AUCTION FORMAT AND AUCTION SEQUENCE IN MULTI-ITEM MULTI-UNIT AUCTIONS

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Extended Abstract

The study is motivated by auctions of emissions permits where large numbers of units (e. g. tons of CO_2) of different items (e. g. vintages[1]) are being allocated. Auctions of allowances have taken place in some EU countries in Phase 2 of the EU Emissions Trading Scheme (ETS), namely Austria, the Netherlands, the UK and Germany, as well as in the Northeast of the United States (Regional Greenhouse Gas Initiative, RGGI).[2]

Emissions permits are also to be auctioned off in the Australian emissions trading scheme which is scheduled to commence in July 2015 after a three year period with a fixed price starting in July 2012. The Australian scheme may issue permits in advance of the scheme by auctioning several different vintages within the same event. This paper presents the results where we experimentally study the effect of auction format and auction sequence (simultaneous vs. sequential) on bidding behavior and auction outcomes in multi-item multi-unit auctions with a large number of bidders. The study was financed by the Australian Department of Climate Change and Energy Efficiency in 2009/10.

We compare sealed bid with open and closed clock auctions. A clock auction runs in multiple rounds, in which each bidder submits a quantity at a given price. The auctioneer increases the clock price, until the aggregate demand falls below supply and the auction stops. In open clock auctions the excess demand is revealed in each round whereas in closed clock auctions this information is not revealed. In contrast, in a sealed bid auction bidders submit their complete demand function at ones, and the auctioneer determines price and allocation based on all submitted functions.

Holt et al. (2007) identified and compared several auction formats as candidates for use in emission permits auctions. In their comparison of one-vintage multi-unit auctions, sealed bid and clock auctions performed equally well. The only experimental study so far which tests auctions of multiple multi-unit vintages is Porter et al. (2009). While the sealed bid auction

[1] An emission permit's *vintage* refers to the year or time period in which the permit allows the emission of a certain quantity of a pollutant. Depending on the further regulations of the scheme, permits may be transferred to other periods as well.

[2] The quantity being auctioned amounts approx. to 3% of the total EU emissions permits for 2008–2012. The following countries are auctioning allowances (based on National Allocation Plan data): Germany (9% or 40.0 Mio. EUA/a; this accounts to 60% of the total amount auctioned in the EU), UK (7% or 17.2 Mio. EUA/a), The Netherlands (3.7% or 3.2 Mio. EUA/a), Hungary (2% or 2.7 Mio. EUA/a) and Austria (1.3% or 0.4 Mio. EUA/a).

yields higher revenues than the clock auctions under inelastic demand, under relatively elastic demand, clock auctions are superior to sealed-bid auctions in terms of revenue, but not different in their efficiency properties. Therefore, unlike Holt et al. (2007), Porter et al. (2009), recommend the use of a simultaneous clock auction for the auctioning of emission permits. In our study, we more systematically explore the impact of the auction format and item sequence on the performance of multi-item multi-unit auctions. Our clock auctions allow for proxy-bidding, and additionally we test the effect of revealing aggregate demand in a clock auction.

In a 3x2 factorial design, we study both simultaneous and sequential versions of the auction formats sealed bid, open and sealed clock. For each of the six treatments we conducted six independent sessions. Each session/auction involved 14 bidders. These 14 bidders participated in 6 consecutive auctions (two for training and four according to treatment) in which 100 units of item A and 80 units of item B were sold. No bidder was allowed to bid for more than 15 units of item A and 10 units of item B. In each auction, individual heterogeneous demand functions were induced which stated individual redemption values for each possible bundle of A and B that could be purchased. The same set of demand functions was used in all 6 auctions of a session. The sets of demand functions (demand structure) differed between sessions within a treatment, but the same 6 different demand structures were implemented in every experimental treatment.

Marginal value functions over bundles of item A and B were randomly generated. The marginal values for item B were either defined as being the same as for item A (discount factor of 1), or were proportionally discounted by a factor of 0.8. To further explore the robustness of the auction mechanisms, we added constant exogenous demand function shocks in each auction, shifting aggregate demand up or downwards.

The auctions in our experiment yield between 79.8% and 92.6% of the revenues which would be predicted by Walrasian equilibrium, i.e. efficient prices reflecting marginal costs. In non-parametric tests, we find no consistent significant effect of the auction design (sealed bid vs. closed clock vs. open clock) on the efficiency of the allocation or prices and revenues. However, we detect higher revenues when auctioning sequentially rather than simultaneously. This difference is significant for sealed bid and open clock formats, but not for the closed clock auction design.

Table 1: OLS regressions of auction outcomes on treatment parameters and controls

Independent	RelEfficiency	RelPriceA	RelPriceB	RelRevenue	RelBidderSurplus
Constant	0.7542***	0.9241***	0.8372***	0.8895***	0.1982
	[0.0096]	[0.0255]	[0.0385]	[0.0282]	[0.1176]
Auction rule					
isClock	0.0068	0.0248	0.0054	0.0165	-0.0335
	[0.0073]	[0.0267]	[0.0358]	[0.0281]	[0.1275]
isClock.isOpen	0.0038	-0.0171	-0.0007	-0.0103	0.0770
	[0.0061]	[0.0266]	[0.0303]	[0.0253]	[0.1135]
Market environment					
isSequential	0.0118**	0.1068***	0.0301	0.0741***	-0.2899***
	[0.0054]	[0.0209]	[0.0258]	[0.021]	[0.093]
Controls					
DemandShock	-0.0006	-0.0090***	-0.0075***	-0.0084***	0.0389***
	[0.0009]	[0.0027]	[0.0028]	[0.0024]	[0.0123]
RelVintValueScheme	0.0020	0.0160	-0.0113	-0.0014	0.0492
	[0.0056]	[0.0139]	[0.0173]	[0.0111]	[0.063]
Obs	144	144	144	144	144
R-squared	0.8514	0.3457	0.1018	0.2636	0.5895

Notes: *, **, and *** denote significance at the 10%, 5%, and 1%-level, respectively. Regressions are based on auctions 3 to 6 from all sessions. All regressions include fixed effects for demand structures. Robust standard errors are calculated at the independent session level and are given in brackets.

To complement the non-parametric analysis, we apply Ordinary Least Square (OLS) Regression Analysis on aggregate auction outcomes. In all regressions, we cluster standard errors robustly at the independent session level, thereby accommodating for the potential relatedness of auctions within a session. Additionally, all regressions control for fixed effects of demand structures. The results of our regressions are reported in Table 1.

We include the following explanatory treatment dummies: *isClock* being 1 in clock treatments and 0 in sealed-bid auctions; *isClock.isOpen* being 1 in clock treatments where the aggregate demand was revealed, and 0 otherwise; and *isSequential* taking the value 1 in auctions where the two items were auctioned sequentially, and 0 in the simultaneous case. Thus, the baseline case is the sealed bid format with both vintages auctioned simultaneously. As further controls we include *DemandShock* which equals the demand shock in the individual auction, and *RelVintValueScheme* which is a dummy variable, with a value of 1 indicating an item B/item A value relation of 1, and 0 denoting a relation of 0.8.

The regression on relative allocative efficiency detects a significant effect of about 1.2% efficiency gains when auctioning sequentially rather than simultaneously. We find no effects of auction format and revelation of aggregate demand in the clock format.

In the price regressions, the estimated coefficient for the binary dummy parameter *isSeq* indicates that the price of item A is almost 11% higher, if it is auctioned first rather than

simultaneously with item B. The regressions of auction revenues confirm the observation of no effect of auction format and a positive effect of auctioning sequentially on auction revenues. The other effects mirror the results obtained for relative prices. This is not surprising, as higher auction prices *ceteris paribus* increase seller revenues and decrease bidders' surplus. Bidder profits show exactly the opposite behavior of seller revenues: they are lower when auctions are sequential rather than simultaneous, and increase in demand shocks which should be neutral to bidder profits according to theory.

Literature

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