

## THE IMPACT OF CHANGE IN AUCTION FORMAT ON BIDDING BEHAVIOR

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### ABSTRACT:

We investigate differences in bidding behavior and participation patterns between simultaneous and multi-round auction formats held in the state of Oklahoma. Theory suggests there could be differential bidding effects arising from synergies and the release of relevant information across the two formats. We find no statistically significant difference in either the number of bids submitted or the bidding patterns observed relative to the control group of auctions held under a uniform format in Texas.

### I. INTRODUCTION

When bidding on multiple objects, bidders' strategic behavior is often underlined by informational effects and considerations of synergies. These factors can have a significant impact on the revenue rankings of different auction formats.

We empirically investigate the impact of a change from a multi-round to a single-round simultaneous auction setting on bidding behavior and participation patterns. Every month, the Oklahoma Department of Transportation (ODOT) calls sealed-bids from prospective bidders to auction off road construction contracts. Until March 2002, ODOT auctioned off these contracts in two separate sessions (semi-sequential) on a single day. A number of projects were auctioned off simultaneously within each session. After the first session, ODOT revealed all information generated, that interested bidders could take into account when submitting bids in the second session. After March 2002, ODOT started holding simultaneous first-price auctions in a single session. Such a change in the auction format can have a significant impact on revenues. Using data from 1997 to 2003, we investigate a number of questions: (1) Is bidding behavior more aggressive when some auctions are performed in a sequence or is it better to auction all contracts simultaneously? (2) Are there important informational effects that can induce more competitive bids in a sequential auction? (3) Is the probability of submitting a bid different in simultaneous and sequential settings? Alternatively, is the number of bids on multiple projects affected by a change in the auction format?

Recent theoretical work on this issue was essentially motivated by the FCC auctions of PCS licenses in the 1990's. One of the primary concerns in these auctions was to allow bidders to realize synergies that arise due to the geographical proximity of some licenses. In the absence of synergies, Milgrom and Weber (2000) conjectured that, due to informational effects and the

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linkage principle, sequential auctions will generate more revenues than simultaneous auctions. When the potential for synergies is present, simultaneous auctions may produce higher revenues. Krishna and Rosenthal (1996) showed that, in the independent private value context, bidders bid more aggressively in the simultaneous auction format if synergies are present. Rosenthal and Wang (1996) analyzed simultaneous auctions when the objects have common values, and observed aggressive bidding behavior among bidders who could realize synergies.<sup>1</sup>

We have found no studies that directly compare seller revenue in sequential and simultaneous sealed bid auctions. The empirical literature has focused on the effect of synergies on seller's revenues within a single auction format. Gandal (1997) examines the competition for Israeli Area Cable Television licenses that were awarded in sequential auctions. He found aggressive bidding behavior over time when the licenses were interdependent. Ausubel et al (1997) and Moreton and Spiller (1998) show that, generally, bidders holding adjacent licenses in FCC spectrum auctions are willing to bid more aggressively. De Silva (2005) observed aggressive bidding behavior due to the presence of geographic synergies in sequential road construction auctions in Oklahoma. Lunander and Nilsson (2004) experimentally compare simultaneous, sequential, and combinatorial first-price sealed-bid auctions and show that, despite potential for synergies, revenue comparison between formats produced statistically insignificant differences. Our goal is to provide field evidence of the relative performance of multi-round and simultaneous first-price sealed-bid auctions while controlling for potential synergies. We find that, even though firms bid more aggressively on projects that present cost complementarities if undertaken with known existing projects, bidders do not react to information provided during the auction, and the semi-sequential format produces bidding behavior similar to the simultaneous format.

## II. DATA

We use data from ODOT and the Texas Department of Transportation (TXDOT) on auctions that took place between January 1997 and August 2003.<sup>2</sup> Note that TXDOT had a uniform policy of holding two sessions within a month throughout our period of analysis. This unique natural experiment allowed us to compare the effects of changes in policy on firms' bidding behavior in Oklahoma and Texas.

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<sup>1</sup> Using the second-price, simultaneous ascending-bid auction format, Albano, Germano and Lovo (2001) compare revenue performance of simultaneous ascending-bid auctions to three other auction formats: sequential auctions, VCG auctions and simultaneous one-shot auctions. They find that the sequential auction format performs poorly relative to the two simultaneous auction formats. Aggressive bidding behavior in simultaneous auctions is due to exploitation of synergies.

<sup>2</sup> The ODOT data were obtained from four reports, namely the project *plan holder list*, *as read bid report*, *low bid report*, and *award notices* which are available on the ODOT website. TXDOT data were gathered from similar reports provided by TXDOT.

Both states provide project information at least 28 days before an auction. Hence, before each project is auctioned off bidders learn the location and the detailed project description, the estimated completion time, the engineer's cost estimates and the plan-holders list (the list of contractors who purchased plans). At the conclusion of each auction, the bids submitted by each bidder, the winning bidder, and the winning bid are revealed.

We use data from January 1997 to March 2000 to create variables based on bidder history such as capacity utilization, whether the bidder is bidding on a location where he has an ongoing project, potential rivals' toughness, and potential rivals' capacity commitment. Data from April 2000 to August 2003 are used to analyze the empirical models.<sup>3</sup> We are interested in examining the bidding behavior of bidders who bid before and after March 2002. Hence, we only utilize data of firms that submit multiple bids between March 2000 and August 2003 to use panel data techniques to control for unobserved bidder heterogeneity. Table 1 provides summary statistics for both states. We have 26,446 plan holders who submit 15,381 multiple bids. There are a slightly higher number of plan holders and number of bidders in both states after March 2002. Further, Oklahoma has slightly higher numbers when considering multiple bids by a firm in a given month and multiple bids by a firm in the same division in a given month. Finally, both states have similar values for relative bids and winning bids.

### III. EMPIRICAL MODEL AND RESULTS

First, we test how change in auction format affected bidding behavior in Oklahoma compared to Texas using a panel-data differences-in-differences (DID) methodology. We model this change by classifying auctions into two time periods. In the first period, ODOT reveals all information generated in first session auctions to second session bidders. For both states, there were at least three and a half hours between the two sessions and firms could submit bids until 15 minutes before the bid letting. Our specification of the DID model will allow for differential effects across the two time periods. Our econometric specification is

$$rbid_{iat} = \alpha_i + \beta_1 D_t^{OK} + \beta_2 D_t^{AF} + \beta_3 D_t^{OK, AF} + X\Gamma + \varepsilon_{iat}$$

where the unit of observation is firm  $i$  bidding in auction  $a$  in time period  $t$ . The dependent variable used throughout the analysis is the relative bid. The independent variables include controls for format change, variables on auction characteristics, bidder characteristics, rival characteristics and characteristics of business environment.

The  $\beta$ 's measure the changes in bidding in Texas and Oklahoma across periods. The coefficient on  $D_t^{OK}$ ,  $\beta_1$ , measures the average difference in bidding in auctions in Oklahoma

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<sup>3</sup> Since April 2000 OKDOT and TXDOT release similar information before and after each session. Before April 2000 OKDOT did not release the engineer's cost estimate.

relative to Texas throughout the period of analysis.  $\beta_2$ , captures the average difference in bidding between all auctions held before and after the format change.  $\beta_3$  measures the difference in bidding that occurs in Oklahoma auctions compared to Texas auctions in the period after the format change. Our main interest is in the coefficient  $\beta_3$ . For an accurate prediction of the effect of the format change in Oklahoma we must control for the other factor that could impact Oklahoma auctions held after March 2002 differently than Texas auctions.

There are two auction-level variables—the number of bidders and a set of project type dummies. We have identified six different project types: asphalt-related projects, concrete work, bridge projects, traffic lights and signals, grading and drainage projects, and erosion control projects. We include two variables that measure the cost heterogeneity of bidders, in addition to firm fixed effects: bidder's capacity utilization rate and bidder's distance to a project. Further, we include a dummy variable, if a firm is bidding on a division where there is an ongoing project, to control for any geographical synergies with existing projects identified by De Silva (2005). We constructed three variables to measure rival characteristics. First, we utilize past information on rivals' bidding success and construct the average winning percentage of all rival plan holders in an auction—rival toughness. Then we include the rivals' minimum distance to the project and the minimum backlog.<sup>4</sup> Finally, we control for changes in factors other than auction format. Four variables control for the business environment. The first is the monthly, seasonally unadjusted, state-level unemployment rate for Oklahoma and Texas, gathered from the US Bureau of Labor Statistics. Next, we use the three-month average of the real volume of projects, constructed by adding the engineering cost estimate across projects up for bid in a month for Oklahoma and Texas, respectively, and deflating the current value by the PPI. Then, we divide it by the average of the real volume for each state to calculate the relative real volume and, take the three-month moving average of the relative real volume. Next, we consider the state-specific three-month average of the number of building permits collected from the US Bureau of Economic Analysis. Finally, we use monthly dummies to control for any seasonal variations.<sup>5</sup>

All DID models are estimated with firm fixed effects and the standard errors reported are cluster-robust where the clustering is on firms. We estimate the models on five distinct samples of bids. One sample includes all bids submitted by multiple bidders. A second sample estimates the model using only bidders who had an interest in multiple projects within a single month and could take advantage of synergies by submitting multiple bids. The third sample considers multiple bids submitted in the same division by each firm that could identify stronger synergies. This sample will assess the potential impact of synergies with a focus on location. The last two

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<sup>4</sup> These variables are similar to variables used by Bajari and Ye (2003), Jofre-Bonet and Pesendorfer (2000), De Silva, Jeitschko and Kosmopoulou (2005) and De Silva, Dunne, Kankanagme and Kosmopoulou (2005).

<sup>5</sup> Our models are estimated with firm fixed effects to control for bidder heterogeneity. Some of those controls have also been used in De Silva, Dunne, Kankanagme and Kosmopoulou (2005).

samples isolate the behavior of those that bid on multiple projects in both periods of time. The variations in the latter regressions measure how bidding varies in the same controlled group of bidders.

Table 3 presents coefficients for the base model using different samples to control for synergies. The key parameter of interest is  $\beta_3$  that shows there is no difference in bidding between Oklahoma and Texas auctions that can be attributed to the format change. This result holds even if there is a possible synergy by undertaking multiple projects in the same division. Firms, however, bid more aggressively in divisions where there are ongoing projects. With regard to the other variables, we identified the following patterns. More competitors result in lower procurement costs. Bidders with a higher capacity utilization rate tend to bid higher. The larger the distance of a bidder from a project location, the less aggressive is his bidding behavior. The negative value of the average rival winning to plan holder ratio indicates that, as rivals get tougher, bids generally decline. The variables that measure business conditions show weak effects. Only the number of building permits has a statistically significant effect, and that is in two of the five specifications. An increase in the relative number of building permits makes bidding less aggressive reflecting the availability of other options. Further, we estimate these models for relative winning bids and find no effect of the format change on winning bids either. These results can be obtained from the authors upon request.

Another way information from an early session can affect the auction process is by changing the probability to submit a bid and the number of submitted bids. To investigate whether participation patterns have been affected by ODOT's auction format change, we first estimate a probit model. In column 1 of table 3, we report the probit model results for bid submission. Column 4 shows the probability of winning conditional upon bidding. In both cases, we find no statistically significant effect in the parameter of interest,  $\beta_3$ . Alternatively, we consider the effect of the format change on the number of bids submitted by a bidder in a single month. We estimate a count data model on the number of bidders. The results of the Poisson model presented in column 3 show no statistically significant change in the number of bids submitted between Texas and Oklahoma. Finally, in column 4, we report similar results for the number of bids submitted by bidders that could potentially exploit synergistic opportunities within a given month.

#### **IV. CONCLUSION**

In this paper, we investigate the impact of format change in ODOT auctions (from multi-round to single-round simultaneous auction structure) on bidding behavior. Using the DID approach, we find that the format change has no statistically significant effect on firms' bidding behavior and bidder participation patterns.

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**Table 1: Summary Statistics of Oklahoma and Texas Road Construction**

<b>Auctions</b>				
<b>Variable</b>	<b>Oklahoma</b>		<b>Texas</b>	
	<b>Before March 2002</b>	<b>Since March 2002</b>	<b>Before March 2002</b>	<b>Since March 2002</b>
<i>Total number of auctions</i>	758	557	1635	1014
<i>Number of awarded projects</i>	620	443	1575	972
<i>Average number of plan holders per project</i>	5.821 (3.659)	6.239 (3.589)	6.578 (3.191)	8.232 (3.400)
<i>Average number of bidders per project</i>	3.174 (1.939)	3.293 (1.944)	4.261 (2.069)	4.988 (2.293)
<i>Relative value of bids</i>	1.038 (.306)	1.014 (.277)	1.060 (.219)	1.029 (.239)
<i>Relative value of winning bids</i>	.916 (.206)	.894 (.182)	.953 (.167)	.917 (.183)
<i>Number of multiple bids by a firm on a given month</i>	5.023 (3.447)	5.750 (4.031)	4.568 (3.251)	4.569 (2.912)
<i>Number of multiple bids by a firm on the same division on a given month</i>	2.913 (1.369)	3.069 (1.547)	2.918 (1.796)	2.797 (1.191)
<i>Number of multiple bids by a firms who bids before and after on a given month</i>	5.035 (3.549)	5.876 (4.062)	4.231 (2.670)	4.725 (2.973)
<i>Number of multiple bids by a firms who bids before and after in the same division on a given month</i>	2.978 (1.472)	3.111 (1.585)	2.912 (1.952)	2.766 (1.083)

**Table 2: Relative Bid Regression Results**

Variable	Base Model	Multiple Bids	Multiple Bids on the Same Division	Before and After Multiple Bidder Bids	Before and After Multiple Bidder Bids on the Same Division
	(1)	(2)	(3)	(4)	(5)
<i>Oklahoma Bids</i>	-.004 (.052)	-.017 (.077)	-.091 (.183)	-.017 (.077)	-.088 (.190)
<i>Bids after March 2002</i>	-.031** (.010)	-.032** (.013)	-.020 (.016)	-.034** (.014)	-.032* (.017)
<i>Oklahoma Bids after March 2000</i>	.009 (.013)	.015 (.015)	.010 (.016)	.015 (.015)	.015 (.015)
<i>Firm bidding on a division where there is an ongoing project</i>	-.011** (.004)	-.009* (.005)	-.010 (.007)	-.008 (.005)	-.010 (.007)
<i>Number of bidders</i>	-.014** (.001)	-.013** (.001)	-.015** (.002)	-.014** (.002)	-.017** (.002)
<i>Bidders capacity utilized</i>	.030** (.009)	.025** (.011)	.036** (.015)	.025** (.012)	.028* (.014)
<i>Bidders distance to the project location</i>	.008** (.002)	.008** (.003)	.006* (.004)	.009** (.003)	.007 (.004)
<i>Average rivals winning to plan holder ratio</i>	-.123** (.059)	-.166** (.058)	-.184** (.074)	-.170** (.066)	-.201** (.084)
<i>Closest rival's distance to the project location</i>	-.001 (.002)	-.000 (.002)	-.000 (.003)	.001 (.002)	.001 (.003)
<i>Rivals minimum backlog</i>	.000 (.000)	.001* (.000)	.000 (.001)	.001** (.000)	.000 (.001)
<i>Seasonally unadjusted unemployment rate</i>	-.005 (.004)	-.003 (.004)	-.008 (.006)	-.002 (.005)	-.001 (.006)
<i>Three month average of relative real value of engineer's estimates</i>	-.005 (.014)	-.006 (.017)	.004 (.020)	-.002 (.018)	.027 (.019)
<i>Three month average of relative number of building permits</i>	.098** (.041)	.065 (.048)	.053 (.050)	.062* (.052)	.032 (.050)
Number of Observations	15831	12337	6542	10259	5168
Adj-R <sup>2</sup>	.144	.129	.148	.113	.127

\*\*Denotes statistical significance at the 5% level and \* denotes statistical significance at the 10% level. Robust clustered standard errors using firm level clusters are in parentheses. All regressions include a constant term, five project class dummy variables, and 11 monthly dummy variables.

**Table 3: Poisson and Probit Regression Results**

Variable	Probit		Poisson	
	Probability of Bidding	Probability of Winning Conditional on Bidding	Number of Bids per Month	Number of multiple bids per auction
	(1)	(2)	(3)	(4)
<i>Oklahoma Bids</i>	-.111** (.025)	.044** (.021)	.040 (.084)	
<i>Bids after March 2002</i>	.023 (.021)	-.049** (.017)	.206** (.054)	.041 (.054)
<i>Oklahoma Bids after March 2000</i>	.007 (.025)	.022 (.021)	-.037 (.064)	-.076 (.057)
<i>Log of engineering Estimate</i>				-.210** (.093)
<i>Log of engineering Estimate<sup>2</sup></i>				.007** (.003)
<i>Number of plan holders</i>				.078** (.003)
<i>Firm bidding on a division where there is an ongoing project</i>	.145** (.014)	.063** (.010)		
<i>Bidders capacity utilized</i>	.048** (.022)	-.035** (.017)	.226** (.053)	.021 (.040)
<i>Bidders distance to the project location</i>	-.022** (.006)	-.019** (.003)		
<i>Average rivals winning to plan holder ratio</i>	.001 (.110)	-.177** (.086)		
<i>Closest rival's distance to the project location</i>	.020** (.003)	.021** (.003)		
<i>Rivals minimum backlog</i>	.004** (.001)	.004 (.001)		
<i>Seasonally unadjusted unemployment rate</i>	.002 (.009)	.002 (.007)	-.059** (.018)	-.020 (.024)
<i>Three month average of relative real value of engineer's estimates</i>	-.038** (.016)	.032** (.015)	-.054 (.044)	-.131** (.046)
<i>Three month average of relative number of building permits</i>	-.312** (.070)	.074 (.072)	-.436** (.129)	-.632** (.190)
Number of Observations	26446	15831	7105	3809
Wald $\chi^2$	420.69	239.07	159.33	1432.95

\*\*Denotes statistical significance at the 5% level and \* denotes statistical significance at the 10% level. Robust clustered standard errors using firm level clusters are in parentheses. All regressions include a constant term and 11 monthly dummy variables. The Poisson models in columns (1) and (2) include 32 project location dummies. In columns (3) and (4) five project class dummy variables are included.