Econ 4567 Auction Theory: Caltrans Paper

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Intro.

1 Data

1.1 Institutional Details

The California Department of Transportation (Caltrans) is the department that manages Aeronautics, Highway Transportation, Mass Transportation, Transportation Planning, Administration, and the Equipment Service Center in California. To outsource the labor for their highway construction projects, Caltrans runs low-bid procurement auctions. Within the auctions, there are typically large and small business bidders. Because small businesses have lower economies of scale, their costs are higher compared to large businesses. Due to the difference in costs, Caltrans grants "bid preferences" to the small business bidders. Small businesses must meet three qualifications to be obtain the Small Business Certification. The certification requires that the business must be independently owned and operated in California, have no more than 100 employees, and over the last three tax years can only earn under $10 million average annual gross receipts. The benefit of the Small Business Certification is that there is a higher probability of winning the auction. Once all bids are submitted, the lowest bid wins the auction. However, if a small business's bid is within 5% of the lowest bid, they win the auction and are awarded the contract for construction. While the 5% discount is used to determine the winner, it is not applied to the actual amount the business is paid for the project: Caltrans will pay the true price the winner bid.

1.2 Data Overview

	Mean	Standard Deviation	Minimum	Maximum
Bids	986241.65	3311628.21	44655.00	58547700.00
Small Business Bids	531334.61	723168.10	49650.00	15485561.50
Number of Bidders	5.70	3.18	1.00	20.00
Engineer's Estimates	943980.19	3734611.68	74000.00	60058000.00
Workday	94.28	155.89	8.00	1430.00

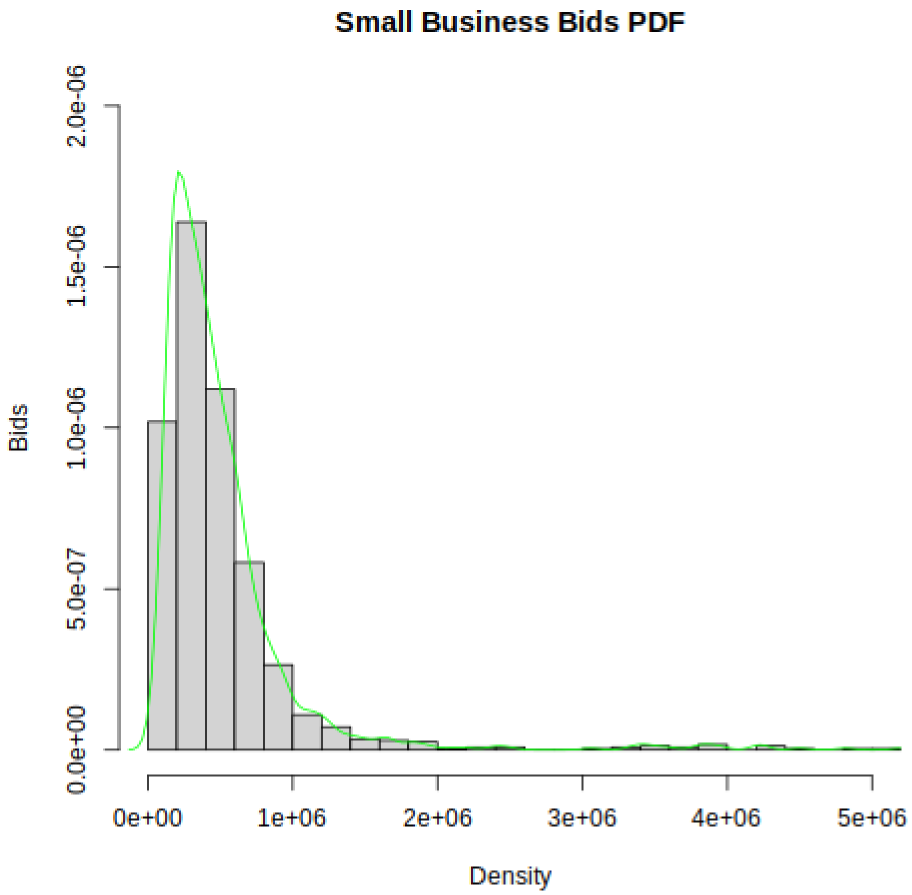
There were 705 auctions in total. On average there were 5.7 bidders in each auction, and the average bid was 968,241.65.

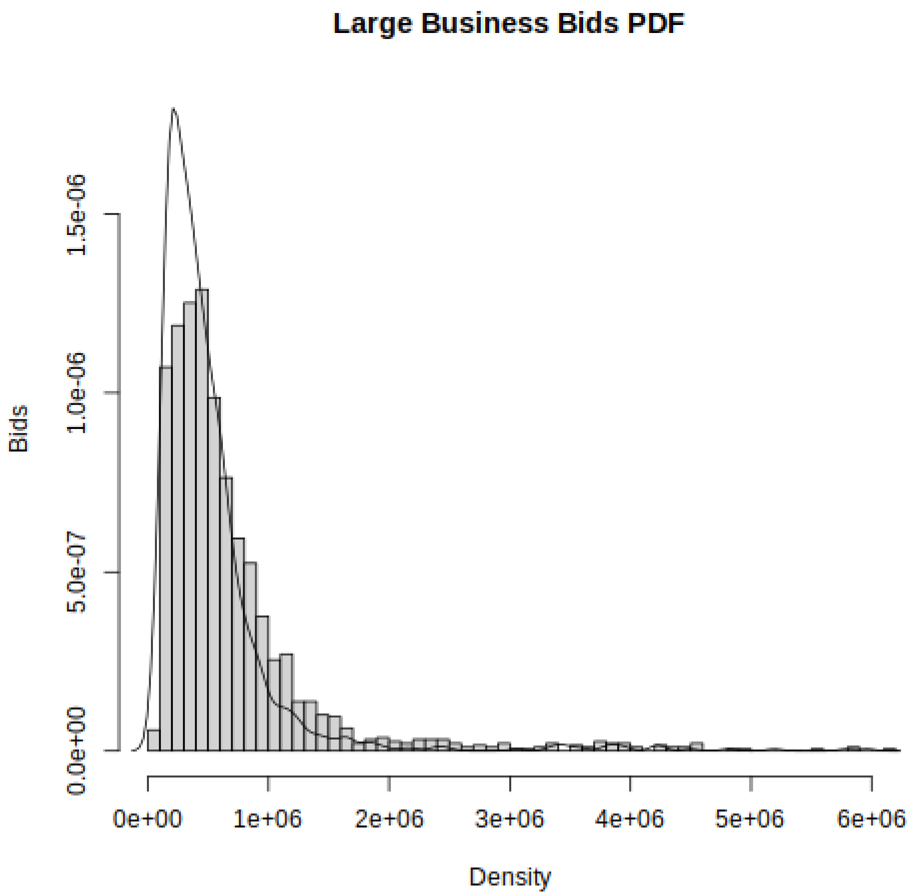
We also see that on average, the winning bid was $39,417 lower than the state's cost estimate. This is a relatively small difference, but it does suggest that competition among the bidders does drive the procurement cost down.

1.3 Bidding Behavior

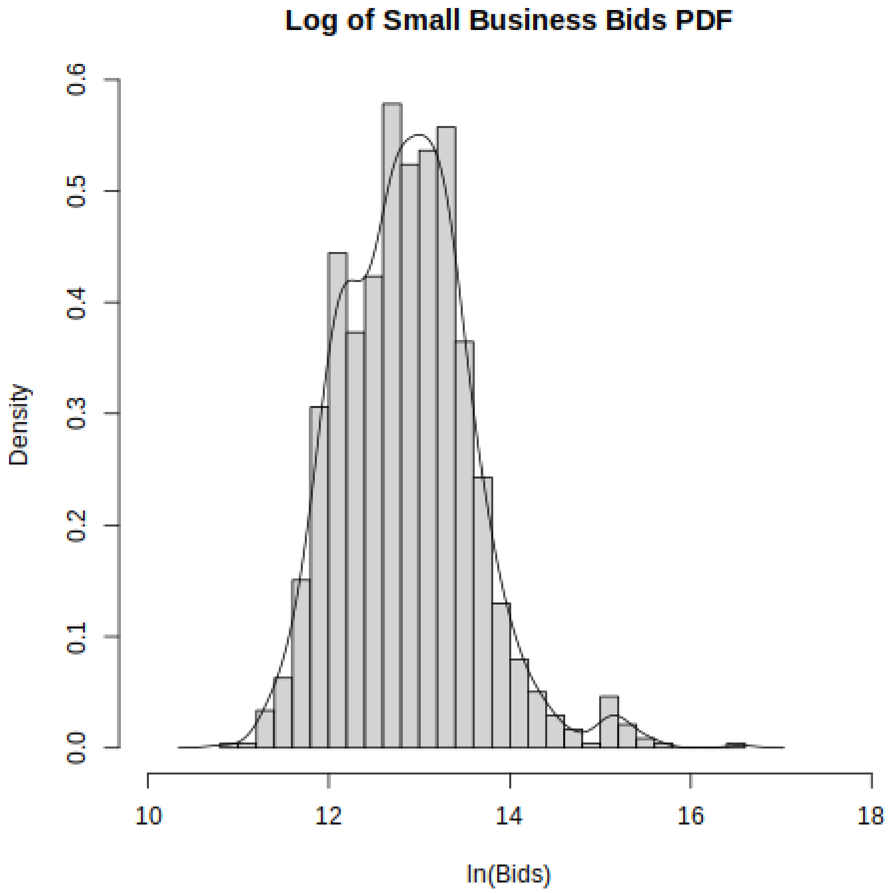
First we estimated the true distribution of bids for large and small businesses using kernel density estimation with a bandwidth selected via leave-one-out cross-validation. Kernel density estimation relies on the second derivative of the density function, and will as a result tend to overestimate peaks and underestimate valleys. We can see that in this plot, where the density estimate is much higher than the first peak.

The large business bids do have a longer tail, which reflects that they are more able to take on projects with a large cost than the smaller businesses.

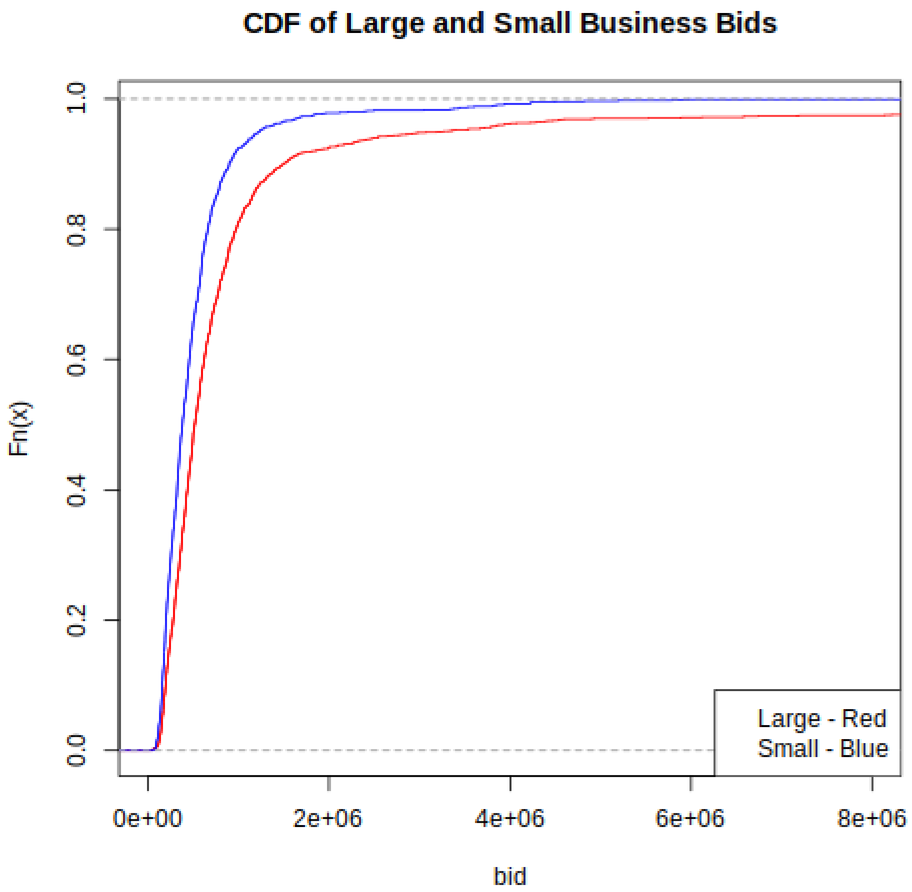




Because of the data's skew, we applied a log transformation to normalize the data and provide a better visualization of the long tail. This reveals a very slight bimodal peak around bids of about $3 million, which might be a common project cost.



We also plotted the CDFs to see patterns in the bid sizes between the two types of bidders. The smaller average bids of the small businesses are very clear in this plot, as the line is strictly greater than the large businesses' estimated CDF.



1.3.1 Regressions

present the estimates in a table properly labled.

To better understand the bidding behavior of business, we ran regressions on bidders, engineer's estimate, and work days. Bidders is how many bidders there were for a certain project, engineer's estimate is the estimate on how much a professional believes the project costs, and work days is how long the project will take. The first regression we ran included both small and large businesses, and below is the result.

$$\text{Bid} = -18,820\text{Bidders} + 0.849\text{Engineer's Estimate} + 716\text{Work Days} + 224,200$$

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	224239.4332	32012.8642	7.00	0.0000
num_bidders	-18815.3332	4617.4432	-4.07	0.0000
Estimate	0.8494	0.0041	205.05	0.0000
WorkDays	715.9631	99.6008	7.19	0.0000

The results of this regression are as we expected. The negative sign on bidders is consistent with the theory we studied, because with more bidders in a particular auction, it drives down the price of the bid.

Further as the engineer's estimate increases, the bid should increase because there is a higher cost for the project. Finally, as work days increases, so should the bid because it is a more expensive project as it takes longer. The next regression we ran contains the same variables, except it only includes small business bidders. The results are below.

$$\text{Bid} = -16,470\text{Bidders} + 0.9496\text{Engineer's Estimate} + 154.3\text{Work Days} + 135,200$$

These results also have the same signs as we expected for the same reasons as above. The only difference in this regression is the degree to which work days influences the bid. The coefficient for the regression with only small business bidders is 154.3 compared with 716 for the regression including all businesses. This might indicate that number of work days does not increase the bid as much because smaller businesses might not be able to handle the cost of larger projects that require more time and capital. Therefore, they can't bid as high.

The next regression includes the same variables again, except it only focuses on large business bidders.

$$\text{Bid} = -22250\text{Bidders} + 0.8398\text{Engineer's Estimate} + 1372\text{Work Days} + 183900$$

This regression also follows the same signs as we expected. The one difference in this regression is the bigger coefficient for work days, such that there is a much larger coefficient on work days for large business bidders. This can be explained by the fact that large businesses can handle the higher costs of lengthier projects. Their economies of scale allow for them to afford projects that require more time and capital. Because of this, they are more likely to pursue such projects and can bid higher for them.

2 Appendix - Code

The following is the R code used to prepare the data section of the paper.

```
load("./src/code/Caltrans_Data/caltransdata.RData")
lintr::lint("./src/code/data.R")

# summary stats on the data from 705 auctions
# here, getting the number of types of bidders (either 1 or 2)
types_bidders <- vector(length =
   length(unique(caltransdata$ProjectID)))
auction_rows <- match(unique(caltransdata$ProjectID),
   caltransdata$ProjectID)
auction_indexer <- 1
for (auction in auction_rows) {
  types_bidders[auction_indexer] <-
    (caltransdata$NumberofSmallBusinessBidders[auction] != 0) +
    (caltransdata$NumberofLargeBusinessBidders[auction] != 0)
  auction_indexer <- auction_indexer + 1
}

sb_bids <- caltransdata[caltransdata$SmallBusinessPreference == 1,
   ]$Bid
```

```
num_bidders <- caltransdata$NumberofSmallBusinessBidders +
  caltransdata$NumberofLargeBusinessBidders

my_smry <- function(x) {
  return(c(mean(x), sd(x), min(x), max(x)))
}
all_bids_smry <- my_smry(caltransdata$Bid)
sb_bids_smry <- my_smry(sb_bids)
num_bidders_smry <- my_smry(num_bidders)
# num_types_bidders_smry <- my_smry(caltransdata$...)
eng_est_smry <- my_smry(caltransdata$Estimate)
workdays_smry <- my_smry(caltransdata$WorkDays)
summary_stats <- matrix(Reduce(c, list(all_bids_smry, sb_bids_smry,
                                       num_bidders_smry,
                                       #num_types_bidders_smry,
                                       eng_est_smry,
                                          workdays_smry)),
```