GENDER DIFFERENCES IN CAPACITY AUCTIONS: A SIMULATION EXPERIMENT WITH *econport*

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ABSTRACT

A simulation environment has been used to study the behaviour of buyers when participating in capacity auctions. Gender differences have been found among buyers, which are university students, according to auction types. Males are more active in auctioning, they are also willing to take more risks and therefore they get more products than they should, but paying more than females for them.

INTRODUCTION

Auction simulators have been extensively used in research and teaching in computational and experimental economics (Kagel and Roth 2011), showing that these simulators might be particularized ad-hoc to study the behaviour of the real world.

We focus in this case on the gender aspect and the different behaviour between men and women in auction processes (Shehryar, 2008; Yeh, Hsiao and Yang, 2012).

We employ, for the first time to our knowledge, an auction simulator which has been particularized to study capacity auctions in general and in the energy market in particular (Otamendi et al. 2012, Otamendi and Doncel 2013).

Out of the available options, we select *econport* due to its wide use and its functional interface (Chen et al. 2003; Cox et al. 2005), as well as its enormous parameterisation potential that favours its particularisation to capacity auctions and facilitates experimentation.

Section 2 is used to define the process to offload liquefied natural gas and the auctioning of related capacity rights while Section 3 is devoted to introduce *econport* and the simulation environment. Section 4 describes the experiment that has been carried out and Section 5 shows the results. Section 6 includes a discussion of the results considering gender aspects while Section 7 is used to conclude and to define new lines of research.

CAPACITY AUCTIONS: THE CASE OF LNG

Companies that wish to offload liquefied natural gas (LNG) at the harbour tanks have to reserve or buy capacity, since the resources are very much limited. The usage of the harbour facilities have been addressed in the literature using simulation (Bruzzone et al. 1998; or more recently, Gyoungwoo et al. 2009), including the problem when unloading ships that carry coal (Otamendi 2008) or the loads on LNG terminals (Rezende et al. 2007).

The procedures to reserve capacity are currently known by the players, but may be rapidly changed, according to the Spanish regulation set back in December of 2007. There is a trend to liberalize the markets by installing auctions at any of the supply chain stages. In addition to those available for the price of gas and LNG, markets will be also set for capacities, that is, for allocation of capacity slots at the harbours for offloading, at the plants for regasification, at the network for transportation or at the underground buffers for storage. In Spain, the auctions started in 2009 with the underground storage capacity auction (Comisión 2012). It looks like the appropriate time for the companies to understand the new system and rules and develop platforms which will help in the new auction era.

Let's further define the offloading system. A company buys LNG that is transported by ship and must be offloaded at a harbour. Ships or tankers are usually large. The investments in LNG are therefore high and the price to pay for not offloading at the proper time is ever increasing with the delays. The size of the tankers will also force the company to buy just a few offloading rights over a long period of time. So timing is very important and bidding for the proper slots in critical.

Therefore, the companies that are going to participate in the auction and buy offloading rights must learn how to proceed in this new situation and design strategies that will allow them to maximize their profit while maintaining the reliability of service. If a simulator

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existed that resembled the capacity auctions… The simulator has been developed in *econport* with the help of Enagás, the owner of the pipelines and responsible for the transportation in Spain.

Other examples of capacity auctions are: slots at airports or the assignment of radio frequencies in public auctions.

econport and CAPACITY AUCTIONS

econport was designed by the Experimental Economics Center of Georgia State University back in 2006 as an experimental tool to research in economics. It has one module that allows for simulating auctions. In particular, it has one routine that resembles one market in which one seller offers several goods to different bidders. This module could be used as the basis for simulating capacity auctions.

To create an experiment, the auctioneer sets the following parameters:

- Number of goods or consecutive periods in which one good is auctioned at a time.
- Value of the goods, which might be individually set by hand or randomly assigned according to a uniform distribution
- Type of auction among four possibilities:
  a) Sealed-bid auctions: all the bidders submit simultaneously a single bid within the allotted time.
     1. First price: the good is awarded to the bidder who has submitted the highest bid.
     2. Vickrey or second highest price: the good is awarded to the bidder who has submitted the highest bid, but at the second highest price.
  b) Dynamic: the bids keep on varying along time, which is limited by design.
     3. English or ascending: the bids keep on rising until time is over. The good is awarded to the bidder who has submitted the last bid.
     4. Dutch or descending: The price keeps decreasing following a pre-set clocked pattern until one bidder stops the proceedings by accepting and paying the current price.

The auctioneer posts then the experiment on the web and sends instructions to the bidders, including a password. Each bidder might then join the experiment and send a message to the auctioneer with the username.

After a good is sold, each bidder knows the selling price, but not the name of the awarding bidder. He also gets information about his performance in terms of profit, calculated as the difference between value and bid. The profit accumulates after each good is sold.

EXPERIMENT DESCRIPTION

Each session lasts about 3 hours, with the following program:

- Theoretical explanation of the four auction types
- Access to the web simulator by the participants
- One experiment with 4 periods, so that the participants get acquainted with the simulator. The experiment is repeated for each of the four auction types. The values were sampled from a distribution of values (V dist) that follows a Uniform distribution that ranges between 0 and 20, U(0,20).
- One experiment with 6 periods, repeated for each auction type. The values were sampled from a distribution of values (V dist) that follows a Uniform distribution that ranges between 5 and 15, U(5,15).
- One experiment with 20 periods, repeated for each auction type. The values were sampled from a distribution of values (V dist) that follows a Uniform distribution that ranges between 0 and 20, U(0,20).

To account for gender, the participants were told to include a username that starts with an H for male ("hombre" in Spanish) and an M for female ("mujer" in Spanish).

To avoid buyer's curse (Kagel and Levin, 1986), a prize was given to the overall winner of the session. The winner was the participant with the highest profit after adding the profits of the last two experiments over the four auction types.

EXPERIMENT RESULTS

One of *econport* miscues is the difficulty to upload the experimental results into a database for further analysis. The output of the program is in *.xlm format and must be converted into MsExcel (in our case).

After tedious coding, the results of all the experiments are included in the same worksheet with the following columns:

- Register Number
- Date: in which the auction took place
- Group: a name for the group of participants
- V dist: random variable for values
- Auction Type
- Incremental Units Bid: the number of decimals allowed for the bids
- Period Length (secs): allotted time to place a bid
- Starting Price: at which to start the auction in clock auctions

- Tick Length: intervals between changes in bids in descending auctions
- Period: identification of the good that it is being auctioned
- Player: internal identification number assigned by the simulator
- Name: participant username
- Value: the random value assigned to the participant
- Bid: the bid placed by a participant
- Buyer: a dummy variable indicating with a 1 that the participant has bought the good
- Awarded Price/Pay: the price that has to be paid by the buyer
- Theoretical Buyer: a dummy variable indicating with a 1 that the participant should have bought the good since its value was the largest among all the bidders
- Efficiency: a dummy variable indicating with a 1 that the participant that should have bought the good had indeed bought it, and with a -1 if it had not bought it
- Value-Bid: absolute risk taken by the participant
- Profit: profit obtained by a participant
- -(Value - Bid)/Value (%): relative risk taken by the participant
- Gender: a binary variable, with H indicating male and M indicating female.

EXPERIMENT ANALYSIS

Two identical sessions were carried out:

- On Nov 16th, 2012, with 24 undergraduates students in Economics, 17 male and 7 female
- On Nov 30th, 2012, with 26 undergraduates students in Business Administration, 9 male and 17 female

Therefore, the participants account for a total of 26 males and 24 females. Each of them might bid a maximum of 104 times, that is, 4 auction types and 26 periods (or an experiment of 6 periods and another of 20 periods). There was however a mishap in the second session in one experiment and only 12 periods were run for the English auction in the Business Administration group, so only 96 registers are available for them. Overall, the total number of registers in the output database was 4992.

Figure 1 shows the analysis by gender according to auction type. The rows of the table show minimum, average, maximum and standard deviation values for each of the following output variables:

- The values, in order to verify the random assignment done by the simulator
- The bids
- The absolute risk, measured as Value-Bid
- The pay or awarded price
- The profit, calculated as Value-Pay

At the bottom of the table, there is also a summary of the awarding process, indicating:

- The number of goods that have been bought
- The number of goods that should have been bought
- The efficiency, calculated as an average between correct assignments of goods to highest value participants and incorrect assignments

The last row of the table includes the bidding strategy of the participants calculated as the number of bids that have been submitted out of the total number of products that have been auctioned.

A series of hypothesis tests on averages and proportion have been performed to study gender differences. The left-hand side columns in Figure 1 include the corresponding z-values. Those values that are black coloured with white figures are those in which the average for males is significantly higher than for females. Those values with a grey background correspond to significantly higher averages for females.

Considering gender differences, it looks like on average terms:

- The values are randomly assigned, not showing differences across gender or auction type.
- The bids are higher for male students, especially during Vickrey auctions, showing a will to take higher risks since the awarded price will be that of the second highest bid.
- There are no differences in absolute risk, although the z-values are all positive, indicating a slightly higher underbid for females
- The amount of money paid is higher in general terms for males. However, by auction type, males pay more during Vickrey and Dutch auctions and females during First and English auction. Once again, the riskier types call for males to get the capacity right.
- There are again no differences in profits, although the z-values are all positive, indicating higher values for female participants.
- Females have a lower efficiency rate, except for Vickrey auctions. They lose some auctions that they should have won.
- Females tend to place more bids except for the Dutch auction, in which they are not as anxious as males.

Significance Level 0.05

-1.9600

Group	(Todas)
Valid	(Todas)

z-values

FEMALE-MALE						GenderFinal	Auction Type									
						FEMALE				Total FEMALE	MALE				Total MALE	Total general
Dutch	English	First	Vickrey	TOTAL	Variables	Dutch	English	First	Vickrey		Dutch	English	First	Vickrey		
					Count Value	624	488	624	624	2360	676	604	676	676	2632	4992
					Mín. Value	0.05	0.07	0.04	0.02	0.02	0.01	0.01	0.04	0.02	0.01	0.01
-0.10	1.40	0.72	-1.22	0.31	Average Value	10.23	10.33	10.18	9.37	10.01	10.26	9.89	9.97	9.72	9.96	9.98
					Máx. Value	19.95	19.98	19.95	19.99	19.99	19.96	19.99	19.99	19.99	19.99	19.99
					Stdev Value	5.25	5.04	5.19	5.17	5.19	5.36	5.17	5.17	5.27	5.25	5.22
					Count Bid	21	129	606	584	1340	30	97	571	539	1237	2577
					Mín. Bid	14.23	2.00	0.01	0.01	0.01	14.18	1.00	0.01	0.01	0.01	0.01
-1.03	-0.51	-0.94	-2.89	-2.72	Average Bid	17.72	13.39	10.10	9.70	10.36	18.29	13.73	10.38	10.60	10.93	10.63
					Máx. Bid	20.50	19.60	20.50	21.00	21.00	20.50	19.80	23.00	25.00	25.00	25.00
					Stdev Bid	2.13	4.45	5.14	5.21	5.26	1.71	5.13	5.08	5.14	5.26	5.27
					Count Value-Bid	624	488	624	624	2360	676	604	676	676	2632	4992
					Mín. Value-Bid	-1.07	-0.52	-1.54	-20.11	-20.11	-3.58	-8.55	-11.57	-12.48	-12.48	-20.11
1.52	0.99	0.89	0.07	1.16	Average Value-Bid	0.15	1.04	0.25	-0.07	0.18	0.09	0.89	0.20	-0.08	0.13	0.16
					Máx. Value-Bid	0.95	16.92	11.06	11.46	16.92	1.20	15.13	7.83	18.75	18.75	18.75
					Desvestp de Value-Bid	0.47	2.37	0.56	1.75	1.45	0.85	2.72	1.32	2.13	1.86	1.66
					Count Pay	624	488	624	624	2360	676	604	676	676	2632	4992
					Mín. Pay	14.23	13.50	14.05	12.19	12.19	14.18	13.25	14.00	14.00	13.25	12.19
-5.31	2.50	3.47	-11.24	-5.35	Average Pay	17.73	17.77	18.58	16.53	17.64	18.29	17.46	18.20	17.86	17.96	17.81
					Máx. Pay	20.50	19.40	20.50	19.51	20.50	20.50	19.80	23.00	20.00	23.00	23.00
					Desvestp de Pay	2.08	1.99	1.83	2.34	2.22	1.71	2.14	2.18	1.87	2.00	2.11
					Count Profit	624	488	624	624	2360	676	604	676	676	2632	4992
					Mín. Profit	-1.07	0.00	-1.54	-1.47	-1.54	-3.58	-6.99	-6.83	-1.60	-6.99	-6.99
0.13	0.91	1.52	0.92	1.90	Average Profit	0.00	0.01	0.00	0.03	0.01	0.00	0.00	-0.02	0.02	0.00	0.01
					Máx. Profit	0.95	1.29	0.55	3.53	3.53	1.20	2.15	0.76	3.20	3.20	3.53
					Stdev Profit	0.09	0.09	0.08	0.25	0.15	0.18	0.40	0.40	0.21	0.31	0.25
					Sum Buyer	22	17	26	26	91	30	27	26	26	109	200
					Sum Theoretical Buyer	24	18	24	30	96	28	26	28	22	104	200
					Average Efficiency	-0.0016	-0.0020	0.0048	-0.0064	-0.0013	0.0044	0.0033	-0.0030	0.0059	0.0027	0.0008
-4.93	7.61	2.50	2.86	6.59	Bid Percentage	3.37%	26.43%	97.12%	93.59%	56.78%	4.44%	16.06%	84.47%	79.73%	47.00%	51.62%

Figure 1. Analysis of bids, pays and profits

CONCLUSIONS

The experiment has shown gender differences among the participants during the simulation games in which capacity rights are auctioned. It looks like males are more aggressive than females although they bid less often. They steal more products to women with the highest value than vice-versa, and buy more during Dutch auctions, where there is no information at all about the values.

Females bid almost always but without any risk, so they pay usually less when they buy a product in Vickrey and Dutch auctions, whereas they buy more in traditional English and First Price auctions.

The simulator has proven to be a reliable tool to perform the experiments, so more games will be carried out to back the preliminary conclusions of this paper up. Moreover, the simulation environment will be used in the future as a test-bench for other behavioural economics experiments.

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