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Sequential bidding in auctions of construction contracts

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Abstract

We analyze bidding patterns in morning and afternoon auctions of construction contracts. We find no statistically significant difference in the probability to bid in the afternoon between those who won and those who lost in morning sessions. As a result, the information released in the morning increases the observable asymmetries and affects bidding behavior. Firms that win in the morning bid more aggressively, in the absolute sense, in the afternoon. However, those who lost in morning sessions bid more aggressively, relative to their morning bids, than those who won in the morning.

Keywords: Asymmetric auctions

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1. Introduction

We investigate differences in bidding patterns between morning and afternoon auctions of construction contracts held by the Oklahoma Department of Transportation in the period from July 1998 to August 2000. The empirical literature on sequential auctions has examined predominantly the direction of expected prices. We emphasize differences in bidding behavior in later sessions conditional on the outcome (success or failure) of earlier auctions. We incorporate the number of bidders in these auctions, the characteristics of contracts, a measure of efficiency for each firm's rivals, and capital commitment that imposes budgetary restrictions. We find evidence of strategic behavior that is consistent with the predictions on asymmetric models of auctions. The asymmetries intensify in afternoon auctions due to the release of information in morning sessions.

The overwhelming majority of the theoretical work on sequential auctions assumes that bidders demand a single object. In auctions of construction contracts, however, there is no statistically

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significant difference in the probability of submitting a bid between winners and losers of morning auctions. In this framework, the assumption of single unit demand would take away much of the asymmetry that characterizes the bidding behavior in later rounds. Since the opportunity cost of completing a contract is different for each potential contractor and the differences become common knowledge through early bidding, asymmetries play an important role in this setting. In the afternoon auctions, there is a significant adjustment in the bidding behavior that is induced by the release of information on prices and bids in morning auctions. Our evidence of bidding behavior in the afternoon auctions is consistent with some of the theoretical predictions in Maskin and Riley (2000). For example, proposition 3.3 predicts that if a weak bidder faces a strong rather than another weak bidder he responds with a more aggressive bid distribution. We find that, on average the more competitive the set of rivals a firm faces the more aggressive are its bids. Even though the difference in the probability of submitting a bid is not statistically significant between winners and losers of early auctions, the losers make a much larger adjustment in their afternoon bids relative to the winners. As shown in Maskin and Riley (2000), identifying the nature of these asymmetries is important for the selection of the appropriate revenue maximizing mechanism.

2. Data

We examine bidding patterns for road construction projects utilizing data from the Oklahoma Department of Transportation (ODOT). The data contain information on all projects offered for bid letting by the State of Oklahoma between January 1997 and August 2000. These projects include road construction and paving projects, traffic signal projects, bridge construction and maintenance projects, as well as, smaller drainage and clearance type projects. The state auctions off projects on a monthly basis and uses a sealed-bid auction where the low bidder is awarded the contract.

To examine the process of sequential bidding we will utilize a particular feature of the auction setting. In Oklahoma, projects are let in both morning and afternoon sessions. Bids must be received half an hour before each session. Hence, the outcomes from the morning session are known before the bids must be received for the afternoon session. In fact, there is a small window of time—3.5 h—between the morning bid openings and the closing of the bids for the afternoon auctions. This allows potential bidders to alter their bids or possibly their decision to participate in the afternoon session. From discussions with state officials, we know that bids do arrive right up to the last possible moment.

The auction data that we utilize include information on the identity of the firms that purchase the plans for a project—'the plan holders', the identity and the bids of all bidders for a project, and the winning bid if the contract is awarded. Since, the data allow us to identify both firms holding plans and firms bidding, we follow individual firms bidding behavior across the morning and afternoon sessions. In addition to information on the identity of potential bidders, the state also provides detailed information on the specific project. This includes a description of the project (e.g. bridge construction, asphalt paving, etc.), the details of the project, how long the project will take (calendar days), the engineering estimate of the project's total cost and the date and time of letting.

Throughout this analysis, we divide our sample of auctions into two time periods—January 1997 to June 1998 and July 1998 to August 2000. The first period is used to create historical based variables such as measures of rival efficiency and capacity commitment for the bidders. We discuss the details

Table 1
Summary statistics of Oklahoma Road construction auctions

Variable	Auction statistics for sample: 1998:7–2000:8	Auction statistics for multiple bids sample
Number of auctions	952	744
Number of firms	213	93
Number of plans purchased	5247	2473
Number of AM plans purchased	2851	1269
Number of PM plans purchased	2396	1204
Number of bids (AM and PM)	2785	1743
Number of AM bids	1511	898
Number of PM bids	1274	845

Note: Standard deviations are in parenthesis.

of variable construction below. In this study, we will only utilize the bidding data of firms that submit multiple bids on a given auction day. The reason for this is that we want to use panel data techniques to control for unobserved bidder heterogeneity in some of our empirical applications. In addition, we are interested in how morning outcomes affect afternoon bidding, so the nature of the problem is one that focuses on firms submitting more than one bid. Table 1 provides data on both the overall sample and the sample restricted to multiple bidders. In the overall sample for July, 1998–August 2000, there were 952 auctions with 5247 plans purchased and 2785 bids submitted. This represents the activity of 213 individual firms. In our multiple-bid sample, there were 93 firms represented and these firms submitted 1743 bids and purchased 2473 plans.

3. Empirical analysis

We first analyze the probability of participation in these auctions. Recall that we know both the plan holders and the bidders and hence we can observe which firms actually submit a bid. The independent variables include controls for project characteristics, characteristics of the bidders and characteristics of the rivals in each auction. The project characteristics include the state's estimate of the engineering cost (log(engest)), and a set of dummy variables for project types (P_i's). The engineering cost estimates are constructed by the state by pricing each feature outlined in the design and then deriving an overall engineering cost estimate for the project.[1]

With respect to bidders' own characteristics, we include a variable that describes capacity commitment (backlog). This variable is constructed in the following way: For every contract won, we calculate the average monthly value. Each subsequent month, we subtract the average monthly value from the initial size of the contract until the completion time of the project. Based on this calculation, we determine at any given point in time, the total remaining value of the projects that a firm has undertaken. A firm that wins a contract today limits its free capacity to complete contracts in the

[1]The project dummies control for broad classes of project types—asphalt projects, clearance and bank protection; bridge work, grading and draining, concrete work, signals and lighting projects. The omitted group is miscellaneous work such as intersection modification, parking lots, and landscaping.

future. Additional commitment of capital implies more budgetary restrictions, since firms must include a payment of 5% of the value of the project upon submission of the bid. This is similar to the capacity measure used in Jofre-Bonet and Pesendorfer (2000). In addition to the capacity measure, we also include dummy variables that indicate whether the firm won or lost in the morning. These are the variables that will pick up differences in the probability to submit bids in the afternoon based on morning results.

We also utilize past information on rivals bidding success to summarize the competitiveness of the potential set of rivals (ARWP). The information that is provided in the plan holder list allows us to identify the rivals for a particular auction. Notice that a bidder must be a plan holder in order to participate in an auction and the plan holder list is made available to all potential bidders prior to the auction. The measure of rivals' past average success in auctions is constructed as the average across rivals of the ratio of past wins to past number of plans held. This variable incorporates two aspects of past rival bidding behavior. It incorporates both the probability of a rival bidding given they are a plan holder and the probability the rival wins an auction given that they bid.

The results of the probit analysis presented in column 1 of Table 2 reveal that there is no statistically significant difference in the probability to bid in the afternoon between those who won and those who lost in morning auctions. This is in contrast to an assumption typically made in models of sequential auctions in which bidders have unitary demand. This assumption is made to avoid the introduction of asymmetries that could complicate the analysis of bidding behavior. It is those asymmetries that we will emphasize in the analysis of bidding behavior in the afternoon auctions conditional on the outcome of the morning auctions. We will show that the asymmetries lead to bidding patterns consistent with the theoretical predictions in Maskin and Riley (2000).

We examine sequential bidding patterns in morning and afternoon sessions with a simple reduced-form model of bidding in a procurement auction. The basic structure of the regression model is as follows

$$\log(b_{igt}) = \beta_{0i} + \sum_{j=1}^{6} \beta_j P_{ji} + \beta_7 \log(\text{engest}_{igt}) + \beta_8 \log(\#\text{bidders}_{igt}) + \beta_9 \text{winAM}_{it} + \beta_{10} \text{loseAM}_{it} + \beta_{11} \log(\text{backlog}_{igt}) + \beta_{12} \text{ARWP}_{igt} + \varepsilon_{igt}$$

Our dependent variable in the regression is the log of the bid. The independent variables include a set of dummy variables for project characteristics (P_i's), the log of engineering estimates, the number of bidders (log(#bidders)), controls for characteristics of the bidders (winAM, loseAM and log(backlog)), and characteristics of the rivals in each auction (ARWP).

Alternatively, we will utilize a fixed-effects estimator that allows for bidder-time period effects. In this case, we specify the error term in the above equation as $\varepsilon_{igt} = \bar{u}_{it} + \eta_{igt}$. The mean effect captured here by $\bar{u}_{it}$ is a bidder time-specific effect. Hence, we are allowing for different bidder effects for each auction date. This is important if bidder efficiency levels that are not captured by the backlog variable vary across time. When we estimate the fixed-effects model, we will drop the backlog variable. We hypothesize that the dummy variables that indicate whether the firm won or lost in the morning will pick up differences in the aggressiveness of bids in the afternoon based on morning results.

The second column of Table 2 presents the OLS regression results and incorporate White-corrected standard errors to correct for heteroscedasticity. The results show that the more capacity a firm commits the less aggressively it bids in an auction. The effect of backlog on bids is small but

Table 2
Regression results

Independent variable	Probit	Dependent variable: Log of bids	
		OLS	Fixed effects
Constant	1.9608*	0.5615*	0.9326*
	(0.3763)	(0.1146)	(0.0989)
Project-1	0.2262	−0.0128	0.0450
	(0.1492)	(0.0365)	(0.0404)
Project-2	0.0991	−0.0117	−0.1224*
	(0.2233)	(0.0959)	(0.0588)
Project-3	−0.0327	0.0172	0.1110*
	(0.1394)	(0.0361)	(0.0388)
Project-4	−0.0868	−0.0418	0.1314*
	(0.1516)	(0.0417)	(0.0423)
Project-5	−0.1491	0.2415*	0.2491*
	(0.3125)	(0.0824)	(0.0827)
Project-6	0.7783*	−0.0850*	0.0102
	(0.2031)	(0.0433)	(0.0622)
Log of engineer's estimate	−0.1513*	0.9629*	0.9327*
	(0.0254)	(0.0084)	(0.0068)
Log of number of bidders		−0.0076	−0.0035
		(0.0138)	(0.0143)
Firms that won in the morning	0.3273*	−0.0905*	−0.0115
	(0.0717)	(0.0169)	(0.0157)
Firms that lost in the morning	0.3364*	−0.0104	−0.0800*
	(0.0650)	(0.0104)	(0.0145)
Log of firm's backlog	0.0206*	0.0032*	
	(0.0043)	(0.0014)	
Average rivals winning to plan holder ration	−1.5531*	−0.1263	−0.2856*
	(0.5301)	(0.1227)	(0.1296)
Number of Obs.	2274	1743	1743
R^2		0.9713	0.9694
Wald χ^2	203.23		

Note: White heteroscedasticity corrected standard errors are in parenthesis. * Denotes 95% significance.

consistent with the theory in Pitchik and Schotter (1988) that attributes less aggressive bidding to budgetary restrictions. It is also consistent with the findings Jofre-Bonet and Pesendorfer (2000). Looking at the afternoon bidding dummies, we find that firms that win in the morning bid more aggressively in the afternoon. However, it is probably the case that our measure of backlog is not fully controlling for differences in firm efficiencies and that the negative coefficient on this variable reflects differences in overall efficiencies (winners vs. losers) as opposed to differences in the bidding behavior in the morning and afternoon. To correct for this potential, we estimate the model with firm-time period effects. As discussed above, these effects should control for differences in unobserved heterogeneity across firms on a given auction day. In contrast to the OLS results which exploit cross firm variation in bids, the fixed effects results allow for a comparison of bidding behavior in the morning and afternoon for a given bidder. The results are presented in column 3. The findings suggest that, on average, those firms that lost in morning sessions bid more aggressively, relative to their morning bid, than those firms that won at least one project. The winners of early auctions are typically the stronger bidders and conditional on the outcome of early auctions, the weak bidders (i.e. the morning losers) adjust their strategies and bid more aggressively in afternoon auctions. In addition, the fixed effects results suggest that the more competitive the set of rivals a firm faces the more aggressively the firm bids. These results are consistent with the prediction in Maskin and Riley, (2000, proposition 3.5) which suggests that if a weak bidder faces a strong bidder rather than another weak bidder he will bid more aggressively and vice versa.[2]

References

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[2]Maskin and Riley (2000) prove that in the high bid auction, the distribution of bids of the strong buyer stochastically dominates that of the weak buyer. In auctions of construction contracts, in which the lowest bidder is awarded the project, the inverse would hold. Notice that stochastic dominance in the distribution of bids implies that the mean value from one distribution will exceed the mean value from the other. In that sense, our results provide evidence supporting their theory.