area under the bid offer curve marked with A in Figure 1. This represents the least cost combination of bids the agency could select within the budget limit[1].

To estimate cost savings from implementing an auction, some basis of comparison is necessary. Conceptually, there are a range of candidate payment policies that could be used as a comparison. All represent approaches that an agency

[1] While simply ordering bids by cost per unit environmental benefit and funding bids in order of cost effectiveness should result in the least cost combination of goods in most cases, an integer programming optimisation is actually a more precise way to choose the least cost combination. This is because bids are lumpy, and in some instances exchanging a large marginal bid for some combination of smaller bids that are less cost effective individually can result in greater benefit given the budget constraint (see Hajkowicz for details).

wishing to purchase conservation actions offered by landholders could use. For clarity in exposition regarding the way that conservation auction policies have been evaluated here and in past studies, it is useful to think of conservation payment policies as involving two elements: a process for selection among offers, and a mechanism for setting payment levels. The selection processes relevant to this and past Australian case studies are: 1) systematic selection of a sample from the entire population of bids based on $/EB ranking as occurs with uniform and discriminant price auctions, and 2) case by case individual and independent selection of bids as occurs in typical input payment policies.

In addition, selection by either process can be until a budget or an environmental benefits level constraint. To date all auctions and input payment policies have been implemented with budget limits on the number of projects that will be funded. Quantity limits are also possible where projects are selected until the desired level of environmental benefits is achieved regardless of budget implications. This approach has been considered in past assessments of conservation auctions (Stoneham *et al*, 2003; White and Burton, 2004). Thus there are four project selection mechanisms that are relevant in classification of actual and comparison policies in this study: 1) systematic selection of the best environmental value subset of all offers with an EBI, and 2) individual and independent selection, both with selection to a budget or a quantity constraint.

Additionally, four payment mechanisms are relevant in a classification of actual discriminant price auctions and comparison policies used in this and past studies:

1. A discriminant price auction payment mechanism involves paying the price offered for tender bids selected,

2. A uniform price payment mechanism involves paying a uniform price per environmental benefit unit equal to the price offered by the least cost effective of all bids that can be funded within the relevant budget or quantity limit,

3. A non-negotiotiated uniform price input payment mechanism as used in standard input payment programs, and

4. A negotiated input payment rate mechanism with differentiated input payment rates achieved through bilateral negotiation of in-kind labour contributions. This is the mechanism used in the input payment program that existed prior to the case study auction evaluated here.

Table 1 is a matrix that allows classification of each of the conservation service purchase policies evaluated here as a combination of a project selection and payment mechanisms.

Table 1 about here

The table indicates that previous studies have only assessed potential for cost saving for a discriminant price auction payment mechanisms in comparison to other payment mechanisms assuming identical systematic project selection using an EBI. One goal of this article is to expand on past analysis by evaluating outcomes of input payment policies using individual and independent project selection without an EBI to outcomes of the actual discriminant price auction that used an EBI to assess benefits of and select projects.

4 Empirical evaluation of cost savings from the Catchment Care conservation contract auction

The Catchment Care program is a procurement auction for conservation contracts that was implemented on a trial basis in the peri-urban setting of the Onkaparinga catchment on the fringe of Adelaide, the capital city of South Australia in 2004. The trial was a discriminant price auction with bids ranked in order of environmental cost effectiveness and funded up to a budget constraint of $150,000. More detail on development of an environmental benefits index, protocols for bid preparation, submission, and selection are explained in Bryan *et al.* (2005a and 2005b).

In the trial, 29 bids were submitted by private landholders and ranked on environmental benefits per dollar bid. As shown in Figure 2, 17 bids were funded resulting in 20.9 million environmental benefit units before the budget precluded funding additional projects. The actual expenditure level of $139,278 did not exactly meet the budget constraint as a result of the discreet or “lumpy” nature of the bids.

Figure 2 about here

Two hypothetical comparison metrics used in previous evaluations are also shown on the graph. The budget constrained uniform price per EB comparison policy is shown as the bottom straight line in Figure 2. It indicates that the result would have been 17.8 million, rather than 20.9 million environmental benefit units if the uniform price per EB unit paid for the last bid accepted in the actual discriminant price auction had been paid to all successful bids up to a $139,278 expenditure constraint. As

shown in Table 2, based on this metric the auction is estimated to increase cost effectiveness by 18%.

The quantity constrained uniform price per EB comparison policy is shown as the straight line near the top Figure 2. It indicates that the expenditure required would have been $1,594,407 rather than $139,278 if the uniform price per EB paid for the last bid accepted in the actual discriminant price auction had been paid to all successful bids until 20.9 cumulative environmental benefits units were achieved. As shown in Table 2, based on this metric, the auction is estimated to increase cost effectiveness by over 11 fold.

Estimates of cost savings from implementation of the actual auction based on the two measures above are very different. Casual inspection of Figure 2 suggests that the differences are largely a result of very steeply increasing cost per EB of the last bids funded in the actual auction. Conceptually, the steeply increasing bid curve could be a result of either: 1) low environmental value of the lower value bids, or 2) high cost per unit of actions offered in lower value bids. Further evaluation is shown in Figure 3, where the cumulative cost of bids at prior input payment program indicative input rates is shown along with the auction outcome. The analysis presented in Figure 3 suggests that the much higher cost of the last bids accepted in the actual auction results largely because the lowest value bids funded offered much lower environmental value rather than because the lower priority bids involved much larger rent seeking than higher priority bids.

We conclude that using a quantity constrained uniform price auction comparison basis leads to a large overestimation of saving possible through implementation of a discriminant price auction. The primary reason is that an implicit

and naïve assumption in the quantity constrained uniform price comparison metric is that an agency would pay some bidders at rates many times in excess of actual input costs involved.

To compare the cost effectiveness of the auction to the cost effectiveness of the input payment comparison policies considered in this study with available data required some assumptions: The first assumption is that the naïve and negotiated input payment policies with projects selected individually and independently as offers arise can be simulated as random selection from the population of discriminant price auction bids. In the naïve input payment scenario it was assumed that all bids would accept the uniform input payment. For the negotiated input payment policy it was assumed that all bids would accept the average costs of inputs from previous years accounting for in-kind contributions that were negotiated.

Monte Carlo simulation was used to estimate the cost of the input payment policy scenarios modelled. This involved choosing 100 random samples from the population of the 29 bids submitted to the actual auction. The sample size in each draw was chosen such that cumulative cost of including another randomly selected bid would violate the $150,000 budget constraint. In the strategic input payment policy scenario, the random selection of bids required a new bid be selected when random selection resulted in a bid with less than the required threshold level of EB/$.

Next, the cost and the environmental benefit level for each randomly selected sample was computed. Finally, the average level of environmental benefit provision from the 100 random samples was computed and divided by average cost for the 100 samples to compute expected value of cost effectiveness for the prior program.

The results of the naïve and negotiated input payment policy in Table 2 indicate that the auction mechanism is estimated to be able to achieve 80% more environmental benefit for the same expenditure as a naive payment policy. The actual discriminant price auction is estimated to provide 56% more environmental benefit for the same expenditure when the comparison is the negotiated input payment policy.

The results of the strategic input payment policy simulation with selected projects order on the basis of environmental benefits per dollar is shown in Figure 3. Notably, the lines representing the actual auction results and the hypothetical comparison policy are very similar. Results in Table 2 lead to the conclusion that cost effectiveness achievable with a discriminant price auction and a strategic input payment mechanism are nearly equal for the case study evaluated.

5 Summary and Conclusions

One key conclusion of this analysis is that the estimated value of the cost savings achievable with discriminant a price auction for conservation contracts depends critically on the cost of the policy to which discrimant price auction outcomes are compared. In this case study, a naïve interpretation of the alternative as an input payment program with no effort to reduce rent seeking or select projects based on environmental cost effectiveness lead to a relatively large 80% estimated cost saving from discriminant price auction implementation. Slightly less (56%) savings from implementation of the discriminant price auction was estimated with the negotiated input payment comparison policy. This negotiated input payment policy represents an interpretation of the input payment policy that was in place in the case study area prior to the discriminant price auction. The strategic input payment policy evaluated included bi-lateral negotiation of payment rates and use of an

environmental benefits index to develop a $/EB. It was estimated that this policy would be negligibly (0.5%) more environmentally cost effective than the actual Catchment Care auction.

The results of this study suggest the need for reconsideration of the conclusions of past studies (Stoneham *et al*; White and Burton, 2005) that significant cost saving are achievable with discriminant price auctions. In this case study, estimated value of cost savings is critically sensitive to assumption about project selection and price setting mechanisms in the policy to which the discriminant price auction is compared. Results of this case study suggest that most of the savings that resulted from the discriminant price auction could be attributed the value of the environmental benefits index in project ranking and selection. It was also estimated that using the EBI for project selection together with a negotiation mechanism, to reduce rent seeking would be as cost effective as a discriminant price auction.

Another key conclusion is that there are fundamental problem with the uniform price per environmental benefit comparison approach used in previous studies to estimate discriminant price auction savings. One issue is this uniform price payments approach is usually very different to policies likely to have been in place prior to discriminant price auctions. The uniform price per EB comparison metric used in past studies involves the implicit assumption that the same set of cost effective projects selected with the discriminant price auction are a relevant basis for comparison. The difference measured is assumed to be in prices paid with a discriminant price auction versus a uniform price per EB for the same selection of projects. That is the approach implicitly assumes benefits assessment and project

ranking with an EBI both before and after implementation of the discriminant price auction.

In fact, no environmental benefits index existed as a basis for selecting projects with policies in place prior to any of the Australian discriminant price auctions. The first step in all of these trials was development of an environmental benefits index. This provides the fundamental basis for calculation of cost effectiveness, comparison, and ranking of bids, and enables selection of the most cost effective bids. For the auction evaluated in this article the prior program was an input payment scheme. Offers were selected individually and independently in the order that offers arose without formal assessment of environmental value as is possible with an environmental benefits index. We suspect that incentive payment schemes in place prior to other conservation auctions would have been similar. Thus, a better conceptual basis for estimating cost savings from discriminant price auctions, and the measure used in this paper, is comparison against environmental benefits resulting from a random draw of bids from the entire population of bids (including both bids that were accepted and rejected in the trialled auction) up to the actual auction budget constraint.

The empirical analysis presented here confirms that measuring cost savings with comparison to uniform price metric using the approach applied in past studies gives very different results than estimating savings by comparison to cost of input payment programs that involve bid selection without an EBI. Auction savings estimated assuming a budget constrained uniform price comparison underestimated savings assessed assuming random bid selection. Auction savings estimated assuming

a quantity constrained uniform price comparison overestimated savings assessed assuming random bid selection by a very large amount (over 6 fold).

We conclude that, using a quantity constrained uniform price auction comparison basis can lead to a large overestimation of saving possible through implementation of a discriminant price auctions. In the empirical evaluation reported here an implicit and we believe naïve assumption in the quantity constrained uniform price comparison metric is that an agency would pay for actions at rates many times in excess of actual input costs involved. We believe that this assumption is very unlikely to be valid in the real world.

The findings from this research point to several key areas for further research:

1. While there are likely to be difference in propensity of landholder to self select themselves as participants in auction versus input payment schemes, determinants and implications of differences are not yet understood. For example, officers of the agency that implemented the Catchment Care auction believed that the limited enrolment period associated with the auction and the delay until outcomes were announced may have limited enrolment relative to the prior input payment program that allowed landholders to submit project whenever they were ready. However, this potential difference in enrolment could not be evaluated quantitatively due to limitations in data on previous program. There is need for rigorous experimental design of evaluation strategies in future MBI trials to allow statistical evaluation of differences in behavioural responses including self selection to participate across various formats of auctions and payment schemes.

2. There may be substantial, and unaccounted for differentials in levels of moral hazard associated with alternative policy approaches. For example, agency officers who ran the auction believed that the prior input payment program left them more latitude to select against landholders who they believed were more likely to default on provision of works or poorly execute agreed works. Again limitations in data precluded testing this hypothesis. Clearly, there is need for more and more rigorous evaluation of how levels of moral hazards and adverse selection vary depending on policy approach.
3. There is a need to further investigate the likely magnitude of surplus included in individual bids for discriminant versus uniform price auction formats. In a uniform price auction all sellers receive a market clearing price that both exceeds their original offer and is determined exogenously of individual bids. Individual payments to sellers are thus inclusive of a trading surplus. As a consequence sellers have a greater incentive to reveal their true costs of recharge reduction, as increasing their bid reduces the probability of bid rejection, without a commensurate raising of the market price. Alternatively, in a discriminant price auction (1^{st} price) the purchaser pays a range of prices that match the bids offered by successful sellers. Sellers therefore face uncertain bid ranking and acceptance although price is assured. Trading surplus is not determined exogenously and must be included in the bid offer. The incentive for sellers is to increase the bid value to include a component of variable trading surplus. Dependent on the marginal cost of reduction, a seller faces a tension and costly learning effort in determining the balance between a higher probability of bid acceptance versus a higher trading surplus. This potential difference in the magnitude of captured producer surplus has not

been rigorously evaluated for formats of auctions likely to be implemented in actual auction trial, (e.g. 1st price discriminant and 1st price uniform auctions).

4. Limited empirical evidence indicates that marginal supply curves for conservation provision may often include a highly elastic initial portion of low cost bids followed by a rapid transiton to a highly inelastic portion of high cost bids. There is a need for further case study evaluation to understand whether the empirical find from this case study that estimated values of cost effectiveness are highly dependent on the relative position on the bid curve of the imputed quantity or budget constraint.

6 References

Bryan, B.A., Crossman, N.D., Schultz, T., Connor, J. and Ward, J. (2005b) *Systematic Regional Planning for Multiple Objective Natural Resource Management: A Case Study in the South Australian River Murray Corridor*. CSIRO Land and Water Client Report, ISBN 0 643 09196 3. See http://www.clw.csiro.au/research/society/peru/publications.html

Bryan, B.A., Gatti, S., Connor, J., Garrod, M. and King, D. (2005a). *Catchment Care – Developing an Auction Process for Biodiversity and Water Quality Gains*. Report to the Onkaparinga Catchment Water Management Board. See http://www.clw.csiro.au/research/society/peru/publications.html

Grafton, Q. (2005) Evaluation of Round One of the Market Based Instrument Pilot Program. National Market-based Instruments Pilots Program, Canberra, ACT, http://www.napswq.gov.au/mbi/round1-evaluation.html

Hailu, A., and S. Schillizzi (2004). Are Auctions More Efficient than Fixed Price Schemes when Bidders Learn? *Australian Journal of Management*, 39(4) pp 147-168.

Harrington, W. (2004). *Choosing Environmental Policy. Comparing Instruments and Outcomes in the United States and Europe.* Harrington, W., in Morgenstern, R.D. and Sterner, T. (eds.). Choosing Environmental Policy. Resources for the Future, Washington D.C.

Latacz-Lohmann, U. and Van der Hamsvoort, C.P.M.C. (1997). Auctioning Conservation Contracts: A Theoretical Analysis and an Application. *American Journal of Agricultural Economics* 79, pp. 407-418.

Latacz-Lohmann, U. and Van der Hamsvoort, C.P.C.M. (1998). Auctions as a Means of Creating a Market for Public Goods from Agriculture, *Journal of Agricultural Economics*, 49(3), pp 334-345.

MBI working Group (2002) Investigating new approaches - A Review of Natural Resource Management Pilots and Programs in Australia that Use Market-based Instruments. National Market-based Instruments Pilots Program, Canberra, ACT, http://www.napswq.gov.au/mbi/pilot-program-review.html

Milgrom P.R. and Weber, R.J., (1982) A Theory of Auctions in Competitive Bidding, *Econometrica* 50, pp 1089-1122.

Randall, A. (2003). *Market-Based Instruments - International Patterns of Adoption, Remaining Challenges, and Emerging Approaches,* Proceedings of the 6th Australian Agricultural and Research Economics Society (AARES) Annual National Symposium; 3 Sep 2003, Canberra, Rural Industries Research and Development Corporation.

Stavins, R.N., 2000. Experience with market-based environmental policy instruments (Discussion Paper 00-09). Resources for the Future, Washington D.C.

Sterner, T. (2003). *Policy Instruments for Environmental and Natural Resource Management.' Resources for the Future.* Washington D.C.

Stoneham, G. V. Chaudri, V., Ha A., Strappazon, L. (2003) Auctions for Conservation Contracts: an Empirical Evaluation of Victoria's BushTender Trial. *Australian Journal of Agricultural and Resource Economics* 47(4) pp 477-501.

White, B. and M. Burton (2005) Measuring the Efficiency of Conservation Auctions. Proceedings of the 47th Annual Australian Agricultural and Resource Economics Society Meetings, February 2004.

Table 1: Options for purchasing conservation services considered in this and past studies

Payment mechanism	**Project selection mechanism**			
	Systematic ranking of all bids with EBI to budget limit	*Systematic ranking of all bids with EBI to quantity limit*	*independent consideration of each bid without EBI to budget limit*	*independent consideratio of each bid without EBI to quantity limit*
Non-negotiated input rates	fixed price auction[2b]	fixed price auction[2b]	Naive input payment policy [3b]	
Negotiated input rates	Strategic input payment policy[3b]		Negotiated input payment policy[3b]	
Discriminant Price - Price bid for selected bids		**discriminant price auction** **[1a,2a, 3a]**		
Uniform price - Price offered by least cost-effective bid selected	Uniform price auction budget constrained[1b,2b, 3b]	uniform price auction quantity constrained[1b,2b, 3b]		

1a actual auction policy evaluated by Stoneham *et al.*,
2a actual auction policy evaluated by White and Burton,
3a actual auction policy evaluated by CSIRO (in this article).
1b comparison policy used to assess cost effectiveness by Stoneham *et al.*,
2b comparison policy used to assess cost effectiveness by White and Burton,
3b comparison policy used to assess cost effectiveness by CSIRO (in this article).

Table 2: Summary of results of auction cost and cost effectiveness estimates

Policy	Cost of achieving actual auction EB level	Level of EB achievable with auction level of expenditure	$/1000 EB	Cost per EB relative to actual auction
uniform price quantity constrained auction	1,594,407	NA	76.6	1161%
uniform price budget constrained auction	NA	17.8	7.8	118%
Actual discriminant price auction	139,278	20.9	6.60	NA
naive input payment policy	NA	11.7	11.9	180%
negotiated input payment policy	NA	14.3	10.3	156%
Strategic input payment policy	NA	21.1	6.63	99.5%

Figure 1: the uniform price auction comparison used by Stoneham to estimate discriminant price auction cost savings

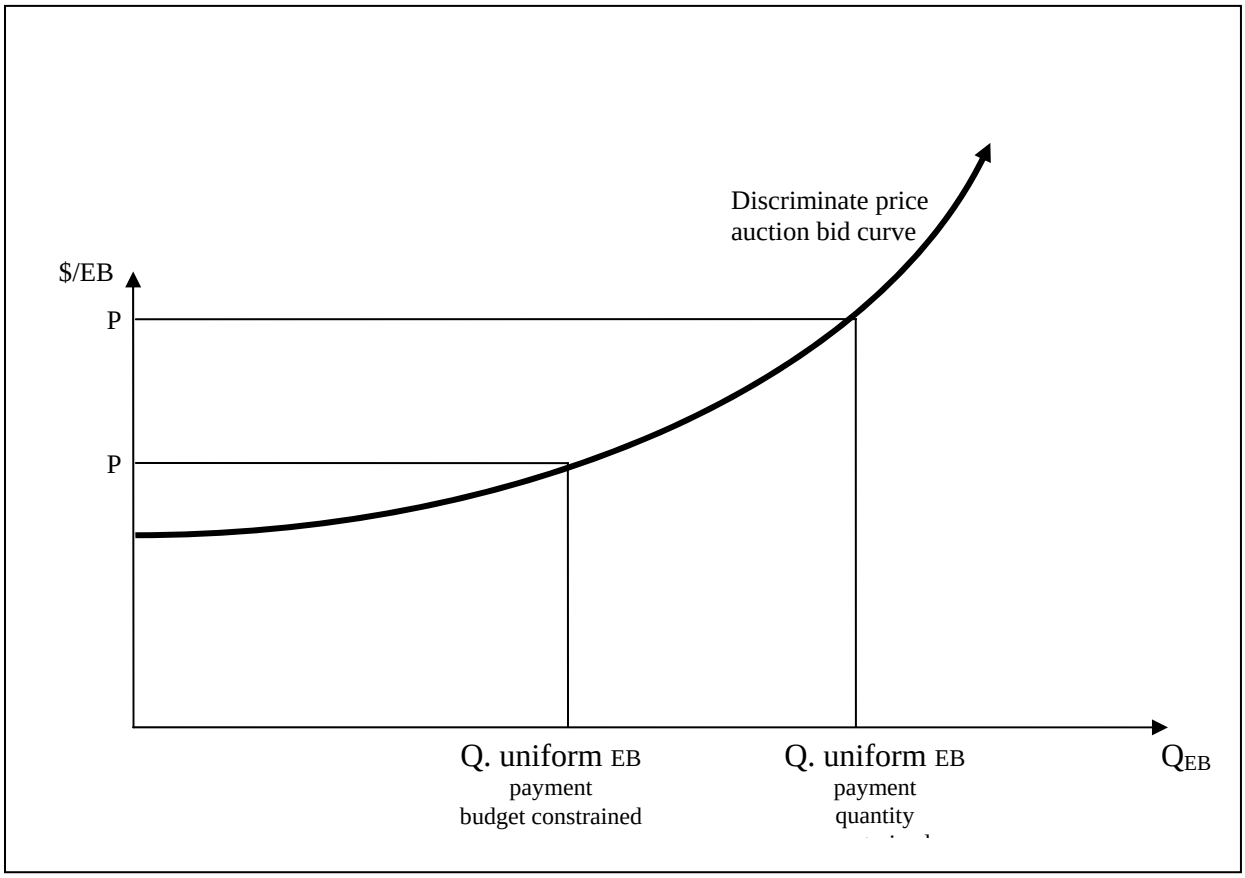

Figure 2: Actual cost and environmental outcome of Catchment Care auction and estimated comparison cost and environmental outcome of uniform price auctions

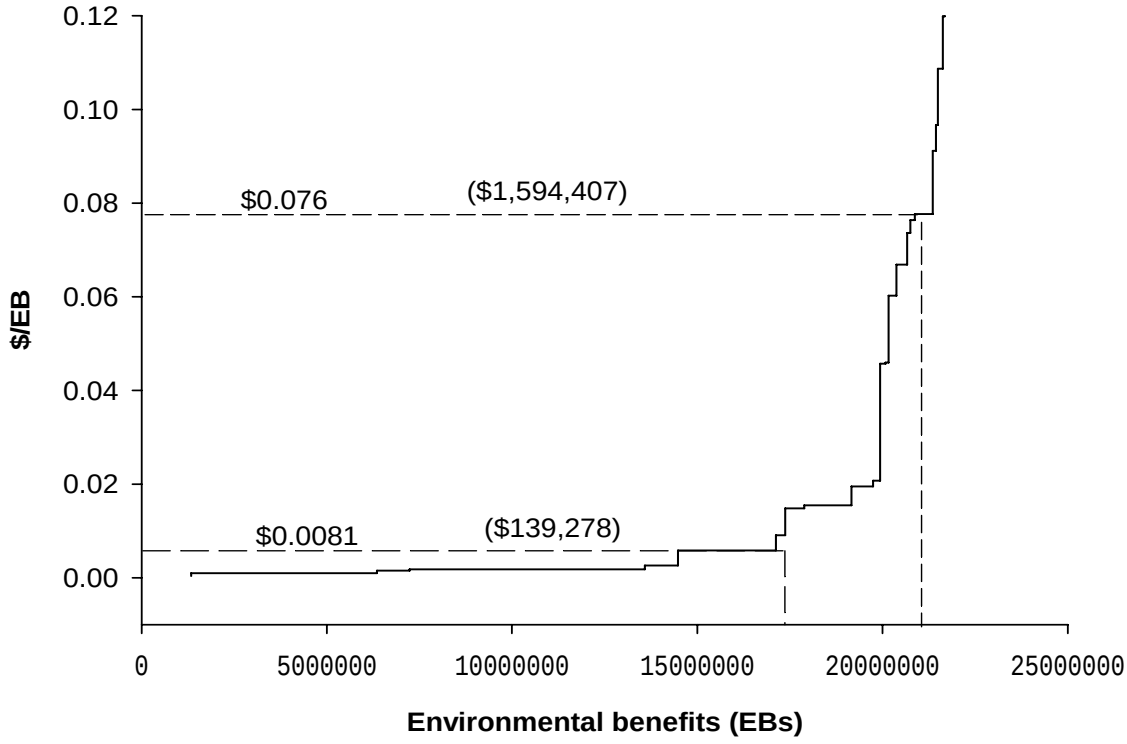

Figure 3: The cost of the actual auction in comparison to the cost of funding project selected for auction at indicative prices used in the prior input payment program

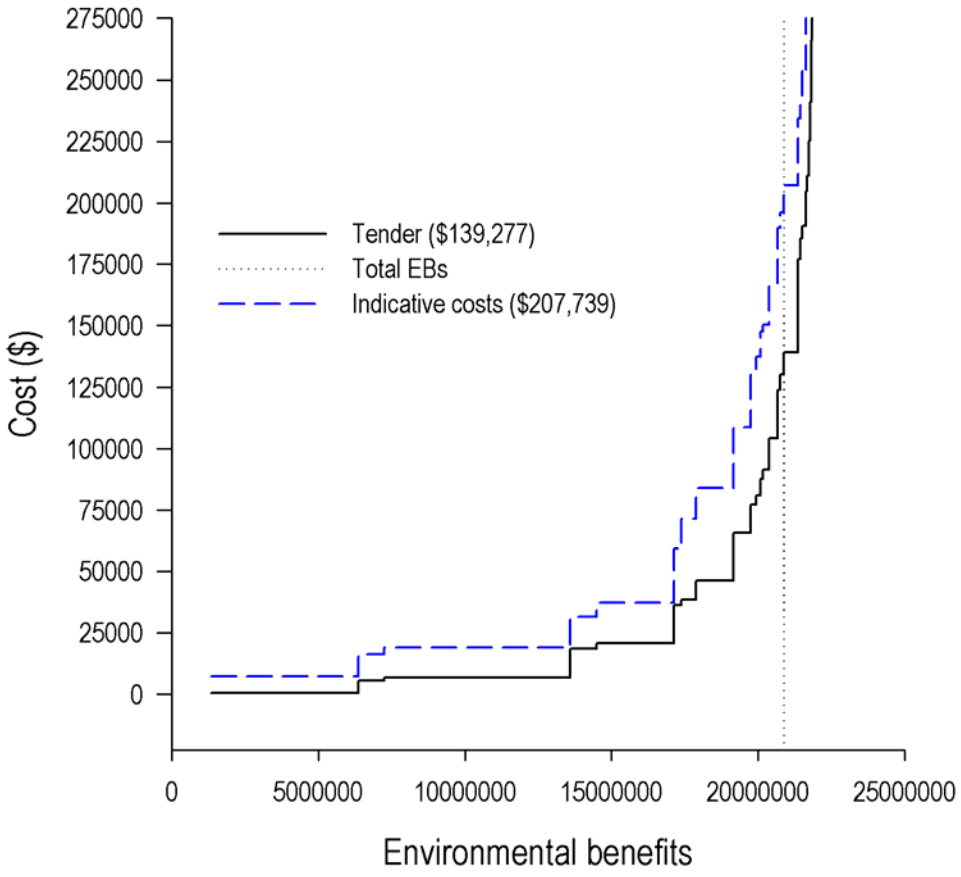

Figure 4: The cost of the actual auction in comparison to hypothetical negotiated payment policy with project selection using EB index