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Designing Auctions for Different Environmental Commodities

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20 January 2014

Citation

Reeson AF and Whitten SM (2014) Designing Auctions for Different Environmental Commodities. CSIRO Sustainable Agriculture Flagship, Canberra.

Acknowledgements

The authors are grateful to Tim Capon, Steve Hatfield-Dodds, Sandra Eady and David Hansen for advice and assistance in preparing this report.

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Summary

Auctions have proven their worth as an efficient and cost effective tool for the public procurement of environmental commodities. But there are many different ways to design and implement an auction, and the details matter. Well designed auctions use competition to reveal information from participants, and minimise the potential for strategic bidding. A key issue is the choice of pricing mechanism. Here, economic theory, laboratory experiments and real-world experience indicate that the uniform-pricing format is in the majority of circumstances the most efficient mechanism, particularly for repeated auctions targeting well known commodities such as water and carbon.

The discriminatory price ('pay as bid') format is generally less effective at revealing true costs, resulting in higher prices being paid on average (or in a budget-constrained auction, a lower quantity being purchased). However, if an auction is likely to be dominated by a small number of sellers, offering supply schedules rather than single projects, the choice of auction format is less clear cut. And for auctions targeting less tangible commodities and public goods (e.g. biodiversity), the discriminatory price format may sit better alongside other environmental policy tools such as awareness and extension campaigns.

The more bidders participate in an auction, the greater the competition and the better the outcomes are likely to be for the buyer. Where multiple rounds are required (e.g. due to the large scale of the program), increasing the length of time between auctions, and not guaranteeing that future rounds will go ahead, should enhance the level of competition in any given round. Fewer rounds, with more participants in each, will provide a more competitive market.

A reserve price is highly recommended in any auction, to reduce the risk of paying excessively high prices; it should be kept confidential to avoid providing an anchor for bid prices. A buyer should also retain some discretion as to the budget to be allocated in order to respond to greater or lesser numbers of competitive bids in any given auction round.

Environmental auctions often have the potential to deliver a range of benefits in addition to the targeted commodity. For example, some carbon projects offer substantial other environmental and social co-benefits such as biodiversity or Indigenous cultural values. These can be sought alongside carbon in an auction, through eligibility criteria or weighting projects based on their co-benefits, but this will inevitably come at a cost in terms of the price of quantity of carbon that can be purchased.

There are many details in auction design which can significantly impact on performance (in terms of bid prices and quantities purchased). Expert advice and experimental testing can prove invaluable in getting these details right. Where some potential participants are unfamiliar with auctions, training and support should be considered.

1 Introduction

1.1 Why auctions?

Auctions (sometimes called competitive tenders) are a form of market-based instrument which are widely applied for the procurement of environmental goods and services. In a typical auction, the buyer (usually a government or environmental agency) will indicate that it wishes to purchase a particular environmental commodity (such as biodiversity or carbon), and will invite potential sellers to submit bids to provide it. Crucially, the process is competitive. The buyer will select those bids which offer it the best value for money, in terms of the amount of commodity offered per dollar requested. The buyer will rank the bids received in order of value for money, and accept bids starting from the best value bid until either the required quantity of the environmental commodity has been purchased or a budget threshold is reached. In this way the most cost effective bids are selected, which means the buyer gets the maximum possible benefit from the money invested.

1.2 Auctions work…

Auctions work because they reveal information about the costs of supplying a commodity. Ideally a buyer would like to know in advance everyone's supply costs, and would then identify the lowest cost providers and contract with them. In reality, the buyer is unlikely to know enough to do this (particularly given the potential for innovation to change production costs). Information on the price at which sellers are willing to provide a commodity can be revealed in an auction, through competition. Each supplier in the auction would like to sell for as high a price as possible. However, because the auction is competitive, offering a lower price increases the chances of success. By identifying and selecting the lowest cost suppliers, a given quantity of a commodity can be provided at the lowest possible cost – this is economic efficiency. While some individuals will do better than others (for example high cost suppliers are always less likely to be successful in the auction), the overall costs to society of providing the desired commodity are minimised.

The benefits of using auctions to procure environmental goods and services have been clearly demonstrated both in theory (Latacz-Lohmann and Van der Hamsvoort 1997) and practice (Stoneham et al. 2003). Australia has been something of a pioneer in the application of auctions to environmental policy issues (Whitten et al. 2008), including biodiversity (with landholders offering conservation on their land), managing dryland salinity (establishing trees in high salt areas), water buybacks and carbon sequestration.

1.3 …but the details matter

While the potential benefits of auctions compared to alternative policy mechanisms such as regulation or fixed priced incentives are potentially large, the details of auction design are all important in determining whether, and to what extent, they will be realised. For example, Klemperer (2002) describes how various European countries applied superficially similar auction mechanisms to sell the rights to mobile phone spectrum in the early 2000s, but with very different results. On a per capita basis, values should be similar across these countries, but prices ranged from 20 Euros in Switzerland to 650 Euros in the UK, with significant implications for public revenue. Klemperer argues that much (though not all) of this variation was the result of differences in auction design, particularly in the extent to which competition between bidders was promoted.

This brief report describes some of the key issues in auction design which an environmental policy maker may wish to consider. In each case the details of the auction need to be matched to its context, including the nature of the commodity being purchased, the number of potential suppliers and the scale required.

2 Key design issues

2.1 Alternative pricing rules

Where a buyer is purchasing a commodity from more than one supplier, as is nearly always the case in environmental procurement auctions, there are two main approaches to determining the price paid. In the discriminatory price format (also called 'pay as bid'), each successful bidder receives the price they specified in their bid (which means different bidders receive different prices), while in the uniform price format all successful bidders receive the same price (usually the price of the highest ranked unsuccessful bid, which means that successful bidders receive at least the price they requested, and probably more). In Australia, environmental procurement auctions have tended to use the discriminatory price mechanism (e.g. Stoneham et al. 2003; Windle et al. 2009).

The discriminatory price format can appear attractive to the buyer (who typically sets the rules in these auctions) as it apparently captures more of the cost savings from the sellers. The buyer gets to purchase units of the commodity from the lowest cost seller at the lowest price, and from the next lowest cost seller at the next lowest price, and so on, until they reach their target. In the uniform price format the buyer must pay all successful bidders the same price, so the lower cost bidders will get more than the minimum price they specified. All other things being equal, in a single auction a buyer will do better with a discriminatory price auction since they pay lower prices to lower cost bidders, enabling a greater quantity of the commodity can be purchased for a given budget, or a target quantity to be purchased for a lower total cost.

2.2 Strategic bidding

However, all other things are not equal. Bidders are likely to change their strategy according to the pricing mechanism being used in the auction. In the uniform-price format, bidders can submit bids which are close to their costs of providing the commodity, knowing that they will get at least that price, and most likely more, if they are successful in the auction. The best strategy for a bidder in such an auction is to submit a bid for the lowest price they would be willing to accept for the commodity. This prompts sellers to submit bids which are close to their costs of supplying the commodity. In this way the auction mechanism achieves its basic requirement of revealing bidders' underlying costs of providing the commodity. However, in the discriminatory-price format bidders will add a premium on top of their costs to ensure the auction is profitable for them, which breaks the link between costs and price, undermining the efficiency of the auction (Milgrom 2004; Dittrich et al. 2012).

This effect has been demonstrated in an experimental economic comparison of the two auction formats; sellers in the discriminatory price format were found to inflate their bid prices in an attempt to seek a profit, which meant that low cost suppliers were often unsuccessful in the auction (Connor et al. 2008). Sellers are uncertain by how much to inflate their price, introducing a random element as some choose higher premiums than others. This means that the discriminatory price format may not succeed in identifying the lowest cost suppliers, which is a fundamental goal of a market mechanism. In the uniform price format, a seller making a single bid typically cannot increase the price they will receive by bidding strategically, so the optimal strategy is to bid their lowest acceptable price; there is nothing to be gained from adding a premium to their price.

In some circumstances the uniform price format can also be susceptible to strategic bidding. Where bidders are offering a range of different quantities and prices by submitting a schedule of bids (indicating the quantity offered at each price) rather than a single bid (indicating a single price and quantity), bidders may strategically withhold supply in order to increase the price they receive (Ausubel and Cramton 2002). This is only likely if a small number of bidders are likely to contribute a large proportion of the total supply, conferring market power (Ausubel and Cramton 2002). In these circumstances, which apply particularly in electricity markets, but also in other markets such as Treasury security (government debt) auctions, the choice between the uniform and discriminatory format is less clear cut (Ausubel and Cramton 2002; Fabra 2006; Genc 2009).

2.3 Multiple rounds

In many cases an auction will need to be run over multiple rounds rather than as a one-off exercise. This complicates the design process as it provides greater opportunity for strategic bidding, and economic theory is less developed for repeated auctions. However, it does provide the opportunity to adapt and refine the auction mechanism based on experience from previous rounds. Repetition increases the likelihood of bids being inflated in the discriminatory price format as sellers learn to increase their prices towards their expectations of the maximum price available (Latacz-Lohmann and Van der Hamsvoort 1997). An experimental study showed that a discriminatory price auction became less efficient than a non-market-based incentive after just three repetitions, as bid prices converged around price expectations rather than reflecting underlying costs (Schilizzi and Latacz-Lohmann 2007).

There is evidence of price convergence in a discriminatory price auction from the US Conservation Reserve Program, in which bidders increased their price premiums over time as they learned about prices paid in previous rounds, reducing the cost effectiveness of this multi-billion dollar environmental incentive program (Reichelderfer and Boggess 1988; Kirwan et al. 2005). Initially most bids were well below a secret reserve price, but by the fourth round the average bid price had risen to the level of the reserve price (Shoemaker 1989). In addition to compromising the economic efficiency of an auction this can also raise equity issues, as those with greater knowledge of the likely maximum price stand to make greater profits than those with less information.

For a bidder with a single project, the expectation of future rounds of the auction might encourage them to submit a bid price higher than they otherwise would, since if their bid is unsuccessful they still have the opportunity to try again next time. It might also encourage a 'wait and see' approach, reducing participation and competition. Having longer gaps between auctions would increase the cost of waiting or missing out due to a speculative bid. Maintaining an element of uncertainty about exactly how many rounds of an auction will be run has also been shown to result in lower prices, as participants are aware that any one round may be their last opportunity (Reeson et al. 2011). It is also recommended to retain some flexibility as to exactly how much funding is allocated in any given round, so that the buyer may respond if the bids received are considered to represent particularly good (or poor) value.

The drawbacks of the discriminatory price format in terms of encouraging speculative bidding will be exacerbated over repeated rounds due to the opportunity to re-bid in future. There is also the potential for prices to ratchet up, as reports of the highest prices paid in one round would form an anchor for bidders in subsequent rounds, resulting in increasing prices to the buyer. If such a format were used, the first round (and even public discussion leading up to it) would be crucial in terms of setting future price expectations. Prices have been found to be less responsive to changes in market conditions (e.g. new demand or supply) under the discriminatory format (Holt et al. 2007); this may limit the extent to which a buyer can benefit from innovation pushing prices down over the course of a major procurement program.

2.4 Tangible and intangible commodities

Given these drawbacks, why are discriminatory-price auctions so widely used for environmental procurement in Australia? In many such schemes, notably those targeting biodiversity conservation and salinity mitigation, the 'commodity' being provided is largely intangible to bidders. For example, conservation auctions typically use complex metrics to estimate the relative quantity of biodiversity being offered by each bid (e.g. Parkes et al. 2003; Williams et al. 2012), requiring a team of experts to develop and implement. And even if it can quantified, biodiversity remains a 'public good' whose value is enjoyed by society rather than being transferred from seller to buyer. In practice, biodiversity auctions focus on the costs of the management actions required of landholders. Sellers tend to remain unaware of the precise quantity they are offering, and rather focus on aspects of the bid most relevant to them, such as how many hectares of land they are giving up, or how many trees they are planting. These management actions can be quite specific to the property in question. Even with the scientific metrics there remains considerable uncertainty about the likely benefits, and actual outcomes can take many years to become manifest.

Given the intangible nature of environmental services such as biodiversity, the discriminatory price format, with its focus on incentivising varied management actions by landholders rather than paying for the production of a commodity, may be considered preferable. In theory a uniform price mechanism could still be applied, but it would lack transparency as the complex nature of the metrics make it difficult to communicate the basis on which the price is determined. The discriminatory price mechanism may also sit more comfortably alongside other environmental schemes running in parallel. In regional natural resource management, the agencies running auctions are also likely to be implementing other initiatives such as extension schemes and subsidies. The greater degree of commoditisation inherent in a uniform price auction runs the risk of 'crowding out' other motivations which contribute to voluntary action (see Reeson and Tisdell 2010).

Other environmental commodities, notably water and increasingly carbon, are far more tangible to potential auction participants. They have clear private value to the buyer or seller (e.g. crop production for water, or meeting greenhouse gas obligations for carbon), rather than remaining public goods. Bidders offering water or carbon will be well aware of the quantity, and will have expectations of its value based on prices observed in other markets. For such commodities the discriminatory price format is unlikely to reveal the underlying costs of provision. Instead, participants are likely to bid as high as they dare, aiming to come in just below the cut-off price. In the context of a relatively tangible commodity and in the absence of significant market power, the expert literature is clear that the uniform price mechanism is the preferred auction format. The strategic bidding incentives in a discriminatory price auction also make it less likely that the benefits of innovation would be captured by the auction mechanism because bidders will be focused on the cut-off price rather than on reducing their costs so as to be competitive.

For a one-off auction with relatively uninformed sellers, the discriminatory price format may allow a buyer to pay lower average prices than they would in a uniform price format (see Stoneham et al. 2003), as well as avoid a perception that some sellers are making large profits and thus taking advantage of taxpayers. However, these savings are illusory in the long run. In the short run they are obtained through reducing seller profits. As sellers learn and incorporate a premium in their bid while seeking to remain competitive, the discriminatory price format is less effective at identifying low cost suppliers (since bid prices are less likely to reflect costs). With repetition and better informed sellers, average prices would increase for the same quantity of carbon purchased. If, however, the auction is budget constrained, less can be purchased in total when bids are shaded upwards. In the budget-constrained context the increase in prices under the discriminatory format would be less obvious, but no less significant in terms of reducing the cost effectiveness of the program.

3 Other considerations

3.1 Reserve price

Buyers in procurement auctions should always consider setting a reserve price (or price cap) in order to ensure that they are not bound to accept bids which they consider too expensive. The level of a reserve price can be determined based on the cost of alternative approaches to delivering the environmental commodity. For example, in a biodiversity conservation auction, a government could base a reserve price on the expected costs of directly purchasing and managing land for conservation; if bidders in the auction request more than this to provide conservation on their own land, a government may decide the money is better invested elsewhere. For commodities such as water and carbon experience from markets and other government programs may also be informative, as this represents an alternative source of supply.

Reserve prices are generally kept confidential, in order to avoid acting as an anchor point for bidders. Rather than submitting bids which reflect their costs, many may instead put bids in at just below the reserve price, resulting in higher prices for the buyer. To avoid the risk of a confidential reserve price being inadvertently leaked, potentially putting some bidders at a competitive advantage (a particularly severe risk where a discriminatory price format is used), it could be determined after an auction closes, before the bids are opened.

3.2 Ensuring competition

Auctions depend on competition. If there is little or no competition, for example because there are only one or a few likely bidders, or the quantity being sought exceeds the capacity of the market to supply, an auction will not be a cost effective policy tool. Auctions need to be designed to ensure sufficient participation to create a competitive environment. This can be done by matching the scale of the auction to the eligible participants, ensuring that the required actions are reasonably aligned with bidders' own aspirations and minimising the transaction costs incurred in submitting a bid (Whitten et al. 2013). Where an auction is run over multiple rounds, unsuccessful bids from previous rounds could be provided with a streamlined entry process.

Ensuring competition is particularly problematic when a small number of participants control much of the potential supply. In such a scenario, greater effort needs to be made to attract smaller players into the auction in order to increase the competition. If the costs involved in preparing and submitting a bid are substantial it may be worth offering assistance or subsidies to attract more participants. It is also necessary to minimise the potential for bidders to collude. Unless the transaction costs are prohibitive, individual bids are far preferable to consortia for competition reasons. Collusion may be inadvertently facilitated if all bidders are required to use the services of a small number of consultants, for example to certify their bids (again there may be stronger incentives for such behaviour under a discriminatory price arrangement).

3.3 Seeking co-benefits

Environmental commodities are rarely produced in isolation. More often than not, the production of one commodity will have flow-on impacts on others. For example, planting trees to mitigate salinity will also have implications (which may be positive or negative, depending on the circumstances) on biodiversity (trees may provide habitat, or displace other species), water availability (reducing downstream flows), carbon sequestration, visual amenity and more. Some impacts, such as lost agricultural production on the tree planting site, are part of the costs incurred by the bidder and so will be addressed by the market. Others, such as impacts on neighbouring properties or public goods such as biodiversity, may not be – in economic terms, these are externalities, which markets fail to provide in sufficient quantity.

Many carbon sequestration and abatement projects are seen as a great opportunity to deliver a much broader range of environmental and social outcomes such as Indigenous cultural values, biodiversity conservation and amenity values (e.g. landscape views) (e.g. Heckbert et al. 2011; Lin et al. 2013). There are also concerns about potential adverse impacts on issues such as water availability and food security. There are a range of policy tools to address externalities, including of course auctions to provide incentives for their provision, as well as regulatory approaches.

It is possible to design an auction to target additional environmental or social outcomes. However, there is no such thing as a free lunch; for each additional attribute that is targeted in an auction, existing attributes must be traded off. For example, actively seeking biodiversity conservation alongside carbon requires trading off carbon and biodiversity. Either less carbon overall can be purchased, or a higher price is paid, as bids which offer better biodiversity benefits but less carbon are favoured relative to those which offer carbon without the biodiversity. If there are no trade-offs, for example because all carbon sequestration projects are equally good for biodiversity, then a market focussed entirely on carbon will still deliver biodiversity, and no formal consideration of the co-benefit is required.

3.4 Testing and training

Every auction is different. This means the details of auction design are very much dependent on the context – there is no 'one size fits all' approach (Klemperer 2002). Key considerations include the buyer's objectives, the number and scale of potential bidders, whether an auction will be run once or multiple times, and much more. Economic theory provides a good basis for auction design, though much of it is limited to simple settings. There is also now a wealth of experience to draw on from the large number of environmental procurement auctions carried out in Australia over the last decade. The role of expert advice can prove crucial (see Klemperer 2004). Holt et al. (2007) provide a useful example of systematically applying theory, experiment and experience to recommend an auction design for a particular context (selling CO_2 allowances).

It is now possible to test the details of any proposed auction mechanism prior to implementation through laboratory experiments. Experimental economics allows alternative mechanisms to be compared under controlled conditions, and has been successfully applied to resolve outstanding design issues and refine auction mechanisms (see Reeson and Nolles 2009). It is also necessary to ensure that potential participants understand the auction mechanism. Even a well designed auction will not work as intended if participants believe they can benefit from strategic bidding. And there is always a risk for naïve participants of pricing their bids too low (particularly for unfamiliar projects), which means they are more likely to succeed in the auction but to lose money on their project (an example of the "winner's curse"), undermining stakeholder support over the longer term. Where inexperience may be an issue, experimental economics techniques may be adapted to provide simple hands-on demonstrations of an auction in action, which can support participation by a broader range of bidders (see Windle et al. 2008). These have proved particularly successful in participant feedback from environmental auctions where they have been offered in Australia.

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