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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). In fact, the price winning an auction is just an anticipation of the actual price arising when the work is completed. Cost overruns, i.e., the difference between final and winning costs, 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). This result postulates 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 may lead to a bad selection of the winner.

In this paper we focus on small size projects, where cost overruns are more likely to arise from bad selection problem than from strategic underinvestment on project design. In this context, procurers would like to face small cost overruns for budget reasons. 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 or average bid procedures (auction format), with open or restricted participation (entry rules).

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). However, the effect of different auction formats on cost overruns has received little attention. The paper more related to ours is DeCarolis (2009), that 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. Our goal is to study the effect on cost overruns of the auction format, in combination with the participation policy.

We find that the average bid auction is associated with lower cost overruns than the first price auction when participation is restricted, while this effect is lost when participation 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. Indeed, the average number of bids under this auction format is usually relatively high, which corroborates the idea that some bidders could participate not to win the auction but to help out with piloting the average bid.

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 curb cost overruns is limited and seems not robust to collusion.

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 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.[1] 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 maintenance (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, henceforth FP and AB respectively) and the access mechanism (open access to the auction as opposed to restricted access, namely access by invitation only).

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

Therefore we observe auctions with FP selection and open access (72 observations, 6.59% of the sample), auctions with FP selection and restricted access (518, 47.39%), auctions with AB selection and open access (371, 33.94%), and auctions with AB selection and restricted access (132, 12.08%). In all the auctions with at least five bidders, the AB format includes a rule according to which bids relatively far from the mean are automatically excluded.[2] 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 AB format and (of course) open access receive more bids on average, and auctions with open access deal with more complex works (there are higher reserve prices and more work days are expected).[3] 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 Table 1 then suggest that, although being formally free, the choice of the auction format is related to the features of the project and the procurer.

TABLE 1 ABOUT HERE

In the analysis we will focus primarily on the cost overrun, defined as the difference between the final price at the end of the works and the price winning the auction, as a ratio to the reserve price;[4] in addition, we will consider the winning discount (defined as the difference between the reserve price and the price winning the auction, as a ratio to the reserve price), and the work delay of time (actual number of work days minus expected number of work days, divided by the expected number of work days). Ratios take values in a more limited range than levels, and their resulting lower variability may be better analyzed with our statistical methods.

Table 1 informs that on average contracts are 8.33% costlier and 122.66% longer than expected. However, our data show large dispersion in these variables, especially the extra work length. The left panel of Figure 1 plots the distribution of our measures of interest in the whole sample. Cost overruns and work delays can be either positive or negative[5], 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 panel of Figure 1 shows the empirical cumulative distribution function of the

[2] 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.

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

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

[5] 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 cost overruns also the cost underruns.

winning discount, the work delay and the cost overrun separately for the four groups of auctions with open or restricted access, and with AB or FP 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 all auctions with open access, and the cost overrun is more highly concentrated around 0 in auctions with AB format and restricted access. However, this evidence may depend on the heterogeneity in the four groups of observations, 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 access mechanism).

FIGURE 1 ABOUT HERE

A final caution is noteworthy. 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 2 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. However, in a robustness check of our analysis we will acknowledge for the possibility of having a biased sample by excluding all the auctions held in 2006.

TABLE 2 ABOUT HERE

3 Results

In this section we report the main results from our regression analysis. In most cases the dependent variable is the cost overrun; our aim is to study the correlation of this variable with some auction features known before the works begin. The basic specification includes variables on the auction format (AB or FP), the degree of competition (the logarithm of the number of participants), and the project size (the logarithm of the reserve price, the logarithm of the expected work length in days). Previous works (e.g., Bajari et al., 2008) found these variables to be important in explaining the cost overrun. In addition, the basic specification includes some control dummy variables on the area of the project (mainly drainage, water, plant, road, buildings), and the year of the auction (2004, 2005 or 2006).

Our analysis is based on panel regression models with fixed effects, where standard errors are clustered by procurer. Statistical tests support this model instead of the pooled regression model without procurer dummies (test for procurer effects), but find it less efficient than the alternative panel regression model with random effects (Hausman test). We still prefer the fixed-effect model as it 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 (number of employees), or its previous experience with similar projects.

Our findings are reported in Tables 3-5; the bottom part of each table displays the results of the two above-mentioned statistical tests. When commenting results, we take the convention that coefficients are "significantly different from zero" only if the p-value associated to their t-test is lower than 5%.

Table 3 reports the results of the first exploratory analysis, where as dependent variable we take the percentage winning discount (Column 1), the percentage work delay (Column 2), and the percentage cost overrun (Column 3).

Several explanatory variables significantly correlate with the winning discount: negatively, the AB format and the (log-) reserve price (the coefficients are worth −3.24 and −1.39 respectively) and, positively, the (log-) length and the (log-) bidders (0.99 and 2.14 respectively). For instance, this means that an auction held with an AB format rather than a FP format, on average, reduces the winning discount by 3.24%, while a 1% increase in the number of bidders increases the winning discount by 2.14%.

Still on Table 3, work delays seem influenced solely by the expected work length, negatively so (−375.90). This makes sense: as more time is allowed to conclude the project, it is less likely that the project will incur in some delay. No other variables – in particular on the auction format – seem to affect this outcome.

Finally, when we take the cost overrun as dependent variable, we find that just one explanatory variable is significantly different from zero: the AB format. Its effect is negative, and the size (-4.11) is quite remarkable as it is roughly half the average cost overrun in the sample (8.33% according to Table 1). It then seems that cost overruns are hardly predictable; this is confirmed also by the R^2 statistics, which are dramatically lower when we take this dependent variable (0.04 as opposed to 0.20 for the winning discount). According to the table, it then seems that the practitioners' argument, that AB auctions reduce cost overruns, is correct. However, this evidence ignores that, even in the context of AB auctions, different access policies may bear different implications.

TABLE 3 ABOUT HERE

We then focus our attention only on cost overruns, enriching the specification to also treat the policy of access to the auction (either open or restricted). This is done in Table 4. In Column (1) we distinguish the auctions in four categories: FP with restricted access (the largest group in the sample, that we take as baseline case), FP with open access, AB with open access, and AB with restricted access. While the AB format still shows to reduce cost overrun, it does so only when it is combined with restricted access (−5.56). All the other three auction types give rise, on average, to similar cost overruns. Hence, only an AB auction with restricted access reduces the cost overrun compared to a FP auction with restricted access, and it does so by 5.56%. The size of the effect is slightly larger than what we found in Column 3 of Table 3, where the effect was incorporating also the insignificant contribution of AB auctions with open access.

DeCarolis (2009) also finds that cost overruns are reduced by around 6% under the AB format. It should be noticed, though, that in his environment 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. 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.

In particular, according to Table 1, auctions with different access policy exhibit different degrees of competition and project complexity. For this reason, we consider a regression specification where we treat these variables separately for auctions with open access and for auctions with restricted access. In Column (2) we then include the interactions between the access policy, the degree of competition and the project complexity. We find a significant effect of only two variables interacted with restricted access: AB (-8.07) and the logarithm of the number of bidders (2.72). The same variables have no effect when interacted with open access. Importantly, we confirm the finding that only AB auctions with restricted access reduce cost overruns, significantly by 8.07%.

In the following we consider further regression models as a robustness check. In our environment, the choice of the access policy (open or restricted) may be endogenous. If so, our estimates would be inconsistent. In what follows we then focus on one dimension (the auction format) conditional on the other (the access policy). In other words we treat the access policy as endogenous, and we assume the auction format to be exogenous for a given access policy. [6]

Columns (3)-(5) report the output of a Heckman selection model, estimated with maximum likelihood, where selection is on the access type (restricted rather than open; Column 3) and the outcome equation is based on the subsample of auctions with restricted access (Column 4) or with open access (Column 5). The selection equation includes variables on the type of procurer (municipality, province /region office, road, health) and its experience (logarithm of the number of past auctions), and it excludes information on the number of bidders (clearly dependent on the access type). From Column 3 we learn that restricted access is more likely chosen when the project is small: in fact, we find significantly negative effects of the logarithm of the reserve price (-0.89) and the logarithm of the work length (-0.22). In addition, municipalities are less likely to engage in auctions with restricted access (the coefficient is -0.34).

The equations on the restricted sample, where we now compare FP and AB auctions, show that the AB format reduces the cost overrun (by 6.12%) relative to the FP format, when all auctions have restricted access (Column 4), whereas the auction format does not significantly impact the cost overrun, when all auctions have open access (Column 5). Hence we still confirm our main results, even if the Heckman's lambda coefficient of sample selection is significantly different from zero in Column (4) – and thus suggests that the choice of the access policy is not exogenous.

TABLE 4 ABOUT HERE

We conclude this section with some additional robustness checks, shown in the three columns of Table 5. In all the cases we consider the specification with interactions between restricted access and the degree of competition and the project complexity; the difference among the columns is that regressions are applied on different datasets, all meant to reduce the variability and, this way, sample selection in the data.

In Column (1) we remove observations on auctions held in 2006, due to our concern on a potential selection problem (see Table 2 and the discussion at the end of Section 2); in Column (2) we disregard the lowest 10% and the uppest 10% overruns, as we may be concerned that our findings are partly driven by project revisions rather than price renegotiation. Indeed, 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. Finally, in Column (3) we consider only auctions held by municipality procurers – that, according to the Heckman model, are less likely to choose restricted access – and with a reserve price between 283 thousand euros (the median in the sample) and 1 million euros.

[6] In principle, we should treat both variables as endogenous. In practice, they are highly correlated in our dataset: FP auctions usually have restricted access, while AB auctions usually have open access (see Table 1). This makes it difficult to fully control for endogeneity using standard methods, and in the absence of good instrumental variables.

We consistently find that only AB auctions with restricted access reduce cost overruns, by 5.37% (Column 1), 4.08% (Column 2) or 9.14% (Column 3). addition, we again find evidence that competition positively affects the cost overrun.

TABLE 5 ABOUT HERE

Based on our findings we thus conclude that cost overruns are lower under the average bid format only in auctions with restricted access. We interpret this result as evidence that winner's adverse selection is an important problem in auctions for small size public works. In the Appendix we formalize this argument; here we just provide a sketch of why we believe this is the case. Some contractors may take part in an auction not to win it, but rather to influence the average bid – submitting bids deliberately far from the expected mean – and this way 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 open access 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 open access auctions may reflect collusion. New evidence that the Italian public procurement sector is plagued by firms coordinating their entry and bidding decision is shown in Conley et al. (2011).

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 that 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.

For this reason procurement law in Italy, like in other EU countries, after 2006 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 suggests that both views of practitioners and policy-makers are partly correct, and partly wrong: indeed we find that adopting the average bid format may work, but only in combination with restricted participation. Most of our estimates show, in this case, the cost overrun falls at a rate between 4 and 6 percent.

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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. We assume that the value of the project for the procurer is larger than $\bar{c}$. 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. At the time of bidding g_i is private information of bidder i. The procurer 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, given that he has win 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 $b_i + g_i < \bar{c}$.[7] 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 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).

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 $S(p, g_3)\frac{1}{3}C(p)$ when bidding p, and $S(q, g_3)\frac{1}{3}C(q)$ when bidding q; the expected surplus of the cartel is $S(p, g)\left(\frac{2}{3}B(p) + B(q)\right)$ when bidding p, and $S(q, g)\left(\frac{2}{3}B(q) + B(p)\right)$ when bidding q.

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

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

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

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	
	Access	Open	Restricted	Open	Restricted
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 reserve price and the price winning the auction, as a ratio to the reserve price. 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. 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 reserve price.

Table 2. 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 3. Panel regression output (fixed effects)

Dependent variable (%)	Winning discount	Work delay	Cost overrun
	(1)	(2)	(3)
average bid auction	-3.239***	11.828	-4.111***
	(1.152)	(30.887)	(1.439)
log(n. bidders)	2.139***	14.164	1.039*
	(0.368)	(17.681)	(0.541)
log(reserve price)	-1.392**	49.186	1.171
	(0.568)	(30.800)	(1.055)
log(n. expected work days)	0.986**	-375.904***	1.415
	(0.443)	(139.086)	(0.997)
auction category: drainage	-3.008	-18.685	-4.466
	(2.039)	(53.708)	(3.686)
auction category: water	-4.440**	344.636	-1.121
	(1.970)	(276.636)	(2.781)
auction category: plant	-0.907	42.403	-3.140
	(2.022)	(47.388)	(2.948)
auction category: road	-5.978***	-6.511	-2.445
	(2.149)	(26.213)	(1.688)
auction category: buildings	-4.798***	53.578	-2.342
	(1.712)	(48.257)	(2.084)
year: 2004	-2.455***	-11.178	-2.964**
	(0.555)	(20.789)	(1.146)
year: 2006	1.022	-40.359	-0.531
	(0.835)	(32.520)	(1.223)
constant	15.698***	1,727.382***	-3.039
	(2.779)	(576.787)	(7.114)
n. auctions	1,093	1,093	1,093
n. procurers	265	265	265
Fraction of variance due to ind. effects	0.396	0.341	0.594
R^2 within groups	0.203	0.254	0.035
Chi-squared Hausman test	60.7	19.07	11.21
(random effects Vs. fixed effects panel)	[0.000]	[0.060]	[0.426]
F test procurer effects=0	1.72	1.46	2.55
(pooled OLS Vs. fixed effects panel)	[0.000]	[0.000]	[0.000]

Note: Cluster-robust standard errors in round parentheses. p-values in squared parentheses; *: significant at 10%; **: significant at 5%; ***: significant at 1%.

Table 4. Panel regression output (fixed effects): cost overrun (%)

Dependent variable: cost overrun (%)			Heckman		
	(1)	(2)	(3)	(4)	(5)
FP, open access	-1.397	8.734			
	(2.989)	(17.555)			
FP, restricted access	-3.121	8.994			
	(2.542)	(16.907)			
AB, restricted access	-5.560***	-8.065***			
	(1.395)	(1.698)			
AB				-6.120***	-0.788
				(2.190)	(2.012)
log(n. bidders)	0.880			1.140	0.255
	(0.635)			(0.948)	(0.778)
log(reserve price)	1.293		-0.894***	-7.351***	0.046
	(1.106)		(0.162)	(2.756)	(4.237)
log(n. expected work days)	1.417		-0.220**	2.362*	-1.191
	(0.996)		(0.106)	(1.399)	(1.095)
log(n. bidders), open access		-0.641			
		(0.785)			
log(n. bidders), restricted access		2.721***			
		(0.847)			
log(reserve price), open access		2.280			
		(1.989)			
log(reserve price), restricted access		0.739			
		(1.297)			
log(n. expected work days), open access		-0.504			
		(1.204)			
log(n. expected work days), restricted access		1.942*			
		(1.161)			
auction category: drainage	-4.417	-4.790	0.246	0.448	-8.954*
	(3.717)	(3.760)	(0.255)	(3.422)	(5.302)
auction category: water	-1.377	-0.615	-0.296	-8.970***	-4.116
	(2.800)	(2.770)	(0.241)	(3.367)	(4.894)
auction category: plant	-3.144	-3.039	0.391	-3.897	-2.610
	(2.928)	(2.909)	(0.361)	(3.421)	(5.743)
auction category: road	-2.424	-1.976	-0.141	-5.382**	-4.723
	(1.636)	(1.631)	(0.160)	(2.471)	(3.440)
auction category: buildings	-2.468	-2.401	0.019	-5.172**	-1.023
	(2.036)	(1.958)	(0.161)	(2.134)	(3.086)
year: 2004	-2.964***	-3.139***	-0.271*	-4.809***	-1.239
	(1.141)	(1.153)	(0.154)	(1.637)	(1.935)
year: 2006	-0.550	-0.531	0.121	1.950	-3.143*
	(1.168)	(1.149)	(0.093)	(1.427)	(1.665)

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	(1)	(2)	(3)	(4)	(5)
log(n. auctions held in the past)			0.060		
			(0.105)		
procurer type: municipality			-0.344**		
			(0.166)		
procurer type: province /region office			-0.065		
			(0.331)		
procurer type: road			-0.159		
			(0.344)		
procurer type: health			0.137		
			(0.270)		
constant	-3.378	-5.480	6.484***	33.759**	20.664
	(7.530)	(9.475)	(1.024)	(16.918)	(30.713)
n. auctions	1,093	1,093	1,093	650	443
n. procurers	265	265	265	166	162
Fraction of variance due to ind. effects	0.591	0.598			
R^2 within groups	0.038	0.051			
Chi-squared Hausman test	10.97	12.54			
(random effects Vs. fixed effects panel)	[0.613]	[0.706]			
F test procurer effects=0	2.54	2.54			
(pooled OLS Vs. fixed effects panel)	[0.000]	[0.000]			
Heckman's lambda				13.946***	-2.825***
				(2.267)	(4.646)
Chi-squared test of independent equations				31.66	0.39
				[0.000]	[0.534]

Note: Columns (3)-(5) show the regressions of a Heckman regression model for sample selection. Column (3) reports the selection equation, where the dependent variable is equal to 1 if the auction follows a restricted access policy, and 0 otherwise; Columns (4) and (5) report the outcome equations conditional on having restricted access and open access, respectively. Also see note to Table 3.

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

Dependent variable: cost overrun (%)	(1)	(2)	(3)
FP, open access	1.543	15.512	-2.793
	(20.876)	(11.861)	(49.312)
FP, restricted access	0.880	14.543	3.200
	(19.466)	(11.682)	(49.565)
AB, restricted access	-5.366***	-4.081***	-9.142**
	(1.409)	(1.054)	(4.489)
log(n. bidders), open access	-0.230	0.076	-1.530
	(0.878)	(0.546)	(1.473)
log(n. bidders), restricted access	1.894**	1.522**	3.120*
	(0.917)	(0.618)	(1.792)
log(reserve price), open access	2.490	1.312	3.639
	(2.744)	(1.458)	(4.883)
log(reserve price), restricted access	0.226	0.474	-1.588
	(1.419)	(0.992)	(3.522)
log(n. expected work days), open access	-0.662	-1.845**	-0.253
	(1.871)	(0.928)	(0.885)
log(n. expected work days), restricted access	1.322	1.410*	4.168*
	(1.699)	(0.767)	(2.468)
auction category: drainage	1.485	-0.210	9.587
	(4.478)	(1.941)	(11.210)
auction category: water	0.635	1.273	1.111
	(3.949)	(2.181)	(3.393)
auction category: plant	-3.121	0.801	-5.804
	(5.192)	(1.484)	(10.560)
auction category: road	-2.194	0.228	-0.094
	(1.866)	(1.088)	(1.633)
auction category: buildings	-2.516	0.904	-1.363
	(2.245)	(1.335)	(3.090)
year: 2004	-2.987***	-1.571***	-1.552
	(1.108)	(0.576)	(1.444)
year: 2006		0.056	1.241
		(0.693)	(1.912)
constant	0.591	-5.041	-6.927
	(11.362)	(6.121)	(28.614)
n. auctions	681	877	296
n. procurers	215	229	108
Fraction of variance due to ind. effects	0.600	0.493	0.593
R^2 within groups	0.056	0.075	0.108
Chi-squared Hausman test	9.50	14.26	11.16
(random effects Vs. fixed effects panel)	[0.850]	[0.580]	[0.799]
F test procurer effects=0	2.17	1.79	1.72
(pooled OLS Vs. fixed effects panel)	[0.000]	[0.000]	[0.001]

Note: In Column (1), we take auctions held between 2004 and 2005. In Column (2), we remove the 10% top and 10% bottom cost overruns. In Column (3), we take auctions held by municipalities and with reserve price above 283,000 euros. Also see note to Table 3.

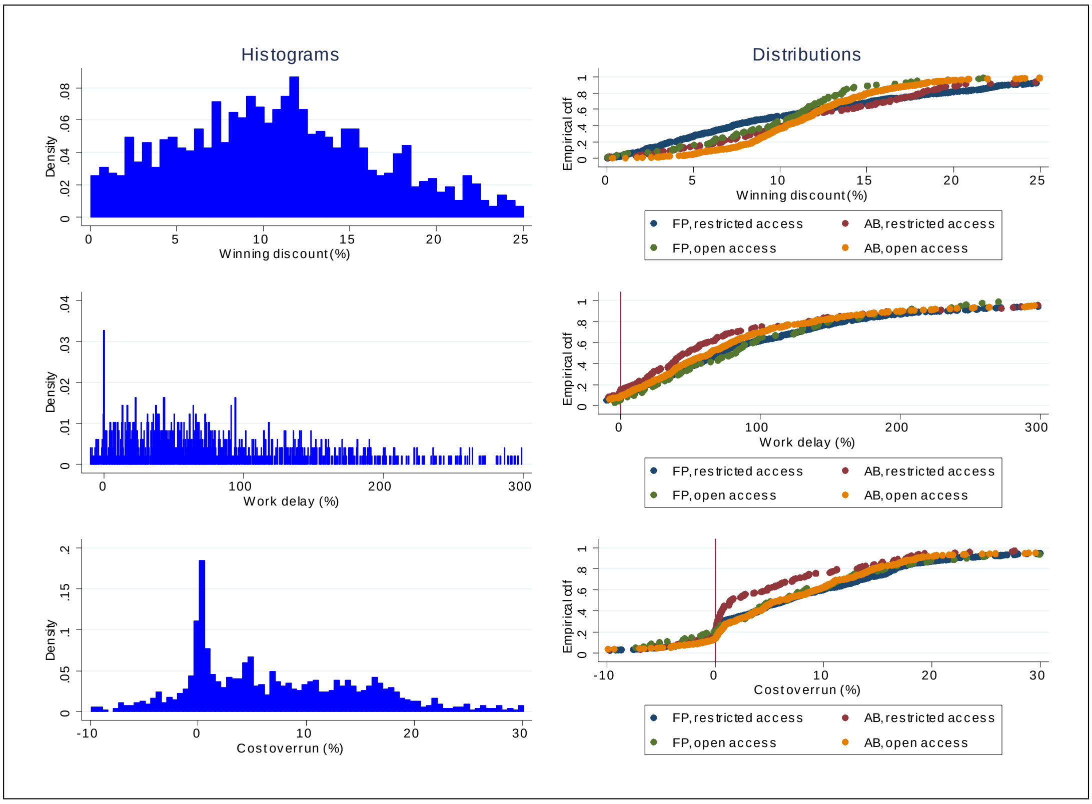

Figure 1. Distribution of the outcome variables