Cost Overrun and Auction Format in Public Works

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Abstract

We study the effect on cost overruns of auction formats (average bid as opposed to first price rule) conditional on the entry mechanisms (open as opposed to restricted participation).The dataset is a panel of auctions held in the Italian Veneto region between 2004 and 2006. It includes small size public projects (with reserve price up to one million euros) in such sectors as road works and building maintenance. It is commonly believed that cost overruns are lower under average bid auctions relative to first price auctions. We find support to this belief only when participation to the auction is restricted.

JEL classification codes: D44; H57

Keywords: cost overrun; average bid; first price; free entry; work delays

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1 Introduction

The final cost of public works is often considerably higher than the price at which the contract is awarded in the tendering process (see e.g. Flyvbjerg B. et al., 2002 and Flyvbjerg B. et al., 2003 for large transport infrastructure projects, and Odeck J., 2004 for small size road projects). Cost overruns may originate in all stages of the project, from planning to completion. In this paper we concentrate on the relation between cost overruns and the mechanism by which the contract is awarded.

The auction literature provides two different explanations for cost overrun. Ganuza (2007) argues that systematic cost overruns may result from procurers' attempt to minimize the information rent of contractors. In order to increase competition, procurers find it optimal to underinvest in initial project design and then recontract both the price and the project specification with the designated contractor. This explanation fits well to the case of complex projects, where the number of competitors is naturally small, and less well to the case of simple projects, where the number of competitors is usually larger.

The alternative explanation comes from Spulber (1990). He shows that, when the cost of production is uncertain at the bidding stage and bidders can renege on their bids, those with lower penalty from reneging will bid more aggressively in a standard auction, and hence the bidder relatively most likely to renege wins the contract (also see Waehrer, 1995; Zheng, 2001; Board, 2007). One can realistically expect that in this situation recontracting will occur and cost overruns will be larger on average. Practical remedies to contractor's nonperformance are third party guarantees or performance bonds (for a theoretical analysis see Calveras et. al., 2004). However, when contractors are small firms and projects are of small size, such remedies can be relatively costly, and in fact they are of limited use in many countries, including our case study. An alternative is to award the project via non standard auctions. In the so-called "average bid auction", first proposed by Iannou and Leu (1993) in the engineering literature, the winning bid is the one closest to the average of all the bids, and the contractor receives his asked price. Versions of the average bid auction have been used in public procurement in many countries like the US, Italy, Belgium, Switzerland, Taiwan, Japan, etc. (for a review see DeCarolis, 2009). This auction format has a Nash equilibrium where all the bids are identical. Hence each bidder essentially takes part in a lottery where it has the same probability of having the project assigned, which weakens the bad selection problem (Albano et al., 2006). It has also been shown that the average bid format represents the awarding procedure that maximizes profits in case of large losses from non-performance (Chillemi and Mezzetti, 2010).[1] These favorable properties postulate that bidders do not collude. However, since the winning price depends on the average of the bids, bidders have incentives to coordinate their bids and pilot the average (Albano et al., 2006). As we will clarify later, collusion is a potential failure of this auction rule, and it may also lead to a bad selection of the winner.

Since our empirical investigation only regards small size projects, we will focus on the bad selection problem and disregard the theme of strategic underinvestment on project design. We use a panel dataset of public procurement auctions with reserve price below one million euros held in the Italian Veneto region between 2004 and 2006, regarding primarily road works and building maintenance. In that period the regional law allowed procurers to use four different award mechanisms: first price and average bid procedures (auction format), with and without open participation (entry rules).

We find that the average bid auction is associated with lower cost overruns than first price

[1] Precisely, the sum of the non-performance loss of the procurer and the defaulting penalty of the contractor must be higher than the production cost.

auctions when entry is restricted, while this effect is lost when entry is open. We interpret this finding as evidence that contractor's adverse selection is an important problem in auctions for small size public works. We also argue that the lack of a significant effect of the average bid auction with open entry may reflect collusion.

These results are relevant for the debate about the public procurement law in EU. Indeed, the European Commission opposed the use of the average bid format in public procurement (see European Commission, 2002). Although being aware of the risk of sub-performance, the Commission argues that the right way to solve the problem of bad winner selection is testing bid reliability and eliminating abnormally low bids after a debate with the bidder. Our analysis moderately supports this view, since the effectiveness of the average bid format to curbe cost overruns is limited and seems not robust to collusion.

The empirical literature on procurement has given attention to the advantages and disadvantages of auctions with respect to negotiation as a selection mechanism (the main contribution is Bajari et al. 2008). The effect of different auction formats on cost overruns has received little attention. The paper more related to ours is DeCarolis (2009). He studies public procurement projects in the Italian Piedmont region and finds that cost overruns are lower in average bid auctions rather than in first price auctions. However, in his dataset participation is always open.

The paper is organized as follows. Section 2 describes our dataset and its main variables. Section 3 discusses the results from our analysis, and Section 4 concludes. In the appendix we formalize a situation in which the bad winner's selection emerges at equilibrium in the average bid auction with open entry and collusion.

2 Data

Our dataset consists of fixed reserve price contracts included in the database managed by the Italian Observatory for Public Contracts. The observatory records publicly procured contracts in Italy with reserve price above 150 thousand euros. We limit our attention to contracts held in a small area (the Veneto region), between the years 2004 and 2006 and completed by the end of March 2009, and with reserve price up to one million euros. There are two main reasons for the choice of these sample restrictions. First, in the period we consider the law in the Veneto region let procurers freedom in the choice of the auction format.[2] Focusing on this sample then allows us to analyze a homogeneous set of auctions showing wide heterogeneity of formats. Second, earlier studies suggest that the distribution of extra costs and time delays varies markedly across Italian regions, often for reasons that are outside the procurer's control (see DeCarolis and Palumbo, 2010). We choose the Veneto region for previous familiarity with these data. Indeed the observatory asked us to double-check the dataset with hard-copy data stored in regional offices, and in case make corrections; this guarantees that the quality of the dataset is generally good. This is an important issue because national data on public procurement auctions very often contain errors.

The sample is a panel dataset, where the observation unit is the procurer, and for each procurer we observe the auctions it held between 2004 and 2006. Our final dataset is made of 1,093 auctions held by 265 procurers. Procurers are mainly municipalities (58% of the sample), while auctions primarily concern road works (40%) and building mainteinance (29%). In the sample there are four groups of auctions, differing along two dimensions: the selection procedure (first price selection as opposed to average bid selection) and the entry mechanism (free entry to the auction as opposed to limited entry). Therefore we observe auctions with first price selection and free entry (72

[2] After 2006 the law changed to comply with the EU recommendation not to use the average bid format.

observations, 6.59% of the sample), auctions with first price selection and limited entry (518, 47.39%), auctions with average bid selection and free entry (371, 33.94%), and auctions with average bid selection and limited entry (132, 12.08%). In all the auctions with at least five bidders, the average bid format includes a rule according to which bids relatively far from the mean are automatically excluded.[3] Table 1 shows the mean value of some variables in our dataset, jointly as well as separately for the four groups of auctions. The table suggests that auctions with average bid format and (especially) free entry receive more bids on average, and auctions with free entry deal with more complex works (there are higher reserve prices and more work days are expected).[4] This evidence is also confirmed by the panel probit regression analysis reported in Table 2. In the first column the dependent variable is worth one if the auction follows an average bid selection with free entry, and 0 otherwise; in the second column the dependent variable is worth one if the auction follows a first price selection with limited entry, and 0 otherwise. The specification, identical in both columns, includes variables on the project complexity, project type, procurer's type and year; these variables are described in detail in Section 3. We find that auctions with average bid selection and free entry are more likely with more complex projects (the signs on the reserve price and the expected work length are significantly positive at 5%) and when the procurer is a municipality, while auctions with first price selection and limited entry are less likely with more complex jobs. It should be noticed that, in the sample we consider, the reserve price and the expected work length are set prior to the auction format, according to objective third-party estimates of the project's complexity. The statistics in Tables 1 and 2 then suggest that, although being formally free, the choice of the auction format is related to the features of the project and the procurer.

In the analysis we will focus on three main variables: 1) the winning discount, defined as the difference between the price winning the auction and the reserve price, as a ratio to the reserve price; 2) the cost overrun, defined as the difference between the final price at the end of the works and the price winning the auction, divided by the reserve price;[5] 3) the work time delay, defined as the difference between the actual number of work days and the expected number of work days (as reported in the contract), as a ratio to the expected number of work days. By taking ratios rather than levels as dependent variables, in our analysis we study relative changes in prices and work lengths, while we will not be able to say anything regarding absolute (changes in) prices and work lengths. There are two reasons for dealing with ratios. First, this way we circumvent the potential endogeneity between the auction format and the project size (reserve price, expected work length) that seems to exist following our above discussion. Second, ratios take values in a more limited range than levels, and their resulting lower variability may be better captured with our statistical methods.

Table 1 informs that on average contracts are 8.27% costlier and 119.70% longer than expected. However, our data show large variability in these measures, especially on the extra work length. Figure 1 plots the distribution of the three measures in the whole sample (left panels) as well as separately for the four groups of auctions (right panels).[6] Notice from the left panel that

[3] In Italy the automatic exclusion rule works as follows (from DeCarolis, 2009). *Step 1*: disregard the top and bottom 10 percent (or the closest integer) of the bids. *Step 2*: compute the average A1 of the remaining bids. *Step 3*: compute A2, the average difference between A1 and all the bids that are greater than A1. *Step 4*: eliminate all the bids that are equal or larger than (A1+A2). *Step 5*: the winning bidder is the bidder with the highest bid among those not eliminated.

[4] All these differences are significant at the 1% level to one-sample mean comparison tests.

[5] This is the standard definition of cost overrun in the literature. Alternatively one may want to divide the difference by the winning price. Using this variable, our conclusions would not change.

[6] In the figures we ignore discounts and overruns higher than 30%, and delays higher than 400%. In the sample there are 52 observations with discounts above 30% and 30 observations with delays above 400%.

cost overruns and especially work delays vary markedly: they can be either positive or negative[7], although they are more frequently positive (it happens respectively in 909 observations, or 83.17% of the sample, and in 986 observations, or 90.21% of the sample), and they often arise together (there are 817 observations, 74.75% of the sample, with positive cost overruns and positive work delays). All this variability is puzzling since, according to the law, project revisions should be allowed only when some pre-specified events occur outside the contractor's control. For instance, in the case of road works, it is stipulated that the price will be revised if unexpected geological or weather conditions severely weaken productivity. However, in informal discussions several practitioners told us that this rule is subject to manipulation. Since we do not have information on the reasons for price revisions, we treat all the deviations from the expected price as evidence of recontracting. As a robustness check of our results we will repeat our analysis by excluding from the sample the observations with the 20% largest (positive and negative) cost overruns, which are more likely to incorporate project revisions.

It is also illustrative to compare the variability of our target measures in the four groups of auctions. The right panels of Figure 1 show the empirical cumulative distribution function of the winning discount, the cost overrun, and the work delay separately for the four groups of auctions with and without free entry, and with and without average bid format. We find no systematic difference in the distributions over the four groups. We only notice that the winning discount is more highly concentrated around its mean in auctions with free entry, and the cost overrun is more highly concentrated around 0 in auctions with limited entry and average bid format. However, this evidence may depend on the heterogeneity in the four groups, noticeably the reserve price and the number of bidders. Our subsequent analysis will isolate the effect of introducing an average bid procedure, after controlling for other procurer and auction features (in particular the entry mechanism).

The fact that we consider only projects completed by March 2009 creates potential selection problems in our dataset, as we exclude auctions held between 2004 and 2006 relative to works that are not yet completed in March 2009. The mean expected (actual) work length in our sample is 203.56 (340.63) days, which suggests that the period we consider is large enough to contain most contracts. However, it might be possible that we exclude more unfinished contracts for auctions held in 2006, thus creating a bias in the dataset. In other words, we might observe contracts with smaller cost overruns and smaller work delays in 2006 as a result of a selection bias, and interpret them as more virtuous behavior. Table 3 shows the results of some comparison t-tests over our key variables. It turns out that, although the expected work length is indeed significantly smaller in 2006, the cost overrun and the work delay are essentially identical to previous years.

3 Results

Our analysis is based on three panel regressions, where the dependent variables are, respectively, the winning discount, the cost overrun (final discount minus winning discount), and the work delay (actual minus expected work length, divided by expected work length).

Our aim is to study the correlation of these variables with some auction features known before the works begin. The specification includes a dummy variable on the auction format (average bid as opposed to first price), and variables on the project size (the logarithm of the reserve price and

[7] When the final price is lower than the winning price we should more properly talk about cost underruns rather than cost overruns. However, for sake of simplicity in this paper we call (negative) cost overruns the cost underruns.

the expected number of work days), and competition (the number of bidders).[8] Previous works (e.g., Bajari et al., 2008) found these variables to be important in explaining the cost overrun. However, since some of these variables show to vary largely with the mechanism of admission to the auction, we treat them separately for auctions with free entry and for auctions with limited entry. In addition, we include control dummy variables on the project category (with the dummies on water, plant, and road projects as opposed to other projects, mainly buildings) and the auction year (2004 or 2006, as opposed to 2005).

Estimation is performed using a panel regression model with fixed effects. This choice makes estimation robust to potential misspecification of procurer-specific explanatory variables. Our outcome variables may indeed be affected by some procurer's characteristics that we do not model explicitly, such as its size, or its previous experience with similar projects. In addition, statistical tests generally support this model instead of the alternative panel regression model with random effects (Hausman test) and the pooled regression model without procurer dummies (test for individual effects). Our main findings are reported in Table 4; the bottom part of the table displays the results of the two above-mentioned statistical tests. Below we comment on each column of Table 4, taking the convention that coefficients are "significantly different from zero" only if the p-value associated to their t-test is lower than 5%.

Winning discount

For auctions with limited entry, the winning discount is related positively to the number of bids (0.48), and negatively to the average bid format (−4.09) and the reserve price (−1.95). This means that having 100 more bidders increases the winning discount by an amount of 0.49%, following average bid rule rather than first price rule reduces the discount by 4.09%, and having a 1% increase in the reserve price reduces the winning discount by 1.95%.

For auctions with free entry, we find significant effect only for the reserve price (negative, −1.41) and the number of bids (positive, 0.02). Moreover, both effects are smaller than in the corresponding case of auctions with limited entry. This all suggests that it is more difficult to predict the outcome of an auction based on free entry access.

Cost overrun

In this case we obtain fewer significant correlations between the explanatory variables and the cost overrun. In auctions with limited entry, we find a positive effect of the number of bidders (0.01), and a negative effect of the average bid format (−6.56). These two variables showed significant effects, and with the same sign, also in the regression with the winning discount as dependent variable. Importantly, the coefficient on the average bid format informs that following an average bid procedure rather than a first price procedure in auctions with limited entry reduces the cost overrun by 6.56%. This decrease is quite remarkable, as it is nearly as large as the average cost overrun in the sample (8.33%; see Table 1). In contrast, in auctions with free entry, we find significant effect of no variable.

Work delay

It seems that work delays are driven by different reasons than cost overruns. In fact, in auctions with limited entry, we find only a negative effect of the expected number of work days (−0.84), meaning that 100 more work days reduce the work delay by 0.84%. A similar significant effect (−0.91) is found also in auctions with free entry; there is no statistical difference between the two effects. Even though it is significant, this effect is practically small if compared with the

[8] The expected number of work days and the number of admitted bids are divided by 100 to have large enough coefficient estimates.

average work delay in the sample (122.66%; see Table 1). We then argue that work delays occur independently from the auction format (average bid or first price) and the auction access (free or limited entry).

Based on these findings we conclude that i) the winning discount is less predictable under free entry than under limited entry, as it shows lower or null correlation with such auction features as its format (first price or average bid), the project reserve price, and the number of bidders; ii) the auction format and the auction entry mechanism have no bearings on work delays; iii) cost overruns are lower under the average bid format only in auctions with limited entry.

We interpret this latest result as evidence that winner's adverse selection is an important problem in auctions for small size public works. Indeed, some contractors may want to participate not to win the auction but to influence the average bid by submitting bids deliberately far from the expected mean in order to favor a designated winner. Such designated winner is the bidder, in the set of colluding bidders, which gains most from being awarded the contract, that is the bidder with the lowest penalty from choosing not to perform when production costs are too high. In this case the effectiveness of the average bid format to mitigate the adverse selection problem is hampered, especially in auctions with free entry where the number of bids is systematically higher than in auctions with restricted entry. Therefore the lack of a significant effect of the average bid format in free entry auctions may reflect collusion. In the appendix we formalize this argument.

DeCarolis (2009) already finds that cost overruns are reduced by around 6% under the average bid format. It should be noticed, though, that in the environment of DeCarolis (2009) the type of auction is set by law, whereas in our dataset it is chosen by the procurer independently. In principle this freedom of choice may give rise to inconsistent estimates and bias our conclusions, since different characteristics of the procurers and the auctions seem to correlate with the choice of the auction type (see Table 1 and the related discussion in Section 2). Our panel estimation method is at least partially unaffected by this problem, as it is robust to potential inconsistency of the estimates due to omitted procurer-specific explanatory variables. However, as a robustness check, we replicate our analysis in a sub-sample of observations where differences among procurers and auctions are limited. Specifically, we consider only auctions procured by municipalities and with reserve price between 283,000 euros (the median value in the sample) and 1 million euros. This sub-sample includes 296 out of our 1,093 observations. Column (1) of Table 5, which reports the output of the analysis on cost overruns, qualitatively confirms our previous findings; this suggests that our conclusions are not driven by the sample selection in the choice of the auction type.

We conclude this section with two further robustness checks. First, due to our concern on a potential selection problem (see Table 3 and the discussion at the end of Section 2), we repeat the analysis excluding observations from year 2006. Second, we may be concerned that our findings are partly driven by project revisions rather than price renegotiation. One may expect this bias to be stronger among auctions for which the final discount is very large or very small compared to the winning discount. For this purpose, we replicate our analysis after removing the observations with the top 10% and the bottom 10% cost overrun. These two further analyses provide for the regression on cost overruns the estimates shown in Table 5, in column (2) and (3) respectively, and they again confirm our main findings. We conclude that our results are robust to potential sample selection problems and lack of information on project revisions.

4 Conclusions

The average bid auction has been used in many countries to award public works. It is supposed to solve the bad winner selection problem which emerges in a first price auction when the contractor can default on his obligations with low penalty. Indeed, it is well known that at Nash equilibrium, the least reliable bidder wins the contract in the first price auction, while all bidders have the same probability of winning in the average bid auction.

This property, however, is not robust to collusion. Moreover, it should be expected that collusion succeeds with high probability: while one bidder suffices to disrupt the collusive equilibrium in the first price auction, also the defection of several bidders may be ineffective in an average bid auction with many colluding bidders.

After 2006 procurement law in Italy, like in other EU countries, prescribes the use of the first price format for procuring public works. Italian practitioners show discontent with this law and would prefer using the average bid format. Their concern about the first price format is that it needs a careful test of bid reliability, which is costly and requires a technical staff that small procurers cannot afford.

Our empirical investigation does not support the practitioners' view, since it suggests that adopting the average bid format alone is not enough; one should also restrict participation in order to benefit from the average bid format.

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5 Appendix. Collusion and bad winner selection

Consider a situation where N bidders take part in a procurement auction. The production cost of performing the job is identical for all the bidders, but it is known not earlier than at the beginning of the job. At the time of bidding, all the bidders know that the production cost is a random variable $c \in [\underline{c}, \bar{c}]$, with density f and cumulative distribution function F. Bidders differ only in their cost of reneging $g_i, i = 1, ..., N$, i.e., the (monetary, reputation, etc.) cost they will face in case they will not complete the job after winning the auction. The procurer does not know g_i, but its cost of non-completion is higher than $\max_i g_i$, which means that completing the job is socially efficient.

A generic bidder i has two options after winning the auction and observing the production cost:

- perform the job, and earn a profit (or loss) $b_i - c$
- renege the job, and incur a loss $-g_i$

Bidder i will perform the job only if $b_i - c > -g_i$, or equivalently if $c < b_i + g_i$. Under these assumptions, bidder i's expected surplus at the time of the auction is

$$S(b_i, g_i) = \int_{\underline{c}}^{b_i+g_i} (b_i - c) f(c)dc + \int_{b_i+g_i}^{\bar{c}} -g_i f(c)dc.$$

It is crucial to realize that $S(b_i, g_i)$ is a decreasing function in g_i for any given b_i, and strictly decreasing if $b_i + g_i < \bar{c}$.[9] This means that, if all the bidders can commit to collude and monetary transfers among bidders are allowed, bidders will let the one with the lowest cost of reneging win

[9] In this case $\frac{\partial S(b_i,g_i)}{\partial g_i} = -g_i f(b_i + g_i) + g_i f(b_i + g_i) - \int_{b_i+g_i}^{\bar{c}} f(c)dc < 0$.

the auction, because he can pay the highest transfer to the others. Then a bad selection of the winner occurs, because the procurer would rather prefer assigning the contract to the bidder with the highest cost of reneging (who is more likely to complete the job). Bad winner selection arises anyway, even if individual costs of reneging g_i are private information. In this case a pre-auction will be held, and the designated winner will be the bidder who can afford offering the largest transfer to the others, that is, again the bidder with the lowest reneging cost.

In the case where only a subset of bidders collude, the bidder with the lowest cost of reneging will not necessarily win the auction. However, a bad selection occurs if bidding rings arise among bidders with relatively low costs of reneging. This is more likely when the procurer cannot restrain participation to the auction and inhibit the entry of potential colluders (that is, when there is open entry). We describe this with an example.

Let $N = 3$, $g_1 = g_2 = g$ and $g_3 > g$, and suppose bids can only take the values p and $q > p$. In a Nash equilibrium without collusion all the bidders have the same probability of winning the auction. Now suppose bidders 1 and 2 collude and bid the same price, while bidder 3 does not collude. If bidder 3 and each member of the cartel bid p, all the bidders have the same probability $\left(\frac{1}{3}\right)$ to win. An identical outcome arises if all the bidders bid q. If instead bidder 3 bids p and the members of the cartel bid q (or vice versa), bidder 3 loses since his bid is farther from the average bid. Then there is a Nash equilibrium where bidder 1 has the same probability of winning as bidder 2, while bidder 3 (the bidder with the highest cost of reneging) has the lowest probability of winning. In this case collusion induces a bad winner selection.

In what follows we derive formally the equilibrium strategies. Let $C(b)$ denote the probability of the cartel playing $b \in \{p, q\}$, and $B(b)$ denote the probability of bidder 3 playing $b \in \{p, q\}$. Then the expected surplus of bidder 3 is $S\left(p, g_3\right) \frac{1}{3} C(p)$ when bidding p, and $S\left(q, g_3\right) \frac{1}{3} C(q)$ when bidding q; the expected surplus of the cartel is $S\left(p, g\right)\left(\frac{2}{3} B(p) + B(q)\right)$ when bidding p, and $S\left(q, g\right)\left(\frac{2}{3} B(q) + B(p)\right)$ when bidding q.

Since in equilibrium it must be indifferent to bid p or q, solving the system of equations

$$\begin{cases} S\left(p, g_3\right) \frac{1}{3} C(p) = S\left(q, g_3\right) \frac{1}{3} C(q) \\ S\left(p, g\right)\left(\frac{2}{3} B(p) + B(q)\right) = S\left(q, g\right)\left(\frac{2}{3} B(q) + B(p)\right) \\ C(p) + C(q) = 1 \\ B(p) + B(q) = 1 \end{cases}$$

yields the equilibrium bidding strategies, that is, the probability of bidding p for the members of the cartel, $C(p)$, and for bidder 3, $B(p)$:

$$\begin{cases} C(p) = \frac{S(q, g_3)}{S(q, g_3) + S(p, g_3)} \\ B(p) = \frac{3S(p, g) - 2S(q, g)}{S(p, g) + S(q, g)} \end{cases} .$$

Some restriction on p and q must hold in order to have $C(b)$ and $B(b)$ well-defined probabilities.

Table 1. Sample means

	Full sample	Average bid		First price	
		Free entry	Limited entry	Free entry	Limited entry
reserve price (k euros)	338.906	411.471	360.977	418.459	270.252
expected n. work days	203.556	221.914	214.992	223.194	184.765
n. bidders	31.269	72.057	17.455	38.000	4.641
winning discount (%)	11.982	11.869	13.605	10.505	11.854
cost overrun (%)	8.328	7.903	5.415	9.017	9.278
work delay (%)	122.662	125.849	83.813	133.393	128.787
n. observations	*1093*	*371*	*132*	*72*	*518*

Note: the reserve price is the price announced by the procurer. The expected number of work days is the number of work days reported in the contract. The winning discount is the difference between the price winning the auction and the reserve price, as a ratio to the reserve price. The cost overrun takes the difference between the final price at the end of the works and the price winning the auction, divided by the price winning the auction. The work delay is the difference between the actual number of work days and the expected number of work days, as a ratio to the expected number of work days.

Table 2. Panel probit regression output

Dependent variable	Average bid, free entry	First price, limited entry
log (reserve price), limited entry	1.110***	-1.685***
	(0.130)	(0.154)
n. expected work days/100, limited entry	0.001**	-0.002***
	(0.001)	(0.001)
auction category: water	0.417	-0.074
	(0.292)	(0.295)
auction category: plant	0.066	-0.064
	(0.263)	(0.236)
auction category: road	0.129	-0.117
	(0.137)	(0.137)
procurer category: health care	-0.092	-0.091
	(0.448)	(0.482)
procurer category: municipality	0.608**	-0.535*
	(0.272)	(0.296)
procurer category: district/region	0.128	-0.024
	(0.488)	(0.558)
procurer category: road	0.264	-0.811
	(0.618)	(0.734)
year: 2004	0.223	-0.557***
	(0.143)	(0.150)
year: 2006	-0.028	-0.045
	(0.141)	(0.139)
constant	-7.768***	10.404***
	(0.814)	(0.934)
n. auctions	1093	1093
n. procurers	265	265
avg. n. auctions per procurer	4.12	4.12

Note: ***: significant at 10%; **: significant at 5%; *: significant at 1%
Standard errors in round parentheses. The dep. variables are dummy variables.

Table 3. Comparison by year

mean			
2006	2004-2005	test	p-value
Expected work length (days)			
190.648	211.366	-2.984	0.003
Cost overrun (%)			
8.502	8.222	0.320	0.749
Work delay (%)			
116.510	126.384	-0.387	0.699

Note: tests are the result of the two-sample comparison t test between the mean in 2006 and the mean in 2004-2005; the alternative hypothesis is that the mean in 2006 is different from the mean in the other years. For a definition of cost overrun and work delay, see the note to Table 1.

Table 4. Panel regression output (fixed effects)

%	Winning discount	Cost overrun	Work delay
average bid auction, limited entry	-4.092***	-6.562***	-45.348
	(1.091)	(1.980)	(66.589)
log (reserve price), limited entry	-1.951***	0.638	14.286
	(0.604)	(1.096)	(36.863)
n. expected work days/100, limited entry	0.005	0.013**	-0.841***
	(0.003)	(0.005)	(0.184)
n. bidders/100, limited entry	0.488***	0.195*	3.474
	(0.059)	(0.107)	(3.610)
average bid auction, free entry	-0.413	-0.940	-17.529
	(1.163)	(2.111)	(70.995)
log(reserve price), free entry	-1.414**	1.204	25.445
	(0.579)	(1.051)	(35.350)
n. expected work days/100, free entry	0.001	0.000	-0.908***
	(0.004)	(0.007)	(0.234)
n. bidders/100, free entry	0.016**	0.006	-0.215
	(0.007)	(0.013)	(0.421)
auction category: water	-0.290	0.848	311.894***
	(1.432)	(2.599)	(87.413)
auction category: plant	2.991***	-0.897	-4.519
	(1.018)	(1.848)	(62.141)
auction category: road	-2.108***	-0.393	4.465
	(0.560)	(1.015)	(34.152)
year: 2004	-2.855***	-3.191***	-10.421
	(0.586)	(1.064)	(35.790)
year: 2006	0.705	-0.703	-34.118
	(0.534)	(0.969)	(32.602)
constant	20.474***	3.308	190.881
	(3.296)	(5.982)	(201.197)
n. auctions	1093	1093	1093
n. procurers	265	265	265
avg. n. auctions per procurer	4.12	4.12	4.12
Fraction of variance due to ind. effects	0.401	0.596	0.374
Hausman test	68.870	10.090	28.480
(random effects Vs. fixed effects panel)	[0.000]	[0.687]	[0.008]
Test individual effects=0	1.610	2.540	1.570
(pooled OLS Vs. fixed effects panel)	[0.000]	[0.000]	[0.088]

Note: ***: significant at 10%; **: significant at 5%; *: significant at 1%

Standard errors in round parentheses. p-values in squared parentheses.

Table 5. Panel regression output (fixed effects); robustness check

Dep. variable: cost overrun (%)	(1)	(2)	(3)
average bid auction, limited entry	-9.518**	-5.143**	-4.267***
	(4.373)	(2.439)	(1.105)
log (reserve price), limited entry	0.827	0.090	0.114
	(2.802)	(1.310)	(0.618)
n. expected work days/100, limited entry	0.025	0.014*	0.012***
	(0.015)	(0.007)	(0.003)
n. bidders/100, limited entry	0.366	0.200	0.188***
	(0.234)	(0.137)	(0.060)
average bid auction, free entry	3.868	-1.554	-1.127
	(4.184)	(2.157)	(1.238)
log(reserve price), free entry	1.830	0.806	1.154*
	(2.757)	(1.258)	(0.597)
n. expected work days/100, free entry	-0.004	0.001	-0.007*
	(0.010)	(0.008)	(0.004)
n. bidders/100, free entry	-0.011	0.021	0.007
	(0.025)	(0.0139)	(0.007)
auction category: water	1.738	1.306	0.359
	(4.150)	(2.981)	(1.467)
auction category: plant	-5.989	-1.818	0.389
	(3.899)	(2.564)	(1.131)
auction category: road	0.165	-1.121	-0.354
	(1.899)	(1.262)	(0.575)
year: 2004	-1.645	-2.814***	-1.494**
	(2.083)	(1.045)	(0.596)
year: 2006	1.039	-	0.094
	(1.919)	-	(0.547)
constant	-2.790	5.796	3.596
	(16.413)	(7.180)	(3.379)
n. auctions	296	681	877
n. procurers	108	215	229
avg. n. auctions per procurer	2.74	3.17	3.83
Fraction of variance due to ind. effects	0.588	0.600	0.492
Hausman test	6.70	2.19	12.010
(random effects Vs. fixed effects panel)	[0.917]	[0.000]	[0.527]
Test individual effects=0	1.77	6.77	1.840
(pooled OLS Vs. fixed effects panel)	[0.000]	[0.872]	[0.000]

Note: ***: significant at 10%; **: significant at 5%; *: significant at 1%

Standard errors in round parentheses. p-values in squared parentheses.

In column (1), we consider only auctions held by municipalities and with reserve price between 283,000 euros and 1 million euros. In column (2), we consider only auctions held between 2004 and 2005. In column (3), we remove the 10% top and 10% bottom cost overruns.

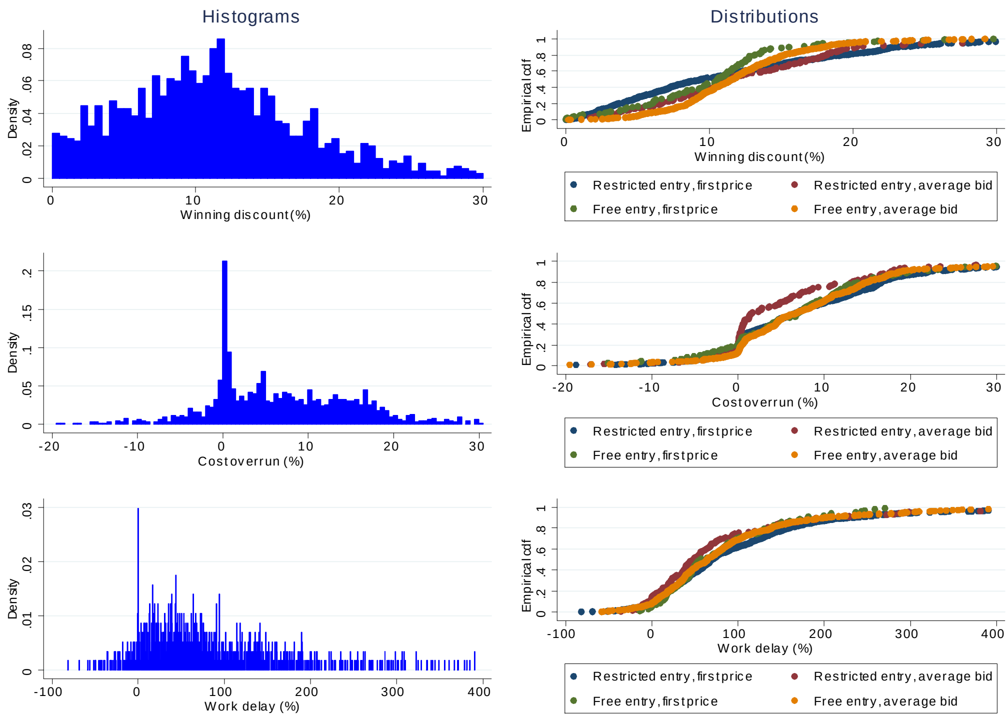

Figure 1: Distribution of the winning discount, the cost overrun and the work delay