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### *Does Publicity Affect Competition? Evidence from Discontinuities in Public Procurement Auctions*

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# *Does Publicity Affect Competition? Evidence from Discontinuities in Public Procurement Auctions*

Decio Coviello<sup>♥</sup> and Mario Mariniello<sup>♠</sup>

### Abstract

Calls for tenders are the natural devices to inform bidders, thus to enlarge the pool of potential participants. We exploit discontinuities generated by the Italian Law on tender's publicity to identify the effect of enlarging the pool of potential participants on competition in public procurement auctions. We show that most of the effects of publicity are at regional and European level. Increasing tenders' publicity from local to regional determines an increase in the number of bidders by 50% and an extra reduction of 5% in the price paid by the contracting authority; increasing publicity from national to European has no effect on the number of bidders but it determines an extra reduction of 10% in the price paid by the contracting authority. No effect is observed when publicity is increased from regional to national. Finally, we relate measures of competition to ex-post duration of the works finding a negative correlation between duration and the number of bidders or the winning rebate.

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# 1 Introduction

Public procurement contracts in Member States amount to a huge slice of the European Union's GDP: 16 % in 2002. Only 16.2 % of the Union's public procurement is published in the European Official Journal, though.<sup>1</sup> Member States and the European Commission are pushing to increase the use of advertising policies by the contracting authorities considering it as the natural device to improve the performance of public procurement markets. For instance, Directive 2004/18/CE stresses the importance of an extensive use of advertising in order to foster the participation of European firms in tenders taking place within the European Market. Surprisingly, however, no consensus in the theoretical and empirical literature exists on the effects of increasing the pool of potential participants on the outcome of public procurement auctions.

In this paper we use regression discontinuity methods (Angrist and Lavy, 1999; Hahn, Todd and van der Klaauw, 2001) to test for the effects of enlarging the pool of potential participants (i.e. of advertising a tender) on the level and nature of competition in public procurement auctions in Italy. Furthermore, we report evidence of the benefits of competition for the ex-post duration of the works.

Assessing the benefits of publicity in public procurement auctions requires going through the following steps: first, one should ask whether, and to what extent, advertising influences competition; second, one should ask how competition, as it is influenced by advertising policy, affects the price paid by the auctioneer to the winning bidder, i.e. it determines the auctioneer's rent. As for the first point, notice that a firm can join an auction only if the firm

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<sup>1</sup>European Commission, 2004.

knows that the auction exists. Since participating in an auction requires sustaining some fixed cost, however, a firm might decide not to participate if it thinks that competition will be too harsh.<sup>2</sup> As for the second point, it is well accepted that an increase in the number of participants increases the auctioneer's rent: firms are pushed to bid more aggressively if the number of bids is increased.<sup>3</sup> Beyond that, advertising can affect participants' characteristics, by stimulating entry of outsiders (i.e. those firms which are located outside the region where the auction is taking place). Outsiders might decrease the likelihood of collusion, since local firms find it more difficult to coordinate, having fewer contacts with competitors.<sup>4</sup> Outsiders can even have a different cost structure: firms located far from the auctioneer participate only if their costs to operate at distance are very low. On the other hand, wide publicity may discourage entry of local firms since, *ceteris paribus*, the incentive to participate is lower when more firms are applying. Local firms may have a deeper knowledge of the procedure implemented and of the work's features and they can exploit scale economies by dealing with the same authority more than once. It turns out that if local firms are driven out of the market, there can be an efficiency loss. It is not clear, then, what is the magnitude

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<sup>2</sup>Indeed, suppose you are an entrepreneur and that yours is one of the few companies which know that the tender is taking place. When deciding whether to participate or not in the auction, you will take into account that the number of competitors that you will face is small and that the likelihood of submitting a winning bid is high. As a result, your incentives to join the auction are likely to be very high. Now, suppose that one day you open your favorite national newspaper and realize that another contracting authority is advertising a similar tender. If the agency did not advertise the tender, surely you would not have participated: you actually would not have any clue that tender was taking place. However, your incentives to participate are now smaller: since the tender is advertised on a national newspaper, you expect competition to be harsh. You might then decide not to participate because your expected profits (which are a function of the probability of submitting a winning bid) are not enough to offset your participation costs. In other words, increasing the number of potential participants has an ambiguous effect on auction's outcome.

<sup>3</sup>See, for example, Brannman et al. (1987) and Klemperer (2002).

<sup>4</sup>See Compte et al. (2005).

of the effect on auctioneers' rent which is associated to publicity and its selective effect rather than to its direct effect, on the number of participants. Figure (1) offers a graphical representation of these simple concepts.

To analyze this issue, we introduce a simple model of first price sealed bid auctions with participation costs where the number of bidders is endogenously determined. Under certain assumptions (namely: that publicity reduces firms' searching costs), we show that the optimal level of publicity can be below its maximum possible level, independently of its cost. It turns out that a rule forcing contracting authorities to a certain publicity level may reduce the revenues of the auctioneer and thus reduce welfare, in a context of public procurement auctions. Next, we empirically test the effect of publicity on competition exploiting the discontinuities generated by the Italian law on public procurement which imposes different levels of publicity according to the auction's starting value. Italian law prescribes that every public procurement auction should be advertised at 1 of the 4 different available publicity levels (Local, Regional, National, European) on the basis of their starting value.<sup>5</sup> Our empirical analysis is based on a unique administrative data set from the Italian Authority for Surveillance of Public Procurement (*"Autorita' per La Vigilanza sui Lavori Pubblici"*, AVLP). The Authority collects data on the universe of Italian public procurement auctions, for tenders starting value greater or equal to € 150,000 (we had access to the data referring to the period 2000-2005). A Regression Discontinuity Design (RDD), a quasi-experimental setting, can then be used to compare the outcomes of auctions with starting value immediately above or below each discontinuity threshold. Auctions above and below the thresholds

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<sup>5</sup>In particular see Law n. 109 del 11 February 1994, so called "Legge Merloni"; *"Legge quadro in materia di lavori pubblici"*

have different publicity levels, but should otherwise be identical in terms of observable and unobservable characteristics determining the outcome of interest, which in our case are: the number of bidders and the winning rebate. Using this source of identification of the causal effect we show that increasing tenders' publicity from local to regional determines an average increase of 19 percentage points in the number of bidders with respect to a sample average of 38, and an average increase in the winning rebate of 4.9 percentage points with respect to a sample average of 16 %. A back of the envelope calculation suggests that if all the auctions that by law are published at local level were published at regional level then average revenues would have been increased by € 25,000 for tenders with average starting value of € 516,000, provided that the average cost of publishing at regional level is € 1,000. In contrast to the regional effect, we observe no effect on the number of bidders and the winning rebate when publicity is increased from regional to national level.<sup>6</sup> Interestingly, on the other hand, we observe that an increase in publicity from national to European level has no effect on the number of bidders but it determines an increase in the winning rebate of 10 percentage points. This suggests that selection of the bidders via advertisement plays a major role when the auction has an European relevance.

Further, we analyze the relationship between competition in auctions and the time to accomplish the works after the auction has taken place. It might be, indeed, that a substantial increase in the number of participants encourages firms to over-bid inducing a non sustainable commitment for the winner.<sup>7</sup> Using duration analysis models, we report evidence of a negative and statistically significant correlation between the time it takes for the win-

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<sup>6</sup>As Table (5) shows, the effect on the number of bidders would be negative, if any, at a 10% significance level

<sup>7</sup>This is the well known winner's curse phenomenon

ner to accomplish the tendered works and the number of participants or the winning rebate.

The rest of the paper is organized as follows. In section (2) we describe the related literature, in Section (3) we introduce the theoretical model, Section (4) describes the institutional framework; Section (5) reports the empirical analysis. Conclusions and policy implications are discussed in Section (7).

## 2 Related Literature

The literature looking at what fosters competition in public procurement auctions is large. In this paper we mainly draw from the theoretical contributions of Levin and Smith (1994) and Menezes and Monteiro (1996, 2000) and we consider the link between publicity and competition in a stylized model of endogenous entry to auctions where entry is costly and advertising tenders decreases firms' search costs. Both Levin and Smith (1994) and Menezes and Monteiro (1996, 2000) consider a mechanism by which firms decide whether or not to participate in an auction. They differ, though, in the timing dimension of their models: in Levin and Smith (1994) firms incur a fixed cost of entry before seeing their values for the object while in Menezes and Monteiro (1996, 2000) firms learn their values prior to incurring bid preparation costs. Their conclusions are thus different: Levin and Smith (1994) suggest that the seller should not limit entry through a restriction policy (e.g. an entry fee) while Menezes and Monteiro (1996, 2000) find that entry fees may be optimal for the seller since they help to screen low valuation bidders when increased competition reduces the seller's expected revenue. Our model follows the one used by Menezes and Monteiro (1996, 2000) and integrates it with the possibility for the seller to advertise the tender.

From an empirical point of view, the effect of advertising tenders on com-

petition has never been directly tested. Bajari and Hortacsu (2003) use a structural analysis to test the model of Levin and Smith (1994) with a dataset of E-Bay coin auctions. They find that the expectation of one additional bidder decreases bids by 3.2% in a representative auction. In addition, they find that the value of the object is among the main determinants of entry. They do not consider advertising, though. Lundberg (2005) investigates the choice of procurement procedure in public auctions in Sweden where the contracting entity may choose one among several available mechanisms which are linked with different restrictions on entry. Indeed, since publicity is a tool used to favor entry, the choice of advertising an auction may be seen as the choice of relaxing entry restrictions. Lundberg's (descriptive) results do not show any significant impact from contract specifications and municipality characteristics on the probability that the contracting authority does not restrict entry. Finally Leslie and Zoido (2007) study how markets can provide private incentives to increase the provision of information in public procurement auctions. They find evidence that the introduction of an 'information entrepreneur', i.e. an entrepreneur who collects and sells announcements about forthcoming auctions, causes a 2.9 % decrease in the cost for drug procurement in public hospitals in Buenos Aires, Argentina.

Our paper aims at supplementing this literature with empirical results based on (quasi-) experimental evidence.

### **3 Theoretical Framework**

In this section we introduce a theoretical framework for the question tested by our empirical analysis. The model described below is a tool which allows to grasp the economic phenomenon underlying the issue tackled by this paper i.e. the effect of an increase in tender's advertisement level. The empirical

analysis, though, is not supposed to test the predictions of the model. Indeed, as described in the following section, the auctions included in our database show some similarities with the traditional first price auction model but cannot be properly considered as such, since they implement a complex model of selection of the bids. While a specific model capable to capture this complexity would go beyond the scope of this paper, the model described below lets us achieve a main result, reported in proposition 1, which we believe to hold also in the context of the data used in the empirical analysis.

Following Menezes and Monteiro (2000) - henceforth (MM) - we model a public procurement auction as a first price sealed bid auction where the number of bidders is endogenous. A single contract is put out to tender. The auctioneer is assumed to have zero reserve price. Firms bid a rebate  $b$  on the auction's starting amount for which they would be willing to do the works. Bidder  $i$  knows her own value  $v_i$  of the contract and the distribution  $F(v_i), \forall i \neq j$  of other  $n$  bidders' values.  $F(\cdot)$  is continuous with support  $[0, \bar{v}]$ . Participating to the auction requires sustaining a fixed cost  $c$  plus some searching cost  $\delta$  which for the moment are assumed to be 0.<sup>8</sup> Each bidder decides whether to submit a bid before knowing how many competitors will participate in the auction. Assuming that everyone else except  $i$  use the same strategy  $b$ , we have that  $i$ 's expected profits are:

$$\pi_i(v_i, b_i, b) = (v_i - b_i)(F(\max\{b^{-1}(b_i), v_\rho\}))^{n-1} - c$$

where  $v_\rho$  solves  $v_\rho F(v_\rho)^{n-1} - c$  and it is such that  $\pi_i(v_\rho, b^*) = 0$  i.e.  $v_\rho$  is the cut-off value when all bidders use the same equilibrium strategy  $b^*$ .<sup>9</sup> The optimal bidding strategy which maximizes  $i$ 's expected profits is then given

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<sup>8</sup>You may well think about  $c$  as the cost of preparing a project and submit a bid, while  $\delta$  is the cost of looking around for existing tenders.

<sup>9</sup>(MM) show that such strategy exists. Notice that for any  $c < 1$ ,  $v'_\rho(n) < 0$ .

by:

$$b^*(v) = \begin{cases} \frac{\int_{v_\rho}^v (n-1)x F(x)^{n-2} f(x) dx}{F(v)^{n-1}}, & v \geq v_\rho \\ 0, & v < v_\rho \end{cases} \quad (1)$$

Equation (1) is crucial. It tells us that increasing the number of potential participants has two opposite effects on the optimal bidding strategy. On the one hand, since the cut-off value  $v_\rho$  value is increasing in  $n$  (provided that  $c < 1$ ), it decreases the probability that a player  $i$  participates to the auction (since that happens only if  $v_i > v_\rho$ ). On the other hand, it increases the equilibrium bid, since participating players take into account that, in equilibrium, other bidders participate only if their value is greater than  $v_\rho$ .

The expected revenue generated by the auction is then given by the highest bid among those submitted:

$$R = \int_{v_\rho}^{\bar{v}} b^*(x) n F^{n-1}(x) f(x) dx$$

MM then show that the revenue generated by a first price sealed bid auction is equivalent to that generated by a second price sealed bid auction when the number of potential players is fixed and participation is endogenous. It turns out that  $R$  can be rewritten as follows:

$$R = n(n-1) \int_{v_\rho}^{\bar{v}} (1 - F(x)) x (F(x))^{n-2} f(x) dx$$

Now suppose that the auctioneer is able to control the number of participants in order to maximize her revenue. MM uses a variable  $\delta \in (-c, 1 - c)$  which represents an entry fee (if positive) or a subsidy (if negative). In our context,  $\delta$  represents firms' searching cost, which are assumed to be decreasing in the level of publicity. Let us introduce a new continuous variable  $p \in [0, \delta]$  which is directly correlated with the auctioneer's advertising effort. Let us assume that a marginal increase in  $p$  is translated in an equivalent reduction in  $\delta$  at a cost  $\frac{p^2}{2} \lambda z$ , where  $z$  is the advertising cost (e.g. the cost of publishing

the tender on a national newspaper) and  $\lambda$  is the shadow cost of public expenditure.

Thus, total revenue can be maximized by:

$$\varphi(\hat{\delta}) = \max_p \left( n(n-1) \int_{v_\rho(\delta-p)}^{\bar{v}} (1-F(x))x(F(x))^{n-2}f(x)dx - \frac{p^2}{2}\lambda z \right)$$

which yields:

$$\begin{aligned} \varphi'(\delta - p^*) &= -n(n-1)(1-F(v_\rho(\delta - p^*)))v_\rho(\delta - p^*) \cdot \\ &\cdot (F(v_\rho(\delta - p^*)))^{n-2}f(v_\rho(\delta - p^*))v'_\rho(\delta - p^*) - p^*\lambda z = 0 \end{aligned} \quad (2)$$

which implicitly defines the optimal level of publicity  $p^*$ .

Equation (2) has a simple and powerful implication: the optimal level of publicity may be lower than its maximum possible level even if its cost is zero i.e.  $z = 0 \not\Rightarrow p^* = \delta$ . In other words, it might be optimal for the auctioneer not to increase the number of potential bidders in order to increase its revenue, even if it did not spend anything to do so. The intuition comes directly from equation (1). Indeed, to show that this is the case, it is sufficient to find at least one case in which the optimal level of  $\delta$  is positive notwithstanding  $z = 0$ . The following example illustrates this possibility.<sup>10</sup>

**Example 1** *Assume that the  $n$  players are represented by random draws from the distribution  $F(x) = x^4$  and  $p = z = 0$ . Expected revenue is then:*

$$R = 4n(n-1) \left( \frac{1-c-\delta}{4n-3} - \frac{1-(c+\delta)^{\frac{4n-1}{4n+3}}}{4n+1} \right)$$

*Assume further that  $n = 20$  and  $c = 0.1$ . It turns out that the level of  $\delta$  which maximizes  $R$  is positive and it is  $\delta = 0.031$ .*

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<sup>10</sup>Example 1 is similar to example 4 of MM.

We can then state the following proposition:

**Proposition 1** *Independently of its cost, the optimal level of publicity can be below its maximum possible level.*

**Proof.** It follows directly from example 1. ■

From a policy point of view Proposition (1) suggests that a rule prescribing a unique level of publicity, given the starting value of the auction can be sub-optimal.<sup>11</sup> In this paper we show that this can be the case once we have considered tenders' publicity at national level. Indeed, the empirical analysis reported in section (5) shows that increasing publicity from regional to national level has no effect on the winning rebate and no or negative effect on the number of bidders.

We now proceed illustrating the data and the institutional framework.

## 4 Data and Institutional Framework

We base our empirical analysis on a unique administrative data set from the Italian Authority for Surveillance of Public Procurement ( "*Autorità per la Vigilanza sui Lavori Pubblici*", *AVLP*), which collects data on the universe of public procurement auctions in Italy for public works with starting value greater or equal to 150,000 euros. For our analysis we refer to the data collected between 2000 and 2005. The database includes information at auction level on the contracting authority (i.e. the auctioneer which is also the buyer), the advertisement level, on the typology of the works which are put out to tender, on bidding behavior and on the identity of the winning firms

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<sup>11</sup>Notice that there might be other reasons why a uniform level of publicity could be desirable, though. The most obvious one is that a case by case analysis for deciding which is the optimal level of publicity would be very expensive and likely unfeasible.

(i.e. the seller). Tables (1) and (2) report the descriptive statistics relative to the sample. Our database amounts to 41510 auctions with direct participation of firms ('Pubblico Incanto' in the terminology used by the law). The contracting authorities are mainly municipalities (52% of the sample). The rest of the sample is made up of tenders invited by provinces (12%), health-care public bodies (ASL) and other public bodies or corporations.<sup>12</sup> The contracting authorities in the sample are mainly located in the North of Italy, (45%), while 25 % are in the Center and 22 % are in the South of Italy. Similar figures are reported in Table (2) once we consider the descriptive statistics for the main typologies of auctions. Some differences in the descriptive statistics of the typology "Road and Constructions" can be observed, although no difference exist in the general provision of the law for the different typologies analyzed.

The contracting authority must define all the details concerning the works that have to be carried on by the winning firm, including the starting price that the auctioneer would pay to the winner if only one firm participates to the auction. On average, the auctions' starting value in the sample amounts to 720 thousands of euros, though the standard deviation is rather high. Indeed, the median starting value is 360 thousands of euros. Notice, moreover, that most of the auctions are done to contract out road's constructions (30.6% of the total) which include maintenance, reconstruction and whatever is necessary to guarantee truckage, by rail and air transport. The contracting authority must define the requirements which have to be satisfied by bidders as well. Bidders have to be certified that they are able to carry on the works of that particular size and in that particular sector i.e. they need to be audited by an attestor society (*SOA, società organismo di attestazione*) and be

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<sup>12</sup>We do not report those figures (they are available on request).

registered for the required category in a specific book. So, for example, if the construction of a road is put out to tender and the contracting authority estimates that the amount of qualified work that has to be done is valued 700,000 euros, the required SOA category will likely be: 3-OG3, where 3 refers to the size of the works and OG3 to the category “road constructions”. The size requirements are mainly based on firms’ turnover.<sup>13</sup> Table (1) reports that 13% of the auctions require the category Buildings e.g. OG1, while 29% of the auctions a SOA category, e.g. size of the works of 3.

All the auctions considered in the following analysis are structured as first-price sealed-bid auctions: firms bid the price for which they are willing to do the works in the form of a percentage reduction - rebate - with respect to the auction’s starting value. In all the considered auctions the selection criterion for the winner is uniquely based on the rebate i.e. the technical component of firms’ offer plays no role (provided that the winner will satisfy some minimum quality standards which are set by the contracting authority). Notice, however, that because of the institutional mechanism prescribed by the law, the winning rebate is not necessarily the highest bidden: in order to prevent firms from over-bidding (i.e. bidding a price which does not allow to recoup works’ expenses) a complex (and criticizable) mechanism is implemented. According to this rule, all bids which exceed the average bid by more than the average deviation from the average are automatically excluded.<sup>14</sup> It turns

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<sup>13</sup>Notice that the required SOA category is not a direct function of the auction’s starting value. Indeed, the works to be done are usually a complex combination of several expertises and hence the required SOA categories may be more than once. For our analysis we consider just the primary required SOA category. Moreover, by a careful study of the Law 109/94 we exclude that both requirements change discontinuously at the publicity thresholds.

<sup>14</sup>Bidders thus have to guess which will be these ‘anomaly thresholds’, as they are called, and try to place a bid within them. As for illustration, consider this simple example. In a hypothetical auction there are three participants placing the following bids (rebates to the auction’s starting value): 5, 6 and 19. The average bid is thus 10. The average difference

out that the auctions included in our database are not proper first price auctions.

The first five rows of Table (1) report descriptive statistics of auctions' outcomes. In the sample, it is observed that the average number of firms participating to the auction is 32 (standard deviation is 35), and a median of 21. The winning rebate is on average 16% (standard deviation is 8.9), which is very close to the median value (15%). To further characterize the nature of competition within auctions we consider three main indicators: the probability of a winner coming from outside the region where the auction is held, the legal nature of the winner, and the indication of whether the winner is a member of a group of related firms. In the sample the probability that the winner is coming from outside the region is 37 % while only 6.5% of the winners are public companies and 18% of the winners are member of a group of firms.

Concerning tenders' advertisement, until July 2006, auctions were classified by the law according to their starting value.<sup>15</sup> Table (3) illustrates that rule: the first column reports  $y$ , the auction's starting value (in hundreds of thousands euro), the second column reports the level of publicity required by the law, the third and the fourth columns reports the correspondent cost of advertising and the percentage of non-compliance to the prescribed rule, respectively.

According to Table (3), auctions with starting value below 500 thousands of

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from the average bid is 6. Thus the bottom and the upper anomaly thresholds are 4 and 16 respectively. It turns out that in this case the winning bid is 6 even if 19 is the highest bidden rebate. Albano et al. (2006b) provide a summary of the properties of several winning methods in public procurement auctions.

<sup>15</sup>From July 2006, Law 163/2006 removes the thresholds and forces the contracting authorities to publish on GURI at a national newspaper level, regardless of the auction's starting value (if it is greater than 150,000 euros). By focusing on data before 2006, this paper provides insights to assess that reform.

euros have to be published on the contracting authority's notice board. This is the least amount of possible publicity, since only firms which have direct access to the auctioneer's premises or have direct contact with its staff may get information on the tender. The cost of publishing on the notice board is zero. Not surprisingly, the degree of compliance is very high: 94% of the auctions observe the prescribed rule. The second interval goes from 500 thousands to one million and it identifies those auctions for which the compulsory level of publicity is regional i.e. those tenders that must be advertised in at least two newspapers spread all over the province where the works should be made and in the official regional journal (*Bollettino Ufficiale Regionale, BUR*). Publishing on BUR is very cheap: an average tender should not cost more than 200-500 euros. Provincial newspapers are cheap as well, since advertisement's price is proportional to the number of printed copies. However, the degree of compliance is rather low: only 71% of the auctions satisfy the publicity requirements. The third level of publicity is national and concerns those tenders with starting values above one million of euros and below the community threshold (five million of SDR, *special drawing rights*<sup>16</sup>). These tenders must be published on two national and two regional newspapers and on the national official journal (*Gazzetta Ufficiale della Repubblica Italiana, GURI*). The average cost for publishing on a national newspaper is about 800 euros (somewhat less for a regional newspaper). GURI, though, is very expensive: publishing a tender's abstract may cost around 7-8 thousands of euros. The degree of compliance is here as well rather low: 78%. Finally, the maximum amount of publicity is enforced when tenders' starting value is above the community threshold. In that case the contracting authority must also advertise on the Official Journal of the European Community (*Gazzetta*

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<sup>16</sup>At the time of writing, 5,000,000 SDR were equivalent to 6,550,000 euros.

*Ufficiale Comunità Europea, GUCE*) in addition to the obligations defined for the tenders belonging to the previous group. Notice, however, that publishing on GUCE is free of charge, so no additional cost is sustained by the contracting authorities. The degree of compliance is consistently rather high: 90%.

A major concern on the assignment of public tenders to publicity levels is the possibility for authorities of splitting the starting value of the auction in order to avoid the publication. Art. 24 of Law 109/1994 prescribes that a public authority must not split or vary a particular procurement need in order to circumvent the monetary threshold requirements. In Sections (5.2) and (7) we provide statistical evidence of no systematic sorting around the thresholds.

Summarizing, in our sample: 92% of the tenders were published on the contracting authority's notice board, 25% on the Regional BUR and about 18% on the GURI. On the other hand, the average number of newspapers on which the advertisement of the tender appeared is: 0.24 for provincial newspapers, 0.42 for regional newspapers and 0.61 for national newspapers. From a more general perspective we can conclude that the sample show a sufficiently large variation in the data leaving the possibility for the econometric analysis which is illustrated in the following Section.

## **5 The Empirical Analysis**

### **5.1 Identification strategy**

Contracting authorities which maximize the auctioneer's revenue implement different advertisement strategies with respect to contracting authorities which pursue other aims, such as maximize political rents through collusion with

local firms. Authorities' unobservable incentives determine a non random assignment to publicity levels which causes endogeneity problem; we thus expect Ordinary Least Squares (OLS) estimates of the effects of publicity on competition to be a wrong estimate of the true causal effect of publicity on competition, no matter how big the sample it is. To disentangle the causality relationship between publicity and auction's outcome discussed in Figure (1), we implement a more refined technique: the Regression Discontinuity Design (RDD). In Section (4) we saw that a higher level of publicity (the *treatment*) is assigned to auctions if an observed covariate, the starting value of the auction, crosses a known threshold. We are aware that using exogenous thresholds which are identified by the law is not equivalent to a controlled experiment because individuals' assignment might be not completely random. Lee (2007), however, shows that in these cases the RDD can nevertheless identify impact estimates that share the same validity as those resulting from a randomized experiment.

In this Section we discuss the assumptions required to implement the RDD. We define  $y_j$  as the  $j$ -th threshold in the auctions' starting value which determines a discontinuity point in the support of the publicity function, as established by the law. The  $j$ -th discontinuity point separates the  $j$  and  $j + 1$  levels in publicity assignment imposed to contractors. We call these levels "publicity brackets". We aim at identifying the causal effect of publicity on auctions' outcomes by focusing on auctions in the neighborhood of those discontinuity points. Let  $Y$  be the auction's real starting value (the so called running variable), and  $Z$  be the level of theoretical publicity that the contractor should implement under perfect compliance to the assignment rule. We denote by  $P$  the level of publicity actually observed in the auction.  $P$  may differ from its theoretical level if the contracting authority does not

comply with the law assignment: indeed, it is very unlikely that a contracting authority would be punished from AVLP if  $P$  differs from  $Z$ .<sup>17</sup> Finally let  $C$  represent the outcome of auctions. In the analysis we alternatively consider  $C$  to be the number of bidders or the winning rebate. Let  $C_l$  and  $C_h$  being the values of  $C$  respectively below and above the generic discontinuity point  $j$ . To identify the causal effect of publicity on competition we need the following continuity assumptions:

$$E\{C_l|Y = y_j^+\} = E\{C_l|Y = y_j^-\} \quad (3)$$

$$E\{P_l|Y = y_j^+\} = E\{P_l|Y = y_j^-\} \quad (4)$$

where  $y_j^+$  and  $y_j^-$  represent the left and the right limits of the starting value of the auction. As in Hahn et al. (2001) and Garibaldi et al. (2007), under the continuity conditions, for an auction in a neighborhood of the cut-off point the mean effect of being assigned to a higher theoretical publicity bracket  $Z = h$  (instead of the lower one  $Z = l$ ) on the actual publicity level  $P$  and on the competition level  $C$  are:

$$E\{P|y_j^+\} - E\{P|y_j^-\}. \quad (5)$$

$$E\{C|y_j^+\} - E\{C|y_j^-\}. \quad (6)$$

(5) and (6) are usually called the *intention-to-treat* (ITT) effects.<sup>18</sup>

Following Angrist et al. (2000) seminal paper we interpret the ratio of the

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<sup>17</sup>Notice, by Law a violation of the publicity requirements invalidates the proceedings of the public auction and the person in charge of the auction can be persecuted by both the criminal and the administrative law for such violations. Nonetheless, to overcome the non-perfect compliance problem of the contracting authorities to the publicity Law, we use a *Fuzzy Regression Discontinuity Design*.

<sup>18</sup>To keep the notation as simple as possible, we omit time subscripts. In the empirical analysis we consider all the relations conditioned on time periods.

two ITT effects of expressions (5) and (6) as the causal effect of  $P$  on  $C$  (of publicity on competition). This can be done only if two more conditions are satisfied: the validity of the exclusion restriction and the monotonicity condition. The exclusion restriction requires that the theoretical publicity  $Z$  affects the outcome,  $C$ , only through the observed level of publicity (which is reasonable in our context, see Section (4) where the Institutional framework is discussed). The monotonicity condition requires that no auction is induced to display a lower (higher) actual level of publicity if the theoretical publicity is exogenously moved from  $l$  to  $h$  (from  $h$  to  $l$ ).

If the three assumptions are satisfied, then the ratio:

$$\Pi(y_j) = \frac{E\{C|y_j^+\} - E\{C|y_j^-\}}{E\{P|y_j^+\} - E\{P|y_j^-\}}, \quad (7)$$

identifies the average effect of a change in the actual level of publicity on the level of competition at  $Y = y_j$  for those who are induced to show a higher level of publicity because their theoretical publicity increases from  $l$  to  $h$ .

We plot in Figure (3) non-parametric estimates of the main variables of interest. The two boxes on the left plot  $P$  on  $Y$  at the discontinuity thresholds 1 and 2, respectively. The other two boxes on the right plot the number of bidders on  $Y$  for the same discontinuity points. We estimate these locally weighted smoothing regression separately on the left and on the right of the cut-off points. Jumps in the plots show the effect of the threshold on the variable of interest thus offering a graphical interpretation of the intention-to-treat effects as defined by equations (5), and (6). As it can be noticed, the figures show that the actual publicity is uniformly not lower than the theoretical publicity on both discontinuities at the left of the threshold. At the right of the threshold we observe some problems of compliance with the law on publicity but not that big to violate the monotonicity condition

required by RDD, as pointed out in Garibaldi et al. (2007). Concerning the number of bidders, we observe a jump at the right of the first cut-off point while a drop at the second. The mean impact of the actual publicity on competition, which is the ratio of the jump of the level of competition and the jump of the level of actual publicity, turns out to be positive at the first discontinuity and negative but very small at the second. The figures show that there is a substantial effect of publicity on competition at the first threshold. This impact weakens at discontinuity 2 and 3 (not reported in the figures).

To implement the RDD to our analysis we go through the following steps, (see Imbens and Lemieux (2007)):

1. Inspect the Graphical Analysis,
2. Estimate the treatment effect using TSLS (IV-LATE) where standard errors are computed using the usual (robust) TSLS standard errors,
3. Assess the identification assumptions by looking at possible jumps in the value of pre-treatment variables at the cut-off point and implement a formal test for the lack of continuity of the density function of the running variable (i.e. auction's starting value),
4. Assess the robustness of the results using alternative models and additional specifications.

## 5.2 Graphical Analysis

According to Table (3) publicity is a discontinuous function of the auction's starting value. We thus have:

$$P = \begin{cases} P & \textit{Geographical Level} & \textit{Running Variable} \\ 0 & \textit{Local} & \textit{if } 1.5 \leq Y < 5 \\ 1 & \textit{Regional} & \textit{if } 5 \leq Y < 10 \\ 2 & \textit{National} & \textit{if } 10 \leq Y < Y^* \\ 3 & \textit{EU} & \textit{if } Y \geq Y^* \end{cases}$$

Where  $Y$  is the starting value of the auction expressed in 100,000 euro (real value year 2000) and  $Y^*$  varies across the year of analysis. Due to non perfect compliance, we construct an indicator of theoretical publicity, which will be used as the instrument for actual publicity:

$$Z = \begin{cases} 0 & \textit{if } 1.5 \leq Y < 5 \\ 1 & \textit{if } 5 \leq Y < 10 \\ 2 & \textit{if } 10 \leq Y < Y^* \\ 3 & \textit{if } Y \geq Y^* \end{cases}$$

Under perfect compliance  $Z$  and  $P$  should coincide. Figure (2) shows that this is not the case in our context: the green line (which represents the actual publicity) indeed do not overlap with the orange line (which represents the theoretical publicity). Because of this differences we consider a "Fuzzy" Regression Discontinuity Design.

To graphically inspect the validity of the continuity assumption we implement two graphical methods that are complementary. We follow Mc Crary (2007), and Lee (2007) to support our identification strategy.

Figure (4) shows that the distribution of the auctions' starting value is right skewed. No significant mass probability around each of thresholds is identified, although a suspect of a peak is observed at discontinuity two. An abnormal mass in the distribution of the starting value around each of the thresholds may suggest a lack of continuity in the density function of the running variable. We further investigate on this possibility considering the

density based test *à la* Mc Crary (2007).<sup>19</sup> The inspection consists in two steps. In the first step we obtain a very undersmoothed histogram of the distribution of the starting value where the bins of the histogram are defined carefully enough that no one histogram bin includes both points to the left and right of the discontinuity point. In the second step we run a local linear smoothing of the histogram where we treat the midpoints of the histogram bins as a regressor, and the normalized counts of the number of observations of the bins are considered as the outcome variable. Figure (5) suggests that there are no jumps in the density estimates.

As discussed in Lee (2007) we further investigate this issue through the pre-intervention variables. We define our set of pre-intervention variables from the detailed information available to the researchers. These variables, in principle, should meet the following two conditions: they should not be affected by the publicity law, but they may depend on the same unobservables (e.g. efficiency/collusion of the contractors with participants), likely to affect the level of competition  $C$ . To test the continuity condition we use the information available on the person in charge to take care of the auction's administrative process and on the administrative nature of the contracting authority. In particular in figure (6) we plot an indicator of whether the age of the person in charge is above the median distribution, and an indicator of whether the contracting authority is the municipality against  $Y$ , the starting values, and we analyze the behavior of the plots around the three discontinuities thresholds. In the graphical analysis we present the plots on these two pre-treatment variables around discontinuity 1 and 2. A characteristic of these variables is they are observed before the determination of

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<sup>19</sup>We comment this graphical inspection of the estimated density function at discontinuity one only, see Figure (5). Results for the other discontinuities are available from the authors.

the publicity levels and before the auction takes place, thus they can be used as pre-treatment variables. The graphical test for the continuity assumption would suggest evidence of sorting and lack of continuity if the plots of these indicators against  $Y$  would show a jump at the cut-off points. Identification would not be possible in those cases since auctions assigned to high theoretical level of publicity  $Z_h$  would be not comparable to auctions assigned to a low level of publicity  $Z_l$  with respect to unobservables relevant for the outcome  $C$ . Figure (6) shows that there are no jumps at the first threshold while jumps are very small at the second.

Thus the graphical analysis suggests the presence of no manipulation of the running variable  $Y$ .

In addition to the graphical analysis, Table (4) reports descriptive statistics of the auctions' observable characteristics around discontinuity 1. In this table we check whether the observable covariates are balanced to the right and to the left of the first threshold. The rationale of this check is that around discontinuities we should not observe any jump in the observable characteristics with the exception of the outcome of the auctions and the publicity level. Except for some differences in the required category (SOA3) we observe no systematic differences around discontinuity one. We further inspect the institutional requirement for the SOA categories, and we exclude by the study of the publicity law any systematic shift of the SOAs' categories at discontinuity one.<sup>20</sup>

In the following Section we further investigates these graphical results by considering a battery of regression based tests.

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<sup>20</sup>see Section (4).

### 5.3 Regression Analysis: Discontinuities Effects

Van der Klaauw (2002), among others, discusses how to estimate the intention-to-treat effects as defined by equations (5), and (6). In this paper we consider a fully parametric model representation to evaluate the causal effects of publicity on competition running several versions of the following equation:

$$C_i = \alpha + \beta P_i + \epsilon_i \quad (8)$$

When assignment to treatment is not random, endogeneity bias in the estimation of  $\beta$  can rise because of a dependence between  $P_i$  and  $\epsilon_i$ . In this case  $E[\epsilon/P] \neq 0$  and then any OLS estimate of equation (8) will deliver inconsistent estimates of  $\beta$ . Using Regression Discontinuity design we have additional information on the selection in to the treatment rule. To see how the effect of publicity can be identified and estimated with RD design we have to compare a sample of individuals within a very small interval around the cutoff because they are essentially identical but they differ for the level of publicity. Van der Klaauw (2002) clearly explain that increasing the interval around the cutoff point is likely to induce a bias in the effect estimate, especially if the assignment variable was itself related to the outcome variable conditional on treatment status. In this paper, as suggested by Angrist and Lavy (1999), Van der Klaauw (2002) and Garibaldi et al. (2007), we specify and include the conditional mean function  $E[\epsilon/P, Y]$  as a “control function” in the outcome equation:

$$C_i = g(Y_i) + \beta P_i + \delta_t + \omega_i \quad (9)$$

where  $g(Y_i)$  is a third order polynomial in  $Y$ ,  $P$  the observed level of publicity,  $\delta$  is a year indicator, and  $\omega = C_i - E[C_i/P_i, Y_i]$ . Providing that we

can correctly specify  $g(Y_i)$  we gain the property that  $E[\omega/Y] = 0$  and thus equation (9) can be correctly estimated via OLS because  $P$  will be free from correlation with the disturbances.

As discussed in section (4) the assignment to treatment is known to depend partially on the running variable  $Y$  and partially on other unobservable phenomena (e.g. local collusion, perverse incentives, or simply measurement error) that can potentially be correlated with the unobservable components of the outcome equation. This second type of Regression Discontinuity design is referred to the literature as “fuzzy”. As in Angrist and Lavy (1999), Van der Klaauw (2002) and Garibaldi et al. (2007) we propose a fully parametric approach and we assume that the assignment to treatment status can be summarized by the following equation:

$$P_i = g(Y_i) + \gamma Z_i + \delta_i + \nu_i \quad (10)$$

We estimate the causal effect of publicity on competition via Two Stages Least Squares (TSLS, or IV-LATE) with  $Z = \mathbf{1}\{Y_i \geq \bar{Y}\}$  as excluded instruments and the polynomial  $g(Y_i)$  as included one.

In reporting the estimation results of equation (9) we comment the estimates at each of the three discontinuity thresholds generated by the publicity law. Table (5) reports the estimated coefficients,  $\hat{\beta}$ , of the effects of publicity on auctions’ outcomes of Equation (9). In the two Panels A, and B, of Table (5), we report the sample averages of the outcomes of interest (the number of bidders and the winning rebate), the intention-to-treat, the OLS and the IV-LATE estimates with the (robust) standard errors for the coefficients of publicity only. The odd rows, starting from the third report the estimated coefficients considering separately the three different discontinuities in the publicity function.

Column 1 of Table (5) reports the intention-to-treat effect of theoretical publicity (e.g. the excluded instrument) on actual (e.g. the observed level) publicity.<sup>21</sup> The estimates indicate that an increase from a lower starting value bracket, say 1.5 – 5 hundreds of thousand of euros, to an higher one, say 5 – 10 hundreds of thousand of euros, shifts the actual publicity by 0.2 with a standard error of 0.02 ( by the 0.36 with a standard error of 0.07 if we consider the second income bracket, and by 0.65 with a standard error of 0.21 if we consider the third income bracket). These results clearly identify a lack of full treatment compliance due to non perfect law enforcement. We believe that this problem is not such big to invalidate the monotonicity assumption required by the RDD, see Garibaldi et al. (2007). Column 2 of Table (5) reports the intention-to-treat effect of theoretical publicity on the number of bidders and the winning rebate (Panel A, and B). The estimates obtained separately for each discontinuity point are not statistically different from zero. The OLS estimates of the number of bidders and the winning rebate on the actual level of publicity suggest different results: they show a negative and statistically significant correlation between publicity and the number of bidders at discontinuity 2 and a negative and statistically significant correlation between publicity and the winning rebate at discontinuity 1 and 2.

Column 4 of Table (5) reports the Instrumental Variables Local Average Treatment Effects (henceforth, IV-LATE) estimates (and robust standard errors below) at each discontinuity. The estimates around discontinuity 1,

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<sup>21</sup>This is the estimated coefficient of the instrument on the endogenous regressor. For all the estimates the ratio between the estimated coefficient and the standard error is the t-statistics which happen to be always greater than two. In this model we have one instrument and thus the first stage F-statistics are just the square of the t-statistics. The first-stage F are always greater than 10 (not reported, but available on request) suggesting that the IV-LATE estimates are not affected by the weak instruments problem.

indicate that an increase in tenders' publicity, from local to regional levels, determines an average increase of 19 in the number of bidders with respect to a sample average of 38, and an average increase in the winning rebate of 4.9 with respect to a sample average of 16 %. Both effects are statistically different from zero at 5 % significance level. As anticipated in the Introduction, this result suggests that increasing the publicity level from local to regional can yield considerable benefits for the contracting authority, such as an average saving of 25,000 euros for an auction with average starting value of 516,000 euros. The empirical analysis support the validity of the law. In other words, the "knowledge effect" of letting more firms know about the existence of the auction here dominates the "deterrence effect" of a fiercer competition to be faced while bidding. This result is especially meaningful if we consider that, at least in Italy, the cost of publishing at regional level is very low. The estimates around discontinuity 2, indicate that, rather surprisingly, an increase in tenders' publicity, from regional to nation levels, determines a decrease of 21 in the number of bidders with respect to a sample average of 38, and an average increase in the winning rebate by 3 with respect to a sample average of 16 %. However, both effects are not statistically significant at 5 %. It appears, thus, that shifting the publicity level from regional to national, at the very last does not attract other potential bidders to the auction. This rather striking result suggests that the regional level of publicity is already sufficient to let potential national bidders be aware of the existence of the auction. Hence, any additional advertisement at national level would yield only additional costs and no additional benefits. Finally, the estimates around discontinuity 3 indicate that an increase in tenders' publicity, from national to European levels, determines an average decrease of 6.4 in the number of bidders with respect to a sample average of 38, and

an average increase in the winning rebate of 10 with respect to a sample average of 16 %. The former effect is not statistically significant at 5 %, while the latter is statistically different from zero at 5 % significance level. This last result appears to be coherent with the previous ones and it suggests an additional interesting consideration: increasing publicity to European level does not increase the number of bidders, but it probably affects the quality of them. When an auction causes a great stir at European level, most efficient firms likely move into play, keeping constant the number of participating firms (because the least efficient firms, knowing that they cannot compete, do not even apply) but increasing the auctioneer's rent by increasing the winning rebate. This explanation is of major interest and should be tested with further empirical investigation. We plan to address this issue when new additional data will be available.

## 5.4 Sensitivity Analysis

One concern with our model so far it is that the apparently discontinuous relationship between the level of competition and the publicity levels may be due to the model specification, to sample selection, or to the omission of the relevant characteristics of public procurement auctions. In Section (3) the baseline model includes the third order polynomial in the starting value and the year effects only. This specification may not be sufficiently flexible to absorb all the auctions characteristics. To assess this possibility, in Table (7) we present estimation results for 5 alternative specifications but we comment the results for the winning rebate, only.<sup>22</sup> In column 1 we reduce the discontinuity sample by more than 50 %.<sup>23</sup> The reduced discontinuity sample

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<sup>22</sup>Results on the number of bidders are available on request.

<sup>23</sup>Given the inclusion of the polynomial in the starting value, the control function, we did not perform a cross-validation selection procedure of both the original discontinuity

includes auctions with starting vale between 4 and 6 hundred thousand euros instead of 3.5 and 7.99 hundred thousand euros at discontinuity 1, auctions with starting vale between 9 and 11 hundred thousand euros instead of 8 and 13 hundred thousand euros at discontinuity 2, and auctions with starting vale between 55 and 75 hundred thousand euros instead of 20 and 111 hundred thousand euros at discontinuity 3. In column 2 we add the fourth order power of the starting value. In column 3 we add the fourth order power of the starting value and reduce the discontinuity sample. In column 4 we add the LARGE information set. The LARGE information set contains the following list of observable characteristics:

- Works' characteristics: wether the works are for roads, education, culture, or other
- Auctions' characteristics: the technical requirement to participate (OG, and RSOA characteristics)
- Auctioneers' characteristics: whether the contracting authority is the municipality or the province.

Finally, in column 5 we add the fourth order polynomial in the starting value and the LARGE information set.

In Table (7) the odd row reports the OLS estimates while the even rows report the across-models IV-LATE effects of publicity on the winning rebate at each discontinuity thresholds. We comment the IV-LATE effects only.

In column 1, the reduced sample in the neighborhood of discontinuity 1 is 

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 sample and the reduced sample in order to select the sample windows around the three discontinuities. As expected we do not observe a remarkable change in the results considering different selections of the sample although we reduced the sample by more than 50 %.

of 5983 auctions instead of the original discontinuity 1 sample of 11434 auctions. The reduced sample estimates of the effect of an increase in publicity from local to regional on the winning rebate is of 6.2 percentage points with standard error 4.4 compared to 4.9 percentage points with standard error 2.1 of the baseline effect. The point estimates appear to be not remarkably different but as expected estimated with less precision. We observe the same pattern at discontinuities 2 and 3. Once we augment the model specification with the fourth order polynomial in the starting value, column 2, we estimate the effect of publicity on the winning rebate to be respectively 6.7 (with standard error 2.7), 2.5 (with standard error 2), and 9.9 (with standard error 4.7) at the three discontinuities. The augmented model results appear to be pretty similar to the baseline estimates that are 4.9 (with standard error 2.1), 3 (with standard error 2.1), and 10 (with standard error 3.8) at the three discontinuities. In column 3 we both reduce the sample size by 50 % and add the fourth order polynomial in the starting value. The estimation results are similar to the baseline effects of publicity on the winning rebate only at discontinuity one where the sample size is larger. Although the effect of an increase in publicity from local to regional is of 5.6 it has a standard error of 4.6 suggesting that it is not statistically different from zero. Estimation results in column 3 are not statistically different from zero at any of the three discontinuities. In columns 4-5 firstly we add at the baseline specification the set of regressors included in the LARGE information set; secondly we add the fourth order polynomial in the starting value. Once we augment the model specification with the LARGE information set, column 4, we estimate the effect of publicity on the winning rebate to be respectively 4 (with standard error 2.1), 2.8 (with standard error 2.1), and 13 (with standard error 6.7) at the three discontinuities. Once we augment the model specification with

the LARGE information set and the fourth order polynomial in the starting value, column 5, we estimate the effect of publicity on the winning rebate to be respectively 5.5 (with standard error 2.7), 2.2 (with standard error 2.1), and 12 (with standard error 6.8) at the three discontinuities. The estimation results of the augmented models reported in columns 4-5, are very similar to the baseline estimates that are 4.9 (with standard error 2.1), 3 (with standard error 2.1), and 10 (with standard error 3.8) at the three discontinuities. Hence, sensitivity analysis results appear to be robust to sample selection, functional form restrictions, and the inclusion of the characteristics of the goods and the auctions.

## 6 Benefits from Competition: Duration Analysis

In this Section we ask whether an increase in competition in auction may lead to the selection of more efficient winners and, thus, to a reduction in the time needed to accomplish the works, provided that the works are satisfying tenders' technical requirements. We consider the time to accomplish the works provided that the works are satisfying tenders' technical requirements. We report evidence of a negative correlation between proxies of competition and the time to accomplish the works. In particular we describe the behavior of the hazard function,  $h(l) = \frac{f(s)}{S(s)}$ , defined as the (instantaneous) probability of accomplishing the works at  $s$  given survival until  $s$ .<sup>24</sup> We use duration analysis models because our data are right-censored: indeed, several works

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<sup>24</sup>Let  $L \geq 0$  be the random variable representing the duration of the works (expressed as the number of days between the moment in which the auction takes place and the accomplishment of the works) and  $l$  the realized duration.  $F(l) = Pr[L \leq l]$  is the cumulative distribution function, while  $S(l) = Pr[L > l] = 1 - F(l)$  is the survival function.

are still not accomplished at the day the data were collected. Hence, for each  $i$  the observed duration  $T_i = t$  is the minimum among the complete duration  $L_i = l$  and the censored duration  $C_i = c$ . We first report non parametric hazard estimates and then we add some structure to the hazard function in order to link its behavior to auctions' indicators of competition. In the non parametric analysis we let  $d_i(t)$  be the number of works accomplished at duration  $t$  and  $r_i(t)$  be the number of works at risk of being accomplished at time  $t$  with duration  $t$  (where  $r_i(t)$  includes the works censored at  $t$  or later). The estimated hazard function is

$$\hat{h}_i(t) = \frac{d_i(t)}{r_i(t)} \quad (11)$$

and the, the Kaplan-Meier estimated survival function is

$$\hat{S}_i(t) = \prod_{s \leq t} \left( 1 - \frac{d_i(s)}{r_i(s)} \right) \quad (12)$$

Figure (7) plots the Kaplan-Meier (KM) estimates of the survival function of the duration of the works, by the number of bidders for road constructions. From left to right, the orange line represents the KM estimates considering all the auctions where the number of bidders are above the median of the sample distribution of the number of bidders. The green line pools together all the observations while the blue line represents auctions with the number of bidders below the median. According to Figure (7) the survival functions are parallel, and always higher for auctions with number of bidders below the median, which implies that they have a higher overall duration rate. Given the properties of the non parametric KM survival function we add structure to the duration analysis and we implement a battery of parametric models to formally test the statistical significance of this finding. In the parametric models we pool together all the available information and control for it by

considering two set of information: MEDIUM and LARGE.<sup>25</sup> We base our analysis on the partial-likelihood approach proposed by Cox (1972).<sup>26</sup> We report the estimates of the  $\hat{\beta}$  of a series of models as follow:

$$h_i(t|x, \beta) = h_0(t)e^{X'\beta} \quad (13)$$

where  $h_0$  is the baseline hazard probability. Table (8) reports the results of the analysis on works' duration. Columns 1 and 2 show the correlations between a shift of the number of bidders and of the winning rebate above the median of their sample distribution, respectively, with the hazard probability. The estimated coefficients are reported in the form of  $\hat{\beta}$  (and not as hazard ratios) with the robust standard errors in parentheses. For instance, the first row  $\hat{\beta} = 0.17$  indicates that a shift of the number of bidders above the median determines an increase in the hazard relative to the baseline hazard of 17% (and hence a significative reduction in the duration of the works). This effect is significant at 1% level. A positive and significant effect is also observed for the winning rebate. Evidence thus suggests a negative correlation between the number of bidders and the winning rebate and the duration of the works. The estimates thus report some preliminary evidence of the theoretical predictions by Compte et al. (2002) suggesting that an increase the level of competition is correlated to the efficiency of public good procurement.

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<sup>25</sup>Those characteristics are discussed in the previous section.

<sup>26</sup>We report the COX-PH model only. Results for Exponential, Weibull, and Gompertz are available on request. Notice that this class of models requires the proportionality assumption to write the hazard function as in equation (11). As suggested in Jenkins' class notes (<http://www.iser.essex.ac.uk/teaching/degree/stephenj/ec968/>), we inspect the shape of the survival function and we observe a parallelism among them. We thus considered feasible the implementation of the proportional hazard class of models.

## 7 Conclusions

Economic theory suggests that increasing the actual number of bidders in an auction has a positive effect on the auctioneer's rent, Klemperer (2002). Increasing the number of potential bidders via an increase in the level of publicity made to advertise the tender has an ambiguous effect on the auction's outcome, though. On the one hand, a firm may not be aware that a tender is taking place if the contracting authority does not advertise it. On the other hand, a firm might be discouraged from participating if it observes a high level of publicity because this signals that competition in the auction will be fierce: if the probability of recouping the participation cost is too low, the firm might decide not to enter the competition.

In the paper we first adapt the model of Menezes and Monteiro (2000) on endogenous entry into auctions allowing for the optimal choice of publicity and show that it can be the case that the optimal level of publicity is not the maximal one, even if publicity comes for free to the auctioneer. That is: it might be the case that keeping the number of potential bidders smaller than what it could be is an optimal policy, because of the trade-off illustrated above. Next, we apply our econometric analysis to the database collected by the Italian Authority for Surveillance of Public Procurement and using the RDD method we disentangle the causal effect of publicity on the number of bidders and on the winning rebate. Our empirical analysis reports evidence of a positive and statistically significant effect of publicity on the number of bidders and on the winning rebate when the level of publicity is increased from local to regional level (+50 % and +31 % respectively). This result suggests that increasing the publicity level from local to regional can yield considerable benefits for the contracting authority, especially if we consider

that the cost of publishing at regional level is rather low in Italy. On the other hand, no statistically significant effect is observed when publicity is increased from regional to national level. It appears, thus, that this increased level of publicity is not useful in attracting other potential bidders to the auction. A possible conclusion that can be drawn from this result is that regional advertisement is already per se sufficient to inform national dimensioned firms, and publishing at national level most likely causes an additional (rather high) cost to the contracting authority without yielding any additional benefit. Finally, publicity is found to have a strong effect on the winning rebate but not on the number of bidders when it is increased from national to European level: +62 %. We can interpret this result as a signal that publicity at European wide level has an impact on the final outcome of the auction which is determined not by the quantity of the participating bidders but, likely, by the quality of the firms which are participating the auction. Publishing on the Official Journal of the European Community might then be a way for the contracting authority to select efficient European firms and ultimately increase its rent.

The results described above are supported by the tests of the continuity conditions which we perform both graphically and within the regression analysis' framework.

We also report evidence of a negative correlation between competition and the time to deliver the public good within a duration analysis framework. Indeed, a shift of the number of bidders above the median determines an increase in the hazard of 12% and a shift of the winning rebate above the median determines an increase in the hazard rate by 10%. These effects are all significant at the 1% level. The empirical analysis thus suggests that, within the context of our data, increasing the level of publicity has a positive

effect on public procurement outcomes. At this level of the analysis, however, we cannot disentangle the positive effect which is due just to the number of potential competitors from several other effects which publicity might have on the nature of competition. Indeed, increasing the publicity level might determine a reduction in the probability of collusion (simply because a 'maverick entry' from outside becomes more likely) or it might attract a particular kind of competitor which might induce local firms to bid more aggressively. We plan to address that issue in further research.

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## Appendix A: Testing for the presence of Sorting and Lack of Continuity Conditions

As discussed in Section (5.1), the RDD identification strategy is mainly based on the validity of the continuity conditions, equations (3) and (4). In this application of the RDD we have in mind the caveat that auctions' starting value is not exogenously determined and that the publicity thresholds are public knowledge. Strategic contracting authorities may set auctions' starting value just below the publicity thresholds. That is, pro-local authorities that do not care of maximizing auctions' revenues may have incentives to strategically reduce the starting value below the discontinuity thresholds in order not to publish the tenders and favor local entrepreneurs. Although we have already discussed that this strategic splitting of the starting value is forbidden by the Law on public procurement and we report graphical evidence of no sorting, we formally test the possibility of such violations. We focus the statistical analysis following McCrary (2007), and Lee (2007). Since the two methods are complementary we comment the results based on the pre-treatment variables only.<sup>27</sup> We estimate the same models as in equation (9) but use as outcomes a set of pre-treatment variables. We extend the graphical analysis of Section (5.2), increasing the available information on the person in charge for the auction's administrative process (age and gender) and on the administrative nature of the contracting authority (Province and Municipality). In Panel A of Table (6) the first pre-treatment outcome that we consider is an indicator of whether the person in charge is above the median distribution of age (52 years old). If the estimates of the coefficients on the actual publicity indicator using the theoretical publicity as an instrument are statistically dif-

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<sup>27</sup>The McCrary (2007) density tests confirm the analysis on the pre-treatment variables and are not reported but available on request.

ferent from zero, that would indicate that there are systematic differences in the age of the profession of the person in charge before and after the thresholds. This would suggest the possibility that in some of the auctions there was selection around the thresholds and lack of continuity in the baseline outcomes. The second indicator is whether the person is the gender of the person in charge. In Panel B of Table (6) the first pre-treatment outcome that we consider is an indicator of whether the contracting authority is the Province and the second of whether it is the municipality. In both Panel A and B we report estimates for the entire sample and for the discontinuity 1 sample. Estimation results reports evidence of no selection around the discontinuities. The intention-to-treat estimates in the first column indicates that a one unit increase in the publicity level is associated with a reduction of 0.0046 of the indicator of the median age of the person in charge. This estimate is small and statistically not different from zero. We find significant effects for the IV-LATE estimates in the fifth and sixth columns of the table when we consider the MEDIUM and the LARGE information set. The MEDIUM information set is the same as for the regression for Table (5) and includes a third order polynomial in the starting value and time indicators. The LARGE information set includes the MEDIUM and indicators on the nature of the good (roads, culture, education) the administrative nature of the contracting authority ( Municipality or Province), technical and financial characteristics required by the contracting authority to the bidders (RSOA, and OG, see section (4)). We further enquire this issue by using other information on the person in charge such as the gender.<sup>28</sup> As in the first row of Table (6), also in the other rows each coefficient comes from a separate regression. For example, the left cell of the row corresponding to the gender

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<sup>28</sup>We obtained this information from the fiscal code.

of the person in charge indicates that an increase in the amount of publicity increases the probability of being male of the person in charge by 0.002 and this estimate is small and statistically not different from zero. The coefficient get smaller if we consider the same regression at discontinuity 1. This is exactly what we should find if our identification strategy is correct and such conclusion is confirmed by the rest of the table. Moreover, all the estimates in Panel B indicate no systematic differences with respect to the indicators of whether the contracting authority is the Province or the Municipality. Estimation results allow us to exclude the existence of sorting around the thresholds.

Figure 1: **Publicity and Competition: Forces at Work**

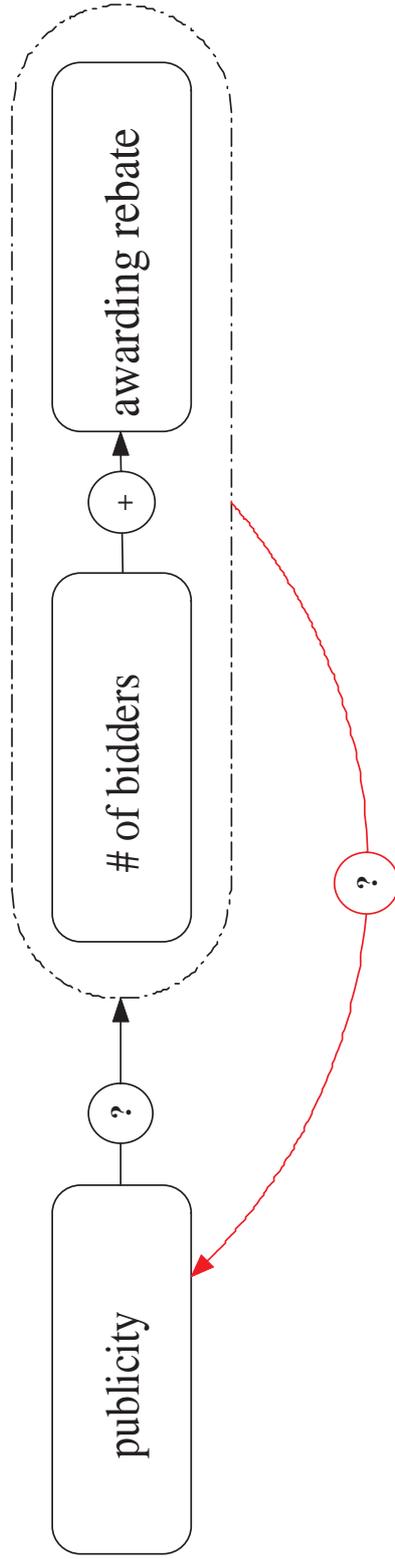


Table 1: **Descriptive Statistics**

	Percentiles							n
	mean	sd	p10	p25	p50	p75	p90	
Number of Bidding Firms	32	35	3	9	21	44	77	41510
Winning Rebate	16	8.9	4.7	10	15	21	29	41510
Notice Board	.92	.27	1	1	1	1	1	41510
Regional Official Journal	.25	.43	0	0	0	1	1	41510
Italian Official Journal	.18	.39	0	0	0	0	1	41510
Number of Province Newspapers	.24	.72	0	0	0	0	1	41510
Number of Regional Newspapers	.42	.81	0	0	0	0	2	41510
Number of National Newspapers	.61	.92	0	0	0	1	2	41510
Starting Value (in 100000 Euro)	7.2	12	1.8	2.2	3.6	7	15	41510
Technical Requirements: Buildings Required Category at least 3	.13	.34	0	0	0	0	1	41510
	.29	.45	0	0	0	1	1	41510
The contractor is a Municipality	.52	.5	0	0	1	1	1	41510
The contractor is a Province	.12	.33	0	0	0	0	1	41510
The contractor is in the North	.45	.5	0	0	0	1	1	41510
The contractor is in the Center	.25	.43	0	0	0	0	1	41510
The contractor is in the South	.22	.42	0	0	0	0	1	41510

Source: Statistics for all the public procurements works tendered between 2000 and 2005.

Table 2: Descriptive Statistics, by Typology of the Object

Typology	Roads	Education	Culture	Others
Number of Bidding Firms	46	23.5	20.4	28.1
Winning Rebate	16.6	15.3	14.1	16.2
Notice Board	.935	.953	.948	.9
Regional Official Journal	.229	.261	.274	.261
Italian Official Journal	.144	.161	.181	.204
Number of Province Newspapers	.252	.228	.236	.234
Number of Regional Newspapers	.407	.341	.422	.432
Number of National Newspapers	.545	.635	.604	.633
Starting Value (in 100000 euro)	6.33	6.95	7.5	7.47
Technical Requirements: Buildings	.0146	.271	.204	.164
Required Category at least 3	.271	.269	.302	.294
The contractor is a Municipality	.5	.608	.774	.459
The contractor is a Province	.208	.269	.0445	.0542
The contractor is in the North	.437	.499	.461	.432
The contractor is in the Center	.237	.246	.327	.242
The contractor is in the South	.243	.191	.169	.235
Fraction of the total	30.6	10.9	7.09	43.1

Source: Statistics for all the public procurements works tendered between 2000 and 2005.

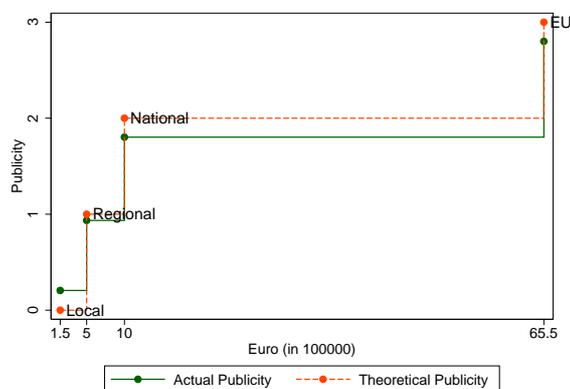
**Table 3: Advertisement: Rules and Costs**

Starting Value $y$ (in 100000 euro)	Theoretical Publicity	Costs of publishing (in euro)	Non-Compliance to the Law (%)
$y \geq 65.5$	EU-Official Journal (GUCE) Italian Official Journal (GURI) National Newspapers (at least 2) Regional Newspapers (at least 2)	Free 7000-8000 800 600	10
$10 \leq y < 65.5$	Italian Official Journal (GURI) National Newspapers (at least 2) Regional Newspapers (at least 2)	7000-8000 800 600	22.5
$5 \leq y < 10$	Regional Official Journal (BUR) Provincial Newspapers (at least 2)	200-500 400	28.9
$y < 5$	Notice Board	Free	6.5

Note: In the table  $y$  represent the starting value of the auction. To compute the third threshold we considered 65.5 as the value of 5,000,000 of SDR in EURO 2000. The cost average of regional official journals, and of the regional, and provincial newspapers are regional and provincial averages.

Source: Law 109/1994 and Authors' interviews with national advertisement companies.

**Figure 2: The Publicity Function**



Source: Theoretical publicity and actual publicity (aggregate average) for all the public procurements works tendered between 2000 and 2005.

**Table 4: Descriptive Statistics of the Characteristics of the Object Around Discontinuity One**

<i>Panel A:</i>					
Characteristics	Roads	Education	Culture	Municipality	Province
Before Disc.1 (sd)	0.31 0.46	0.11 0.31	0.07 0.26	0.53 0.50	0.11 0.31
After Disc.1 (sd)	0.30 0.46	0.11 0.31	0.08 0.27	0.50 0.50	0.12 0.33
Total (sd)	0.30 0.46	0.11 0.31	0.07 0.26	0.52 0.50	0.12 0.32
<i>Panel B:</i>					
Characteristics	North	Centre	South	Tec.Req.: Buildings	Req. Cat. at least 3
Before Disc.1 (sd)	0.45 0.50	0.25 0.43	0.23 0.42	0.14 0.34	0.05 0.22
After Disc.1 (sd)	0.47 0.50	0.24 0.43	0.21 0.41	0.13 0.33	0.51 0.50
Total (sd)	0.46 0.50	0.24 0.43	0.22 0.41	0.13 0.34	0.26 0.44

Source: Statistics for all the public procurements works tendered between 2000-2005.

Figure 3: Intention-to-treat effects

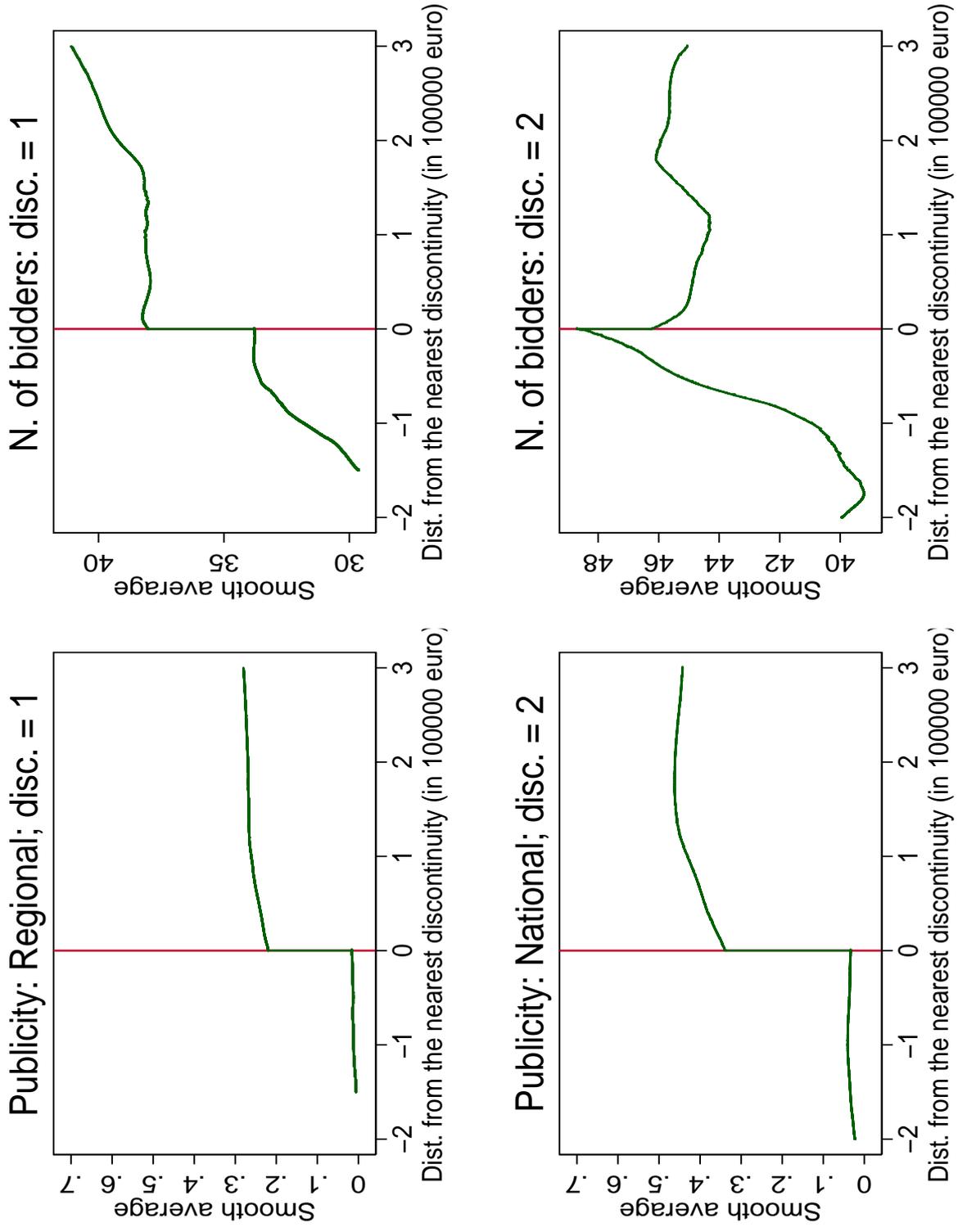


Figure 4: The distribution of the Starting Value

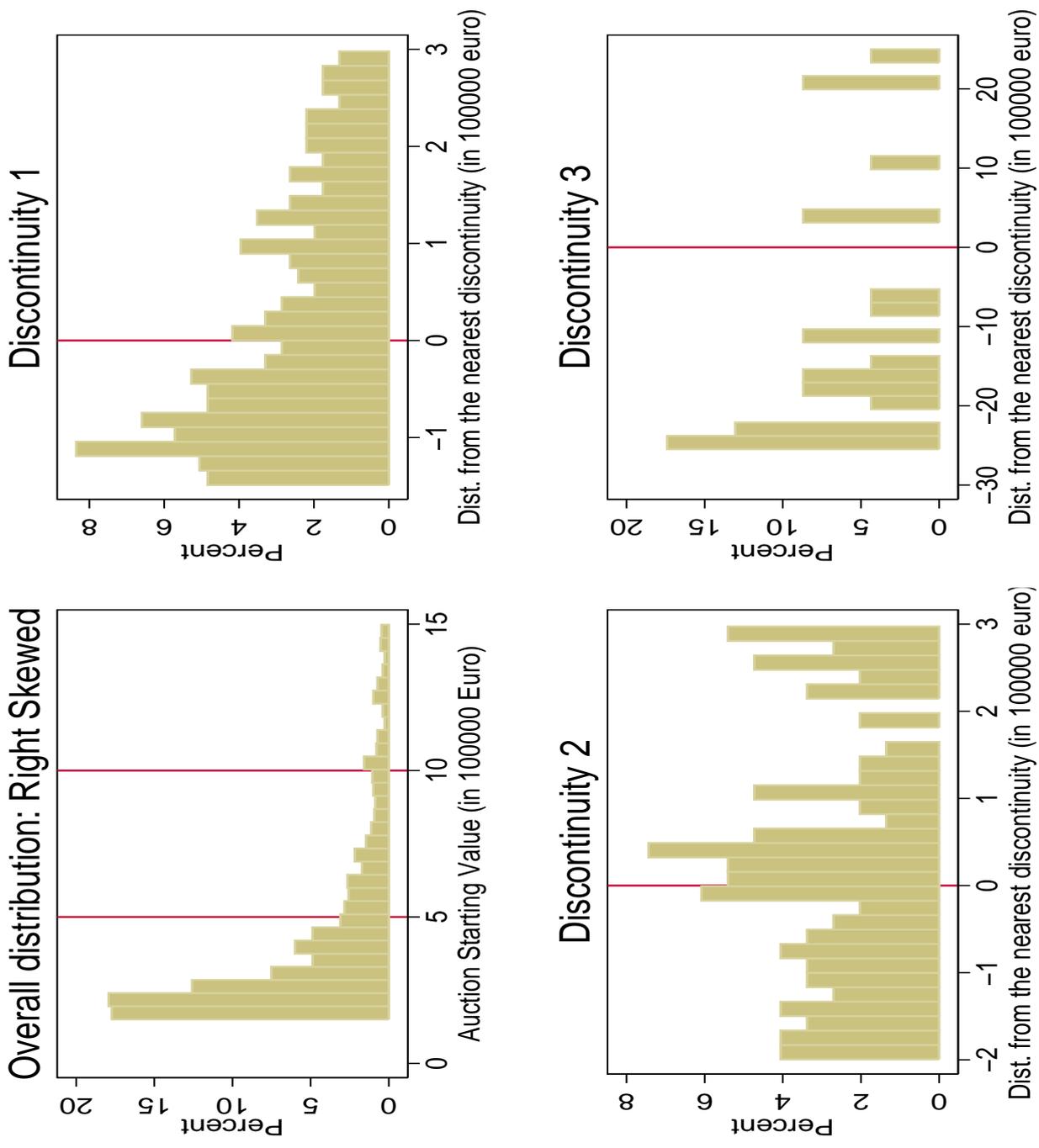
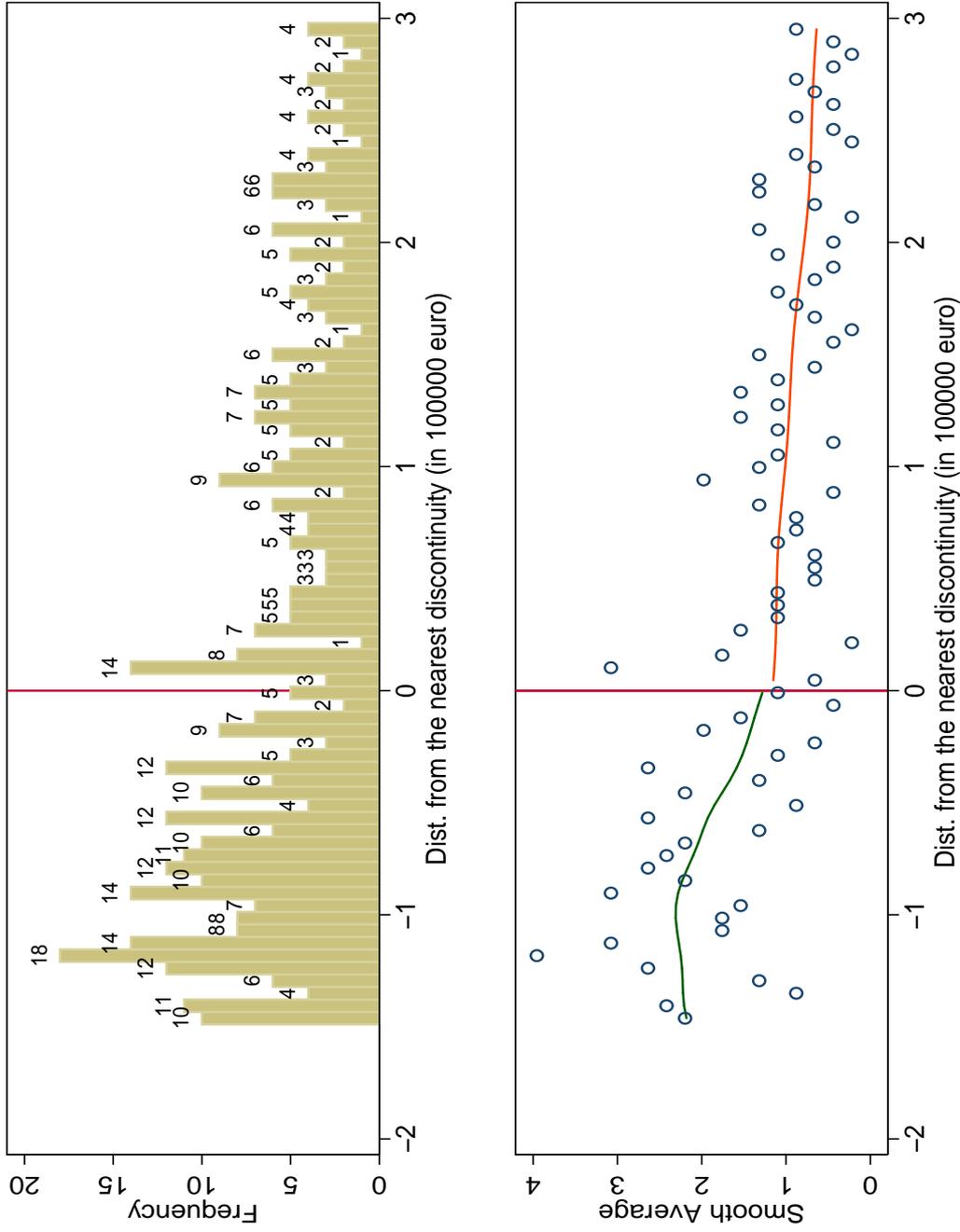
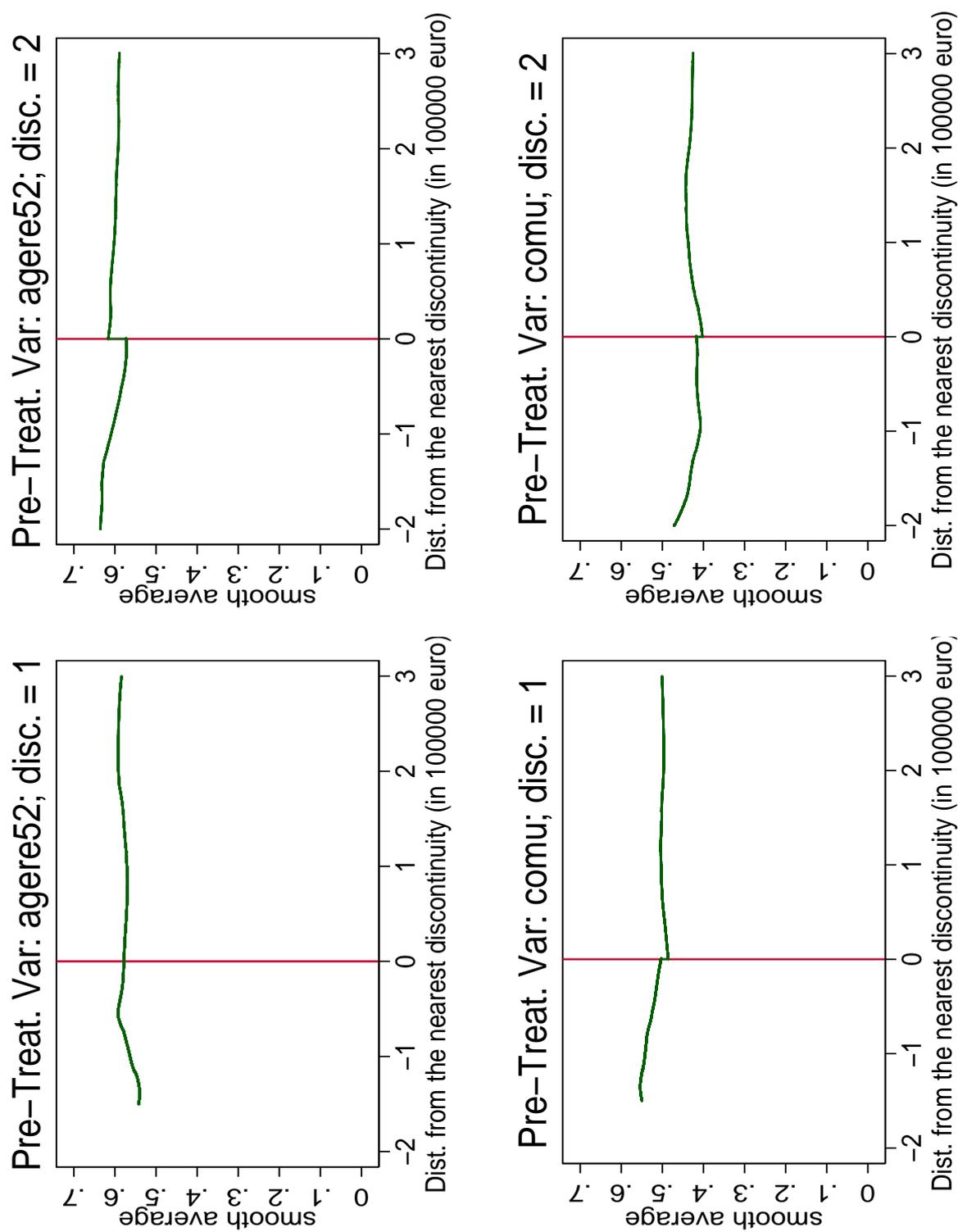


Figure 5: Graphical Density Test for Lack of Continuity and Sorting of the Running Variable



Source: Statistics for all the “Roads and Construction” tendered in year 2000 around Discontinuity 1.

Figure 6: Continuity conditions and sorting: Age of the person in charge and Municipalities



**Table 5: Discontinuity Estimates of the Effect of Publicity on Competition**

Method	OLS-ITT	OLS-ITT	OLS	IV-LATE	N. of Obs.
Dep.Var	Publicity	Auction's outcome	Auction's outcome	Auction's outcome	
Treatment	Theo.Publ.	Theo.Publ.	Publicity	Publicity	
Instrument				Theo.Publ.	
	(1)	(2)	(3)	(4)	
<i>Panel A: Number of Bidders</i>					
Mean-Outcome	.	.	38	.	17336
(sd)	.	.	35	.	.
Discontinuity 1	.2	3.1	.	.93	11434
(se)	.019	1.6	.	.96	.
Discontinuity 2	.36	-4.6	.	-3.5	3528
(se)	.069	3.7	.	.9	.
Discontinuity 3	.65	-4.6	.	.56	2374
(se)	.21	4	.	.67	.
<i>Panel B: Winning Rebate</i>					
Mean-Outcome	.	.	16	.	17336
(sd)	.	.	8.7	.	.
Discontinuity 1	.2	.82	.	-1	11434
(se)	.019	.39	.	.22	.
Discontinuity 2	.36	.81	.	-1.1	3528
(se)	.069	.65	.	.17	.
Discontinuity 3	.65	6.1	.	-.16	2374
(se)	.21	1.6	.	.18	.

Note: Each coefficient (and standard error in parenthesis) is an estimate of  $\beta$  obtained from the regressions of the form:

$$C_i = g(y_i) + \beta P_i + \delta_t + \omega_i$$

where C is the actual level of publicity in column 1 and: the number of bidders in Panel A, and the winning rebate in Panel B; P is the theoretical publicity in columns 1 and 2, and the observed publicity in columns 3 and 4.  $g(y_i)$  is the third order polynomial in the starting value. Columns 1, 2 and 3 report OLS estimates: column 4 IV using the theoretical publicity as instrument for observed publicity.  $\delta_t$  are year indicators.

Source: Statistics for all the public procurements works tendered between 2000 and 2005.

**Table 6: Tests for the Presence of Sorting and for the Validity of the Continuity Conditions.**

Method	OLS-ITT	OLS-ITT	OLS	OLS	IV-LATE	IV-LATE	N	N
Treatment	Theo.Publ.	Theo.Publ.	Publicity	Publicity	Publicity	Publicity		
Instrument	MEDIUM	LARGE	MEDIUM	LARGE	MEDIUM	LARGE	MEDIUM	LARGE
Info. Set								
<i>Panel A: Information on the Person in Charge</i>								
Age above 52	-.0046	-.0045	.003	.0028	-.026	-.027	17336	17336
(se)	.0029	.0032	.0016	.0016	.0084	.0097	.	.
Male	.0038	.0048	.01	.0088	.017	.022	17336	17336
(se)	.0048	.0056	.0032	.0032	.015	.018	.	.
Age above 52	.01	.0096	-.00024	-.0005	.019	.019	11434	11434
(se)	.0069	.0069	.003	.0029	.031	.031	.	.
Male	-.0079	-.007	.015	.013	.0072	.012	11434	11434
(se)	.014	.014	.0068	.0068	.07	.071	.	.
<i>Panel B: The Contracting Authority is</i>								
Province	.0042	.0047	-.004	-.0021	.027	.024	17336	17336
(se)	.0043	.0049	.0033	.0032	.015	.017	.	.
Municipality	-.028	-.025	-.073	-.068	-.021	-.023	17336	17336
(se)	.0068	.0079	.0049	.0049	.022	.026	.	.
Province	.0039	.0023	.0062	.01	.039	.026	11434	11434
(se)	.013	.013	.0081	.0078	.07	.068	.	.
Municipality	-.0092	-.0063	-.069	-.062	.055	.061	11434	11434
(se)	.021	.021	.012	.012	.11	.11	.	.

Note: Each coefficient (and standard error in parenthesis) is an estimate of  $\beta$  obtained from the regressions of the form:

$$K_i = g(Y_i) + \beta P_i + \delta_t + \omega_i$$

where  $K$  is the pre-treatment outcome indicated in each row of column 1.  $P$  is the theoretical publicity in columns 1 and 2, and the observed publicity in columns 3 and 4.  $g(y_t)$  is the third order polynomial in the starting value. Columns 1-4 report OLS estimates: column 4-6 IV using the theoretical publicity as instrument for observed publicity.  $\delta_t$  are year indicators. Columns 2, 4, 6 includes indicators on the nature of the good (roads, culture, education) the administrative nature of the contracting authority (Municipality or Province), technical and financial characteristics required by the contracting authority to the bidders (RSOA, and OG) and 21 regional indicators. Statistics for all the public procurements works tendered between 2000 and 2005.

**Table 7: Sensitivity Analysis: Discontinuity Effects of Publicity on the Winning Rebate**

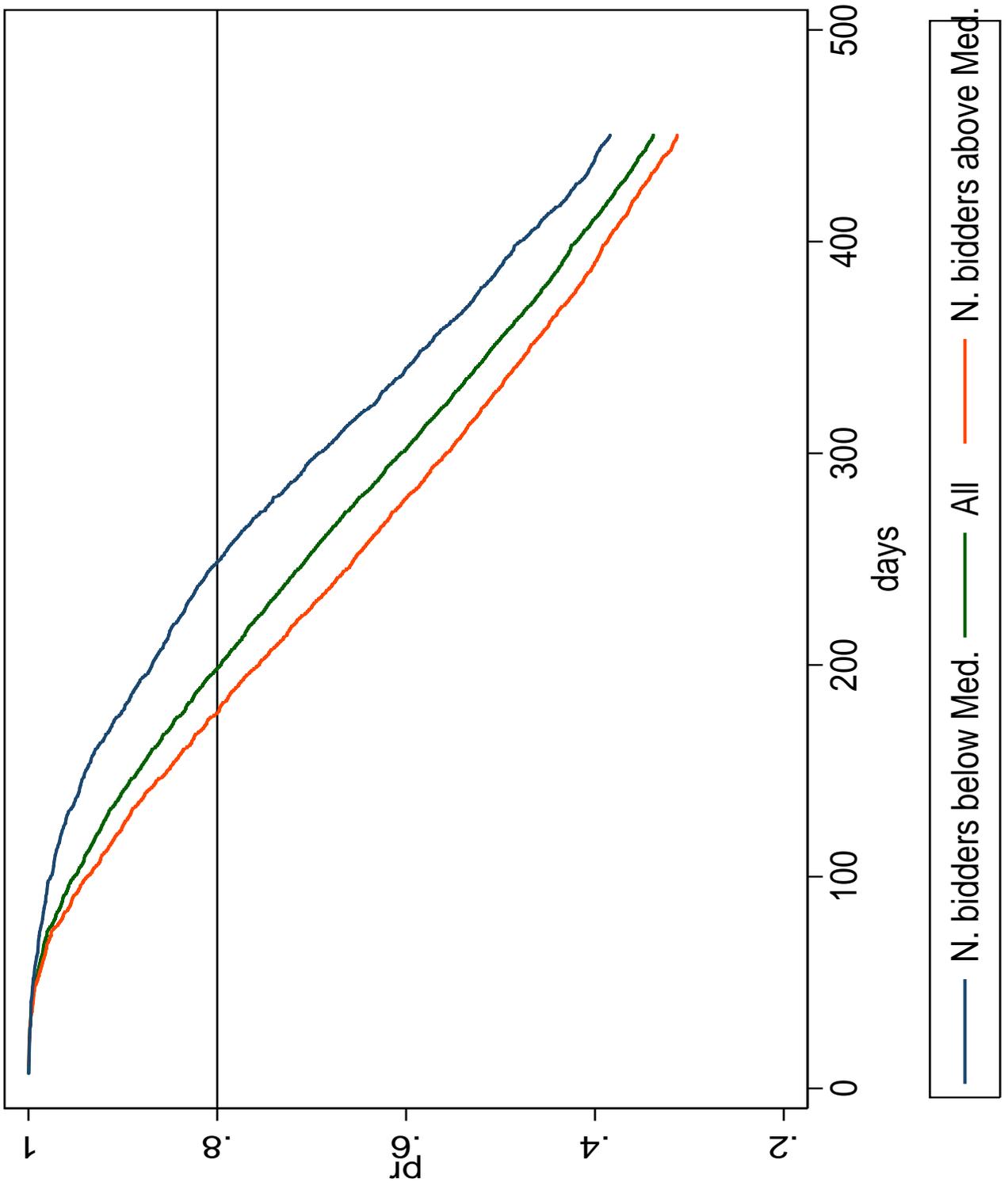
Model	Reduced sample	4 <sup>th</sup> Order polynomial	Reduced sample + 4 <sup>th</sup> Order polynomial	LARGE Info-Set	LARGE Info-Set + 4 <sup>th</sup> Order polynomial
	(1)	(2)	(3)	(4)	(5)
<i>Panel A: Discontinuity 1</i>					
OLS	-.42	-1.1	-.43	-1.2	-1.2
(se)	.3	.22	.3	.22	.22
IV	6.2	6.7	5.6	4	5.5
(se)	4.4	2.7	4.6	2.1	2.7
N	5983	11434	5983	11434	11434
<i>Panel B: Discontinuity 2</i>					
OLS	-1.3	-1.1	-1.3	-1	-1
(se)	.28	.17	.28	.17	.17
IV	6.9	2.5	8	2.8	2.2
(se)	4.1	2	4.6	2.1	2.1
N	1495	3528	1495	3528	3528
<i>Panel C: Discontinuity 3</i>					
OLS	1.8	-.18	1.6	-.093	-.1
(se)	.65	.18	.65	.18	.18
IV	12	9.9	20	13	12
(se)	16	4.7	50	6.7	6.8
N	209	2374	209	2374	2374

Note: Each coefficient (and robust standard error in parenthesis) is an estimate of  $\beta$  obtained from the regressions of the form:

$$R_i = g(Y_i) + \beta P_i + \gamma X_i + \delta_t + \omega_i$$

where  $R$  is the winning rebate and  $P$  is the actual level of publicity,  $X_i$  a vector of observable characteristics and  $g(y_i)$  is the polynomial in the starting value. Odd rows report OLS while even rows IV-LATE estimates using the theoretical publicity as instrument for observed publicity.  $\delta_t$  are year indicators. In columns 4-5 the LARGE info-set includes indicators on the nature of the good (roads, culture, education) the administrative nature of the contracting authority (Municipality or Province), technical and financial characteristics required by the contracting authority to the bidders (RSOA, and OG). Statistics for all the public procurements works tendered between 2000 and 2005.

Figure 7: Competition and Time to Accomplish the Works: Kaplan-Meier Estimates for Roads



**Table 8: Works' Duration, Estimated Hazard Ratios from Cox-PH Models**

Information Set	Number of bidders	Winning rebate
	above	above
	median	median
MEDIUM	.17	.054
(se)	.016	.016
LARGE	.12	.1
(se)	.018	.019
N	20214	20214

Note: Each coefficient (and standard error below) is an estimate of the  $\beta$  obtained from the regressions of the form:

$$h_i(t|x, \beta) = h_0(t) e^{(g(y_i) + \beta C_i + \delta X_i)}$$

where  $h_i$  is the hazard function (i.e. the instantaneous probability of accomplish the works at  $t$  given survival until  $t$ ) and  $h_0$  the baseline hazard.  $g(y_i)$  is the third order polynomial in the starting value. The columns report the effects considering separately the 2 proxies for competition ( $C_i$ ). The MEDIUM information set includes as regressors the third order polynomial in the starting values. The LARGE information set includes indicators on the nature of the good (roads, culture, education) the administrative nature of the contracting authority (Municipality or Province), technical and financial characteristics required by the contracting authority to the bidders (RSOA, and OG) and 21 regional indicators. Source: Statistics for all the public procurements works tendered between 2000 and 2005.