Court efficiency and procurement performance

very preliminary and incomplete version[*]

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April 29, 2011

Abstract

Contracts are a good deterrent for opportunistic behavior only insofar they are credibly and effectively enforced. In this paper we study the effects of courts' efficiency on contractors' incentives to delay public works. We present a simple model showing how courts' inefficiency may lead public buyers to refrain for applying contractual penalties for late delivery to avoid costly trials, leading contractors to strategically delay in particular large and complex projects. We then present empirical evidence from two sources of Italian data. First, we find that in provinces with longer trials, public works are delivered with higher delay. These results are not driven by omitted environmental variables, since we show that the delays in delivery are still affected by courts efficiency when province fixed effect are included in the model. Second, for a subsample of contracts we also observe whether penalties for delay are exercised, finding that in most cases they are not and that a reduction in courts efficiency leads to a less likely application of contractual penalties.

Keywords: public procurement contracts, enforceability of rules, "efficiency" of the legal system.

JEL: H57; L33; K41

[*]We would like to thank Luigi Moretti for research assistance.

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1 Introduction

This paper investigates how the efficiency in judicial enforcement affects public procurement performance. Explicit contracting is the crucial governance instrument for public procurement transactions because accountability concerns severely limit civil servants' discretion and with it the scope for relational contracting (Kelman, 1990 and 2002). Similarly, reputational considerations based on non-verifiable performance assessment are typically not admitted in the evaluation of public procurement tenders.[1] The crucial role played by explicit contracts in public procurement makes the efficiency of court enforcement particularly relevant. Contract enforcement costs are often significant (Djankov et al. 2003). Contracting parties may therefore choose not to exercise contractual rights to avoid these cost if the benefits from doing it are low (Doornik 2010; Iossa and Spagnolo 2011). Uncertainty linked to judicial mistakes and high legal costs linked to slow trials may reduce the parties willingness to exercise their contractual rights, the credibility of the threat of contractual remedies for poor performance, hence the ability to deter opportunistic behavior of suppliers.

We aim to verify whether firms' opportunistic behavior in public procurement transactions is more likely where the local court is less efficient. Our intuition is that public contractors' opportunism may be fostered by the inefficiency of the local courts, particularly in the case of large and complex projects. Then contractors may be able to win trials and avoid paying penalties for non-compliance even if they did not deliver in time because of a strategic decision. Because of this uncertainty, contracting authorities may then be unwilling to exercise contractual remedies to avoid being involved in a long and costly trial.

The starting point of our simple sequential model is a public procurement contract for the provision of a task between a public buyer, the Contracting Authority (CA), and a private seller, the Firm (F). The contract can be enforced by a local court whose efficiency is common knowledge among all agents. We focus on F's decision whether to strategically delay the execution of the contracted task, given that there are gains from late delivery for F, penalties for delay that *can* be exercised by CA and that F can dispute in the local court. The more inefficient the court, the more likely a wrong decision, particularly for more complex contracts, the longer/more costly the trial for the party that loses and bears most legal costs.[2] If a suit is filed after a delay and consequent exercise of contractual remedies, F is the plaintiff and the CA the defendant: the former may start the trial after the delay is punished with penalties because she expects to convince the court that it was not her fault (in which case penalties should not be levied, according to most legal systems) and recover the penalties, at least with some probability. The higher F's probability of winning the trial, the higher the expected cost for the CA of entering a judicial dispute, an effect that increases with court inefficiency.[3] The CA can avoid such a expected cost by not exercising the penalty; but if this is anticipated by F, strategic delay will be maximal. Our simple model therefore predicts that:

- when courts are more efficient and contracts of limited size/complexity, F would not file a suite if penalties are rightly exercised, CA would therefore exercise penalties if a delay takes place, hence F does not strategically delays;

- when courts are more inefficient and the contract is larger/more complex, F would file a suite after a penalty is exercised, CA may therefore prefer not exercise contractual penalties, hence F does strategically delays delivery.

Note that in both these cases contractual penalties are not exercised, a prediction that we will try to verify empirically. For some intermediate parameter configurations a third case also exists, in which F files a suite after a penalty is exercised, CA prefers to exercise contractual penalties

[1] This is particularly true in Europe where reputational considerations are (erroneously) seen by law-makers as sure source of entry deterrence and discrimination of foreing suppliers (EC Directives 17 and 18, 2004).

[2] In the model we assume that part of the legal costs stay with the parties that incur them directly, and part of them are paid by the losing party. We then check what happens when these components are larger or smaller. For a survey on theoretical comparisons between different rules for allocating legal costs, see Hause (1989).

[3] The CA costs of being involved in a trial can be increased by further "economic" and "political" cost: being filed in a suit may delay further the provision/completion of the contracted task, or may suggest electors poor management of public resources by the CA.

upon delays and F still strategically delays. This region however disappears for large contracts or mildly inefficient courts; and it reduces - and disappears - when there is asymmetry in the parties' non-reimbursable legal costs.

We then provide empirical evidence of the relationship between inefficiency of local courts and performance of public procurement contracts in terms of delays in execution (time overrun). We use data on public works collected by the AVCP (Italian Authority for the Vigilance on Contracts for Public Works, Services and Supplies) for the period 2000-2006, which includes information on every contract for public works valued 150,000 euros or more awarded in Italy. This dataset is characterized by its huge variability in terms of category, size, complexity and geographical localization of the works involved and gives the opportunity to test the predictions of our model without having to restrict the attention to very particular markets. The dataset contains information on several aspects of each procurement contract, such as award mechanism, starting value, execution time and costs. We observe large variability between provinces, categories and size of works, with an average value of delays of about 157 and a maximum of over 1500 days. This gives us a measure of the costs associated with this phenomenon. We merge this dataset with informations from ISTAT-Italian Statistical Institute on information on the duration of civil trials at province level for each year which has a large variability among provinces and over time (ranging from about 200 to over 2000 days, with a mean value of about 900 days, during the period of analysis), and other provincial time-varying characteristics. We then estimate a model specification which includes controls for the category and complexity of works, award mechanisms, province (or contracting authority) and year fixed effects. Our results show that the duration of civil trials is positively and significantly associated with the delays of execution of public work, in particular with larger/more complex projects. These results are confirmed also for a sub-sample of provinces belonging to Northern Italy where the accuracy of data filling is better than the average.

As additional evidence on the relationship between efficiency of local courts and the management of public procurement contracts, we employ another dataset containing CONSIP's (Italian Public Procurement Agency) controls on public bodies' management and application of procurement contracts for goods and services. From this set of information we can observe whether the procurer has deviated from contract terms and whether a penalty has been applied in case a violation has been detected. Evidence suggests again that the likelihood of deviating from contract terms is (weakly) higher when the efficiency of the local courts is lower and - more importantly - that the application of contractual penalties took place only in about 3% of the cases of a detected contractual violation. These results are line with the prediction of the model and the empirical evidence on public works: 1) suppliers have an higher incentive to deviate when the time of the trial are usually longer; 2) contracting authorities usually do not apply penalties because of the cost of the trials.

Related literature. (TO BE COMPLETED) The role of courts in procurement transaction is at the hart of the work of Johnson, MacMillan and Woodroof (2002). They analyze the role of court efficiency in maintaining trust and reducing transaction costs in private procurement transactions. Their focus, however, is on the interaction between courts and relational contracts, crucial in governing private transaction in less advanced countries, or in a group of former communist countries. Their findings stress that although the main instrument for the governance of buyer-supply exchanges are indeed long-term relationships, transaction costs are significantly lower when courts are effective.

As we mentioned, in public procurement self-enforcing relational contracts and reputational forces are severely limited, and explicit contracting is therefore central on its own. Most of the literature on contracting however adopts polar assumptions regarding contract enforcement, i.e. either costless or prohibitively costly judicial enforcement. Recent papers more closely related to our approach are Chakravarty and MacLeod (2009), Doornik (2010) and Iossa and Spagnolo (2011) who analyze instead parties ex post decision whether or not to enforce previously signed explicit contractual clauses by weighting the costs and benefits of doing it....EXPLAIN here DIFFERENCES...

Contract enforcement costs linked to court efficiency have been studied by Djankov et al. (2003),

who showed how much countries differ along this dimension. Using - among others - the length of the trial in civil courts as measure of judicial efficiency in 109 countries, they investigate how this efficiency belong to different level of procedural "formalism" and development in the judicial systems. Their findings stress such formalism is higher in civil than in common law countries, and is typically associated to higher expected duration of trial, less fairness in judicial decisions and more corruption; moreover, they underline where the judicial enforcement of contractual clauses is inefficient, agents' opportunistic behavior and private solutions of litigation often arise. Our analysis of within-country variation complements their empirical analysis besides helping understand how court efficiency affects the governance of public-private exchanges.

- Bajari and Lewis (2009) on time incentives in public procurement contracts

- Models of private bargaining with costly enforcement as a threat point (Cooter et al. 1989).

- Papers on circumstances under which disputing parties incur the costs of a trial rather than settlement (see, e.g., Bebchuk 1984; Reinganum and Wilde 1986).

- Literature on renegotiation: Aghion et al. (1994) etc., *but renegotiation strongly limited in public procurement.*

- A recent literature takes the view of the court of law as an active player in judicial enforcing: in so doing, Gennaioli and Shleifer (2006) investigate in a formal analysis the court's exercise of judicial fact discretion. Their result XXX (see also Gennaioli and Rossi 2009). Anderlini and Felli (2006) build a model where parties sign a contract with unforeseen contingences and - ex-post - a court of law can decide whether to void or uphold the contract. Their result XXX

Our analysis mainly refers to intermediate costly enforcement of contractual rules and to the effects of a decision making (efficient - inefficient) court of law. Following the tradition started with Goldberg and Erickson's (1987), in this paper we investigate public procurement practice in Italy as a starting point for understanding efficient contract design. The agenda of the paper is as follows. In Section 2 we outline a simple procurement model where disputes on contractual clauses are addressed by a local court of law: in this setting we investigate how the efficiency of the court affects the enforcement of penalties by the contracting authority and the decision to infringe the rule by the firm. In Section 3, the institutional features of Italian public procurement and rules on time incentives in those contracts are presented; the empirical model and estimation results on Italian data are then provided and discussed. Section 6 collects conclusions and policy implication.

2 A simple model on firm's strategic delay

A firm (F) undertakes a public procurement contract, earning a profit π from its execution;[4] the profit from the contract is supposed to be proportional to the contract's value and to its complexity. Moreover, F gains from delaying the contract's execution a value $v(d, \pi)$: such a gain is a function of the number of day of delay, with $v'(d) > 0$, $v''(d) < 0$, and of the contract's profit, with $v'(\pi) > 0$, $v''(\pi) < 0$. Assuming F is capacity constraint, postponing the contract's execution could be a realistic option for the firm: indeed, delaying d days the contract's execution allows F to carry out an higher number of contracts, not paying extra-cost to increase its capacity[5]. However, when F delays the contract's execution, a daily penalty $p(d, \pi)$ can be levied; this penalty is included as a clause of the contract between the two parties, and is defined as proportional to the contract's value, with $p'(d) > 0$ and $p'(\pi) > 0$. Let's assume that

$$v(d, \pi) < p(d, \pi), \tag{1}$$

that is, penalties are high enough to disincentive the firm's delay in delivering the contract.

[4] Profit margins for firms undertaking Italian public procurement are usually assumed to be about 10% of the contract value (see: .Consiglio di Stato, Sect. IV, 11 October 2006, n. 6059).

[5] For a private firm working with public procurement, where contracts are often allocated through competitive auctions, it could be very difficult to efficiently and timely plan its capacity; and flexibility in capacity could result very costly.

The contracting authority (CA) awarding the contract obtains a benefit $B(\pi)$,with $B'(\pi) > 0$, when the contract is executed on time, and suffers a loss $s(d, \pi)$ if F delays delivering, with $s'(\pi) > 0$, $s''(\pi) < 0$ and $s'(d) > 0$, $s''(d) < 0$.[6]

As shown in the game tree (Figure 1 below), once the CA awards the contract to the F, the latter can deliver the contract on time, or delay the execution. In the case of contract's timely execution, payoffs for F and the CA are simply π and $B(\pi)$, respectively.

When F delays delivering, the CA can enforce the penalty or not. If the CA doesn't exercise the penalty, the firm's payoff is $\pi + v(d, \pi)$ and the CA's payoff is $B(\pi) - s(d, \pi)$. If the CA withdraws the penalty, the former gets $\pi + v(d, \pi) - p(d, \pi)$ and the latter obtains $B - s(d, \pi) + p(d, \pi)$. Following the CA's enforcement of the penalty, F - in the aim to receive back the collected penalty - can open a trial to show that the realized delay belongs to unexpected reasons, or to events which do not fall in the firm's responsibility.[7]

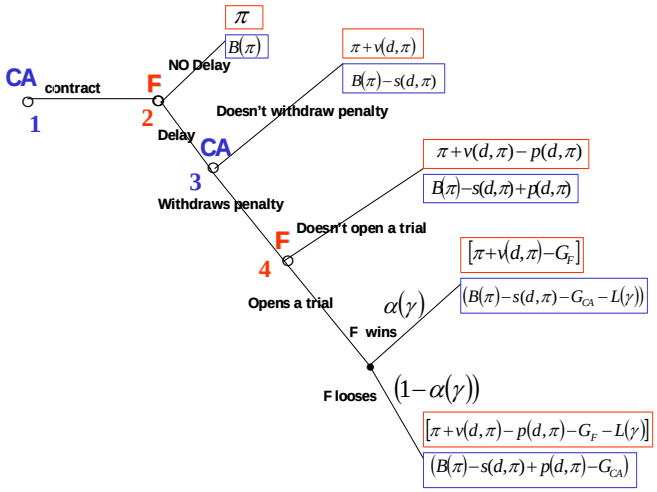


Figure 1: Game Tree

Assume now that F has α probability to win the trial. F is the plaintiff in this setting: opening a trial (and thus transmitting information about crucial facts) provides a signal affecting positively the F's probability of winning.[8] Moreover, the higher the inefficiency of the local court in performing the trial, the larger the F's probability of winning: this is because an inefficient court of law will have less resources to verify the F's transmitted info in each judgment, and this represents an advantage for F as plaintiff. The inefficiency of the local court is captured by the observable parameter $0 \leq \gamma \leq 1$ which refers to the average length of time to conclude a trial, i.e. higher court inefficiency means a higher γ. Thus, we assume the F's probability of winning the trial α as weakly increasing in γ: $\alpha(\gamma)$ and $(1 - \alpha(\gamma))$ are the F's probability of winning and of losing the trial, respectively.

The cost of the trial incurred by the firm is composed of a component G_F that is born in any case because of the hassle of following the trial, and a component of documented legal costs $L_F(\gamma)$

[6] The CA (i.e. regions, provinces, and towns local bodies, health local authorities ...) awards public work and service pursuing its mission in the interests of citizens: benefits and losses belonging from the contract execution affect the CA's reputation in implementing public services. In this study we do not consider explicitly the direct citizens' benefit/loss from the contract execution.

[7] We are here assuming that the litigation process is a bargaining game where the noncooperative solution is given by the adversarial trial; we assume no cooperative solution by the court, i.e.: no settlement by the court. For the economic analysis of stages in legal dispute see: Cooter and Rubinfeld, 1989, p.1069.

[8] "A stronger signal increases the probability that the judge or jury will favor the facts as represented by its sender", Cooter et al., 1989, p. 1072.

that can be recovered in case of a favorable verdict[9]. Analogously, the CA's legal costs for the trial are $(G_{CA} + L_{CA}(\gamma))$. The component of documented legal costs are - for both the F and the CA - increasing in the inefficiency of the courts[10] γ, and we let total recoverable cost be denoted by $L(\gamma) = L_{CA}(\gamma) + L_F(\gamma)$.

Solving the model by backwards induction - see the Appendix for details - the condition determining the F's decision whether to open a trial is

$$\alpha(\gamma) \geq \frac{G_F + L(\gamma)}{p(d,\pi) + L(\gamma)} \tag{2}$$

Focussing on the CA's choice on the enforcement of penalty, for $p(d,\pi) > 0$, we get that the CA will always exercise the penalty if F delays and does not go to trial. if F delays and goes to trial, i.e. (2) is satisfied, the condition according to which the CA exercises the penalty results

$$\alpha(\gamma) \leq \frac{p(d,\pi) - G_{CA}}{p(d,\pi) + L(\gamma)}. \tag{3}$$

Summing up, the CA exercises the penalties and F - delays and - goes to trial if

$$\frac{G_F + L(\gamma)}{p(d,\pi) + L(\gamma)} \leq \alpha(\gamma) \leq \frac{p(d,\pi) - G_{CA}}{p(d,\pi) + L(\gamma)}. \tag{4}$$

Condition (4) requires that $G_F + L(\gamma) \leq p(d,\pi) - G_{CA}$, that is, F's small legal costs - in both its components, G_F and $L(\gamma)$ - relative to the CA's large net benefit from the penalty's exercised (legal costs G_{CA} small enough w.r.t. the exercised penalty).

Let's now consider in details the F's initial decision on whether to strategically delay. Given (1), the F's strategic delay will occur as the probability to win the trial, $\alpha(\gamma)$, is large enough as compared with the probability the CA exercises the penalty. Condition (4) outlines three parameter regions as follows:

1. *Parameter Region (A)*, or low $\alpha(\gamma)$. In this parameter region (2) is not satisfied, (3) is satisfied and penalties are always enforced by the CA, no trial is started by the firm upon exercise of penalties, and therefore F chooses no strategic delay since $v(d,\pi) \leq p(d,\pi)$.

2. *Parameter Region (B)*, or intermediate $\alpha(\gamma)$. Here, both (2) and (3) are satisfied; penalties are enforced and the trial is started; then F chooses positive strategic delay only if

$$\alpha(\gamma) \quad \geq \quad 1 + \frac{G_F - v(d,\pi)}{p(d,\pi) + L(\gamma)} \tag{5}$$

   Given that $G_F, L(\gamma), p(d,\pi)$ should be positive or equal to 0, and $0 \geq \alpha(\gamma) \geq 1$, condition (5) results satisfied only if $v(d,\pi) \geq G_F$.

3. *Parameter Region (C)*, or high $\alpha(\gamma)$. When $\alpha(\gamma)$ is sufficiently large that (2) is satisfied but (3) is not, then penalties are not exercised and F always maximizes delay because $\pi + v(d,\pi) \geq \pi$.

We can sum up the analysis on the Parameter Regions in the following Proposition.

Proposition 1 *The values of $\alpha(\gamma)$ define three parameter regions in which: (A) penalties are always enforced by the CA, trial is not open by the F, and no strategic delay occurs; (B) penalties are enforced and trial started: F chooses positive strategic delay only if $v(d,\pi) > G_F$; (C) penalties are never enforced by the CA, and the F's strategic delay is always maximized.*

[9] In Italy, a part of the trial's legal costs are to be reimbursed by the loser party: the reimbursement's amount is discretionally decided by the judge (Marchesi, 2003).

[10] We could further assume that recoverable component L of legal costs is increasing in γ at a larger rate than the G component.

Figure 2 below illustrates *Proposition 1*, having $0 \leq \pi \leq 500.000$ on the vertical axis, and $0 \leq \gamma \leq 1$ on the horizontal one. *Parameter Region (A)* is below the decreasing curve - representing the left side of (4) - and above the increasing one - representing the right side of (4). *Parameter Region (B)* is above the decreasing curve and above the increasing curve, *Parameter Region (C)* is below the increasing curve and above the decreasing one. *Proposition 1* highlights that for large values of γ, the *Parameter Regions (B)* disappears, and *Parameter Regions (C)* - where the F maximizes strategic delay and no penalties are enforced by the CA - becomes the only one settled.

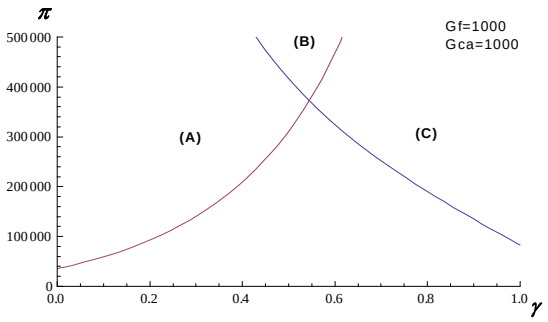


Figure 2: Parameter Regions (A), (B), (C)

To investigate how variables γ, π, $L(\gamma)$, G_F, G_{CA} affect the parameter regions where the F chooses strategic delay (i.e.: *Parameter Regions (B) and (C)*), and those where the CA exercises penalties (i.e., *Parameter Regions (A) and (B)*) rewrite (2) and (3) respectively as

$$C_F = \alpha(\gamma)\left(p(d,\pi) + L(\gamma)\right) - G_F - L(\gamma) \geq 0. \tag{6}$$

$$C_{CA} = \alpha(\gamma)\left(p(d,\pi) + L(\gamma)\right) - p(d,\pi) + G_{CA} \leq 0. \tag{7}$$

Corollary 2 *Comparative statics on (6) and on (7) shows that, under mild assumptions,*
$\frac{\partial C_F}{\partial \gamma} > 0$, $\frac{\partial C_F}{\partial \pi} > 0$, $\frac{\partial C_F}{\partial L} \leq 0$, $\frac{\partial C_F}{\partial G_F} < 0$ *and* $\frac{\partial^2 C_F}{\partial \pi \partial \gamma} > 0$
$\frac{\partial C_{CA}}{\partial \gamma} > 0$, $\frac{\partial C_{CA}}{\partial \pi} \leq 0$, $\frac{\partial C_{CA}}{\partial L} > 0$, $\frac{\partial C_{CA}}{\partial G_{CA}} > 0$ *and* $\frac{\partial^2 C_{CA}}{\partial \pi \partial \gamma} > 0$

Positive partial derivatives make easier to satisfy condition (6): both the *Parameter Regions (B) and (C)* grow and, thus, the F's strategic delay would be more frequent. The reverse is true for condition (7): negative partial derivatives make *Parameter Regions (A) and (B)* larger.

Note that the cross derivatives of (6) and (7) w.r.t. π and γ are both positive; but while in the former condition it means that the joint effect of π and γ makes easier for the F to delay and open the trial, in the latter condition it makes more difficult for the CA to exercise penalties.

Asymmetric (Non-Reimbursable) Legal Cost Each party's legal cost incurred in the trial can be thought as decreasing with the "size" of the institution itself: a large firm (or a large contracting authority) with its own internal law office, will have a lower legal cost than a small firm (a small CA, respectively) with external legal experts. According to this view, we assume that the larger the F's (or the CA's) size, and the smaller the G_F (the G_{CA}, respectively) component[11] and we investigate in what follows how this cost affects condition (4). In the previous analysis, we did not assumed any specific relationship among parties' legal costs; now we consider two different settings:

[11] We focus here on the G component which is a sunk cost for both the F and the CA. An extension on asymmetric reimbursable legal cost is under construction.

i) $G_F < G_{CA}$, a large F vis-à-vis a small CA;
ii) $G_F > G_{CA}$, a small F vis-à-vis a large CA.

In setting *i)*, (4) becomes easier to be satisfied on the left-hand-side relatively to right-hand-side: when a large supplier faces a small CA, $G_F < G_{CA}$, the condition according to which F decides whether to delay and open a trial becomes slack and the condition for the CA's decision to exercise the penalty becomes tight.

In setting *ii)*, the opposite is true: when a small supplier faces a large CA, (4) becomes tight for the former and slack for the latter.

Corollary 3 *For asymmetric non-reimbursable legal costs, the area (B) - where CA enforces penalties, F delays and starts the trial - becomes smaller or disappears. Moreover, when F faces lower non-reimbursable legal costs than the CA,a smaller* γ *is needed to give the rise to the area (C).*

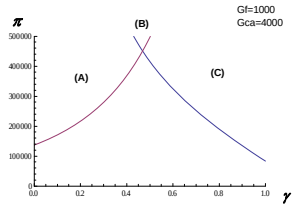


Figure 3A: $G_F < G_{CA}$

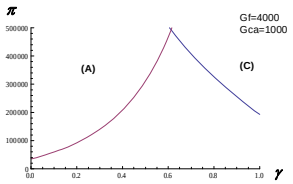


Figure 3B: $G_F > G_{CA}$

The asymmetry in non-reimbursable legal costs is shown in Figure 3 above: in 3A is represented the case for $G_F < G_{CA}$, a large F vis-à-vis a small CA; in 3B, $G_F > G_{CA}$, a small F vis-à-vis a large CA.

3 Italian public procurement: empirical evidence

In this Section we first briefly illustrate the institutional setting for public procurement contracts in Italy in the period between 2000 and 2006 and how times incentives rules are regulated. We then present data on Italian public contracts and on courts of law we refer to in our empirical analysis. Finally, we discuss the empirical model, our results and robustness checks.

3.1 Institutional setting

In Italy, until August 2006 contracts for public works were governed by the Law no. 109/94[12] and then by the Public Procurement Code[13], which acknowledges the EU Directives 2004/17/EC and 2004/18/EC[14]. The Law no. 109/94 saw the light in the early 90s, immediately after the crushing wave of scandals that literally wiped out almost the entire Italian political class, which used systematic bribery in public procurement (not only) to finance their parties. The historical context helps us to understand the rigidity of that law, which reduced the possibility to use auctions with scoring rules, limited the opportunity to award contracts through private negotiations and imposed new strict rules on the price revisions. The three main different types of participation guidelines for public procurement auctions there provided are:

- the *Pubblico incanto (*open procedure), where participation is open to any certified firm that is qualified to complete the specific type of project;

- the *Licitazione privata* (restricted procedure), which is similar to *Pubblico incanto* except that the CA invites all firms satisfying some technical requirements;

[12] Framework Law on Public Works Contracts - a.k.a. "Legge Merloni".

[13] D.Lgs no. 163/2006 - Code of public contracts relating to works, services and supplies

[14] The Code essentially provides a single framework for contracts for public works, supplies and services and - as we will see- the rules governing the former are not very different from the previous ones, since the Regulation (Presidential Decree no. 554/1999) has been barely touched.

- and the *Trattativa privata* (private negotiation), where the CA only invites a restricted number of firms, with a minimum of 15.

The choice of a particular participation mechanism depends on the starting value of the auction, plus some other technical components. Auctions with invitations are allowed for small works with a reserve price below 300,000 euros. The standard awarding procedure provided by the law was the open procedure (*pubblico incanto*) with a somewhat cumbersome mechanism to identify an "anomaly threshold" for the received bids to prevent firms from over-bidding (that is, bidding a price which does not allow to recoup works' expenses). Bidding firms submit a percentage reduction (a rebate) with respect to the auction's starting value (the reserve price). After excluding the top/bottom 10% of the collected bids, the bids exceeding the average by more than the average deviation are further excluded, and the winning bid is the highest among the remaining bids (i.e., the one just below this "anomaly thresholds"). Thus, the auctions included in the employed database are not proper first-price auction.[15]

The contractual conditions (e.g., deadlines, possibility of subcontracts, etc.) the winners have to respect when delivering public works are reported in the call for tender.[16] However, some terms of the procurement contract (the time of delivery and the cost of the project) might be renegotiated in cases of unforeseen or extreme meteorological events.

3.1.1 Time incentive clauses

In Italian law, the *General Terms for Procurement of Public Works Contracts* [17]: i) prescribes that time incentive clauses in the form of liquidated damages have to be necessarily included in each contract, ii) regulates the lower and upper limit of such penalties and iii) describes the procedures to be adopted in case of delay. Specifically, the penalty is to be calculated on a daily basis and must be set in the range of 0.03% and 0.1% of the value of the contract[18].

A relevant feature of these time incentive clauses is that the total amount of the liquidated damages is capped and cannot exceed 10% of the contract's value. In fact the legislator considers this 10% as the firm's (average) profit: thus, the *ratio* for the time incentive rule is that the CA can make a claim on the whole firm's profit but cannot exceed it. Should the accumulated delay imply liquidated damages exceeding that threshold, the CA must terminate the contract and start another awarding procedure for the completion of the work (and perhaps go to court to claim for further payment of damages). In this case, the completion of the work will be further delayed because of blockage of the construction site and the new awarding procedure.

The Italian law grants the CA a considerable degree of discretion in the actual exercise of the penalty for delayed delivering. The firm can always request the total or partial non-implementation of the penalty fee whether able to show either that it is not responsible for the delay (i.e.: wrong plans, adverse weather conditions, unexpected events, etc.) or that the fee is "manifestly disproportionate" with respect to the CA's interests harmed. The CA evaluates the firm's claims and decides whether to (partially) accept or reject them. In the latter case, the firm has the possibility to require an arbitration[19] or to go to court[20]: both the options turn out to be often very costly for the CA[21] and this determines strong incentives to the CA not to initiate litigation against

[15] See Decarolis (2009) and Conley and Decarolis (2010) for an analysis of this type of auction.

[16] Subcontracting part of the works is permitted by the law, but requires the approval of the public administration.

[17] See the Ministerial Decree no. 145/2000, art. 22 and the Presidential Decree no. 554/1999, art. 117 (*Regulation implementing the framework-law on public works no.109/94*)

[18] The exact percentage chosen by the CA is indicated in the *Special terms* of each contract where is also specified whether the delay has to be computed once at the end of the entire work (the standard case) or - given different contractual deadlines for separated phases of the work - for each single delayed phase.

[19] The *Authority for the Vigilance on Contracts for Public Works, Services and Supplies* (AVCP) reports in its "Relazione al Parlamento - 2008" (p. 208) that the CAs are almost invariable the losing parties (89% of the times) and pay on average 28% more than originally agreed. These unfavourable outcomes can explain why contracts signed by ANAS (National Company of Motorways and National Roads) exclude the possibility to resolve disputes through arbitration since 2007.

[20] This solution is often very time-consuming for the parties due to the average duration of civil trials in Italy.

[21] Legal costs for the CA are not limited to the resources devoted in following the trial; litigation can further affect the CA's reputation and the related political interests.

contractors and to exploit its degree of discretion to accommodate problems.

3.2 Data

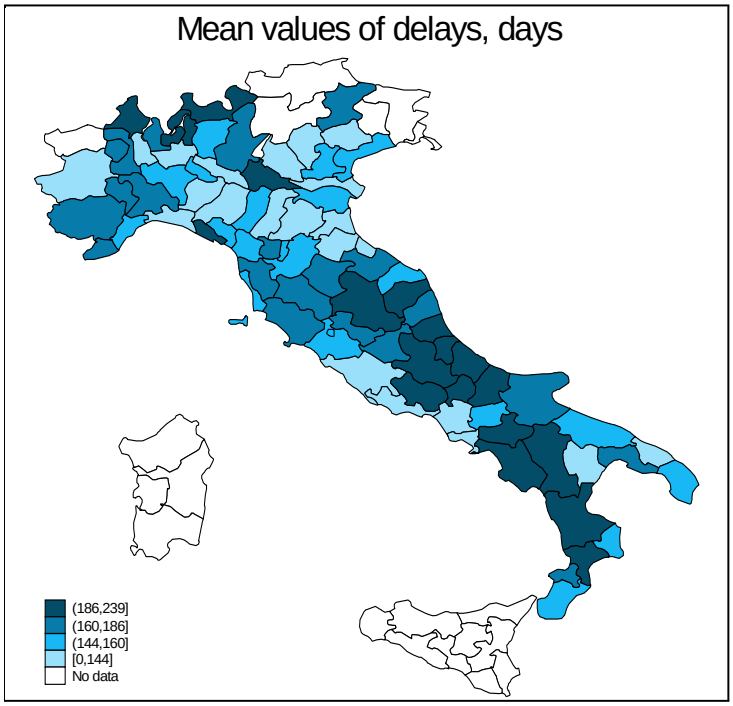
3.2.1 Data on Italian public works

We employ the AVCP dataset as the main source of information on procurement contracts in Italy: this dataset collects information on every public contract awarded and valued 150.000 euro or more. Information on several aspects of each procurement contract such as award mechanisms, starting values, winning rebates, number of bidders, execution times, and much more are included in this dataset. Thus, these data allow us to test the predictions of our model without having to restrict the attention to very particular markets.

Each CA is required by law to transmit data on every contract for public works awarded to the corresponding *Regional Observatory* respecting some predetermined deadlines. In particular, the CAs have to communicate all relevant information "on the making", i.e. each *Regional Observatory* actually acts as a monitoring unit for each contract in its territory. In turn, each *Regional Observatory* has to periodically transmit all the collected data on both completed and uncompleted works to the AVCP.

Our sample consists of contracts awarded between 2000 and 2006, in 15 ordinary statute regions - 15 out of 20 - since the other 5 (Val D'Aosta, Trentino Alto-Adige, Friuli Venezia-Giulia, Sicily and Sardinia) enjoy an extensive legislative autonomy and have rather different rules for public procurement contracts. After several steps of data-cleaning, summary statistics of the employed sample show that the average delay in the execution of public procurement contracts in Italy, defined as the difference between expected end and actual end of the work, is of about 157 days, with a maximum of 1578 days. There are indeed works completed on time and even in advance but about 88% of the observed works are delayed.

Map 1 shows that there is important territorial variation across provinces for the average days of delay in the execution of public works, with an higher concentration of delays in the Centre and South of Italy.



Map 1: Average delays in the execution of works

About 50% of the works in our sample are located in Northern Italy, the richest part of the country while 32% are located in Central Italy and 18% in the South. The starting values (at current prices) of the contracts range from 150,000 to 30,000,000 euro (average: 628,000 euro). More than 7 out of 10 contracts are awarded through competitive auctions while negotiations account for just 11% of all transactions.

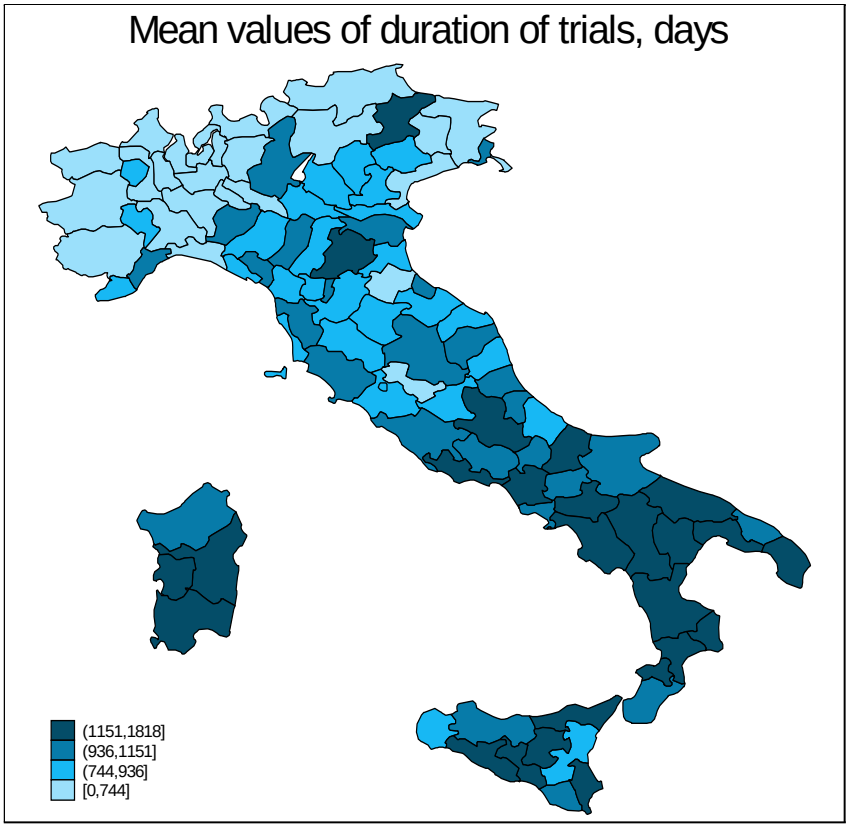
More than half of the CAs (53%) are municipalities; also important are provinces (15%). Construction of civil and industrial buildings accounts for almost one third of all works, while the construction and renovation of streets, highways, bridges and railway viaducts cover a little less than 30% of the works.

3.2.2 Data on local courts' efficiency

Measuring the efficiency of courts is not an easy task, as deeply documented Djankov et al. (2003), and, as these authors highlighted, there could be different definitions of court's efficiency. In this paper, we employ an outcome measure, that is the average duration of trial, which is computed as follow:[22]

$$\text{Average duration of trial} = \frac{\text{initial - final } \textit{lites pendentes}}{\text{new trials - finished trials}}$$

Our data refer to the duration of civil trials (*procedimento civile di cognizione*) at province level for each year between 2000 and 2006 and are provided by ISTAT (Italian National Statistics Institute).[23]



Map 2: Average duration of trials

[22] This measure is widely used in the economic literature in cross-country and with-in country studies. See, for example, Djankov et al (2003) for a cross-country study, and Jappelli, Pagano, Bianco (2005) on the relationship between duration of trials and banking market performance on Italian provinces.

[23] Indeed, the trial for a dispute in the execution of a public procurement contract in Italy should be presented to a civil tribunal, while dispute on the awarding phase to a local administrative tribunal.

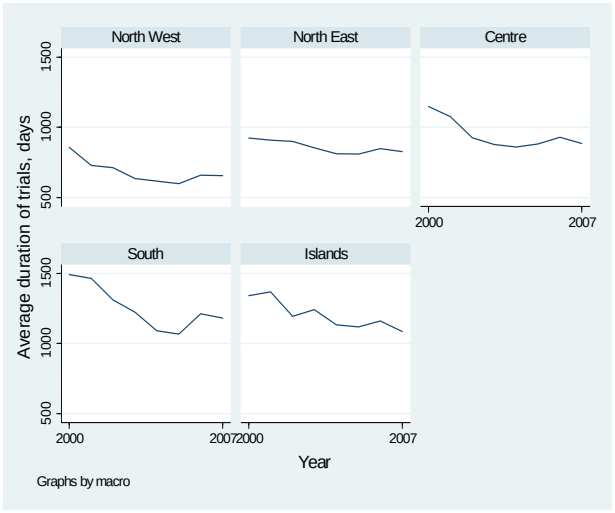


Figure 1: Figure 3: Variation of average duration of trials

The average duration of trial for Italy during the period 2000-2006 has an mean value of 911 days, a minimun 205 days and a maximum 2221 days (in our estimated sample the mean is 926, the minimum 205, the maximum 1578 days, and a standard deviation of 288.2), with a large variability across provinces (see Map 2) and a significant variation over time (see Figure 3). This variation over time will allow us to identify the effect of duration of trials even in the framework of a fixed-effect model.

3.3 Empirical model

We use the average duration of civil trials as proxy for the probability of enforcement of time incentives in the procurement contract; we estimate the following model of the delay in the execution of public works:

$$D_{igt} = \alpha + \beta_1 T_{gt} + \beta_2 T_{gt}^2 + X'_{1,it}\delta + X'_{2,gt}\gamma + \eta_g + \upsilon_t + \varepsilon_{igt} \tag{8}$$

where the dependent variable D is the delay in execution of public work (i), in province (g), in year (t), measured as the difference between the number of days actually taken to complete the project and the days prescribed in the contract. T represents the average duration of trials in days in the province where the work takes place and in the year when the contract is awarded; the X_1 and X_2 are works and province specific observable characteristics; η_g, and υ_t are sets of province and time fixed effects. X_1 and X_2 includes the following set of regressors:

population: resident population in the province where the contract is executed at the time of its awarding;

starting value: starting value of the contract defined by the CA (engineer's estimate of the cost of the contract plus a "normal" profit);

competitive auction: indicator for the open procedure;

private invitation: indicator for the restricted procedure;

simplified restricted procedure: indicator for the simplified restricted procedure;

design-and-construct: indicator for the design-and-construct contract;

private negotiation: indicator for the private negotiation;

type of CA: type of contracting authority (e.g. municipality, region, etc.);

type of work: main category of the work at stake.
We estimate equation (8) including time and province or CA fixed effects, and by clustering the standard errors at province level for the whole available sample and for a sub-sample of regions for which we observe a better data quality.[24]

3.4 Estimation results

Table 1 shows estimation results of the model described above using the whole sample of public works.

Columns 1-2 and 5-6 of Table 1 have fixed effects for the provinces, while columns 3-4 have fixed effects for each CA. Indeed, the CA-fixed-effects models seem to fit the data better: this fact suggests that the variability in the execution time of the works is strongly correlated with local factors not observable by the econometrician. Among them one can think about the relative personal attitude of a CA manager to be more or less strict in the enforcement of the contract, everything else being equal.

In column 1, 3 and 5, where the average duration of trial enter with a single term, its effect is not statistically significant. However, when we add its quadratic term (columns 2, 4, and 6) the effect of the average duration of the trials on the delay on the execution of the contract is positive (decreasing), strong and statistically significant. This positive but decreasing effect is not unexpected and might be interpreted as, for extremely high values of the duration of trials, further increases don't change firms' perception of inefficient of justice as much as for lower ranges. A standard deviation change of the duration of the trials induces an increase of the mean value of delays of execution of 9.8% in the province-fixed-effect model and of 10.6% in the CA-fixed-effect model.

The value of the contract appears to be one of the key factors in explaining the amount of the delay: in all six models the coefficient is statistically significant, and its effect is positive but decreasing.[25]

Consistently with the theoretical model in the previous section, we also test the differential effect of duration of trial on work delays for project with different complexity of the contract. Following Bajari MacMillan and Tadelis (2009), as a proxy of project complexity we employ the starting value of the bidding competition (which usually comes from the CA's engineers computation) and we estimate our model specification augmented with the interaction between this proxy variable and the duration of trial. Estimation results in Table 1 columns 5-6 show that higher is the complexity of a project, larger and statistically significant is the effect of an increase in the duration of trial on the delays of execution.

[24] We will always report also the estimation results obtained on the model specification that does not include the squared term of the duration of trials.

[24] In the aim to investigate further about this relationship, in a future revision of this paper, we will employ a Regression Discontinuity Design empirical strategy to link the presence of a court with delays in the execution of works (this approach is similar to Litschig and Zamboni, 2008).

[25] Positive but decreasing effects of the average duration of trials and complexity of works is captured by the assumptions of our theoretical model on $v''(d) < 0$ and $v''(\pi) < 0$.

Table 1. Delays in the execution of works and duration of trials. Estimation results.

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent	Delays	Delays	Delays	Delays	Delays	Delays
Mean value (days)	157	157	157	157	157	157
Duration of civil trials, in days	0.002	0.081**	0.001	0.098***	-0.006	-0.0727**
	(0.007)	(0.031)	(0.008)	(0.030)	(0.008)	(0.033)
Duration of civil trials, squared		-0.000***		-0.000***		-0.000**
		(0.000)		(0.000)		(0.000)
Duration of civil trials*Starting value					0.002**	0.002**
					(0.001)	(0.001)
Starting value (100.000 euro)	12.633***	12.635***	13.801***	13.809***	10.400***	10.405***
	(0.777)	(0.775)	(0.332)	(0.332)	(1.137)	(1.127)
Starting value, squared	-0.108***	-0.108***	-0.128***	-0.128***	-0.108***	-0.108***
	(0.011)	(0.011)	(0.005)	(0.005)	(0.010)	(0.010)
Resident population (100000)	0.051	-0.425	0.121	0.129	0.451	-0.022
	(2.969)	(2.644)	(0.348)	(0.348)	(2.944)	(2.615)
Restricted procedure	2.631	2.704	-7.418	-7.203	1.978	2.052
	(6.482)	(6.461)	(4.869)	(4.869)	(6.481)	(6.459)
Simplified restricted procedure	-23.107***	-23.145***	-13.018***	-13.063***	-22.985***	-23.003***
	(5.097)	(5.163)	(4.860)	(4.859)	(5.087)	(5.153)
Design-and-construct	9.555	9.819	9.628	9.706	9.078	9.342
	(32.719)	(32.770)	(31.248)	(31.243)	(32.116)	(32.170)
Negotiation	-8.935	-8.8778	-15.994***	-15.864***	-9.154	-9.097
	(7.543)	(7.540)	(3.606)	(3.605)	(7.541)	(7.538)
Type of CA effects	Yes	Yes	Yes	Yes	Yes	Yes
Category of work effects	Yes	Yes	Yes	Yes	Yes	Yes
Province effects	Yes	Yes	No	No	Yes	Yes
CA effects	No	No	Yes	Yes	No	No
Year effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	32449	32449	32449	32449	32449	32449
R^2	0.130	0.130	0.402	0.402	0.131	0.131

Robust standard errors (clustered at province level) in parentheses. *** p<0.01, ** p<0.05, * p<0.1

The estimated sample contains information on public works in Italy during the period 2000-2006 (source: AVCP). Dependent variable in columns 1-6 is days of delay in the execution of public works (defined as the difference between expected end and actual end of the work). Duration of civil trials is the average duration in days of a trial in the courts of a province in a given year. Starting value is the starting value of the bidding competition (which usually comes from the CA's engineers computation). Resident population is the population of a province in a given year. Format of auctions: restricted procedure, simplified restricted procedure, design-and-construct, private negotiation. All columns include type of CA (e.g. municipality, region, etc.) as well as main category of the work at stake effects. Columns 1-2 and 5-6 include province and year fixed effects, while columns 3-4 include CA and year fixed effects.

3.4.1 Robustness checks

One might argue that our results might be affected by the quality of data for public works, as there might be some missreporting or underreporting of the days of delay. We run the same model specification on a sub-sample of regions (Piemonte, Lombardia, Veneto, and Emilia-Romagna) all located in the Northern area of the country) for which we detect a better quality of data

compliance.[26] Even we restrict our sample to the richest part of the country, as shown in Figure 3 and Map 2, we still have enough variability for average duration of trial between provinces.

Estimation results in Table 2 show that the statistical significance and magnitude of the estimated results hold. In columns 5-6 of Table 2, we also show that the duration of trials does not seem to affect the rebates. Indeed, it seems that firms does not discount the information about the local enforcement of contractual clauses when they bid for the contract. Instead, the starting values of the contracts and the format of auctions seem to explain a large part of rebates (both these elements are decided by the CA).

Table 2. Robustness checks. Estimation results.

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent	Delays	Delays	Delays	Delays	Rebates	Rebates
Mean value	146	146	146	146	15.38	15.38
Duration of civil trials, in days	0.005	0.144**	0.001	0.131*	-0.001	-0.002
	(0.016)	(0.070)	(0.016)	(0.074)	(0.001)	(0.002)
Duration of civil trials, squared		-0.000**		-0.000*		0.000
		(0.000)		(0.000)		(0.000)
Duration of civil trials*Starting value			0.002**	0.002*		
			(0.001)	(0.001)		
Starting value (100.000 euro)	10.135***	10.150***	8.739***	8.809***	0.275***	0.275***
	(0.546)	(0.547)	(0.847)	(0.859)	(0.023)	(0.023)
Starting value, squared	-0.091***	-0.091***	-0.090***	-0.090***	-0.002***	-0.002***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.000)	(0.000)
Resident population (100000)	-11.494	-7.666	-11.432	-7.808	0.901	0.910
	(10.080)	(9.359)	(10.073)	(9.405)	(1.220)	(1.213)
Restricted procedure	3.639	3.732	3.445	3.541	-1.594***	-1.595***
	(11.396)	(11.424)	(11.415)	(11.442)	(0.404)	(0.404)
Simplified restricted procedure	-24.721***	-24.766***	-24.523***	-24.573***	-1.440**	-1.439**
	(8.879)	(8.883)	(8.901)	(8.901)	(0.674)	(0.673)
Design-and-construct	-9.811	-8.962	-11.653	-10.774	-2.802	-2.807
	(39.556)	(40.002)	(38.885)	(39.382)	(1.995)	(1.942)
Negotiation	-17.705***	-17.910***	-17.567***	-17.766***	-5.404***	-5.405***
	(4.675)	(4.721)	(4.699)	(4.744)	(0.596)	(0.595)
Type of CA effects	Yes	Yes	Yes	Yes	Yes	Yes
Category of work effects	Yes	Yes	Yes	Yes	Yes	Yes
Province effects	Yes	Yes	Yes	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	14595	14595	14595	14595	32449	32449
R^2	0.102	0.102	0.102	0.103	0.507	0.507

Robust standard errors (clustered at province level) in parentheses. *** p<0.01, ** p<0.05, * p<0.1

The estimated sample in columns 1-4 contains information on public works for a sub-sample of Italian regions (Northern Italy's regions: Piemonte, Lombardia, Veneto, Emilia-Romagna; which have a better quality of data) during the period 2000-2006 (source: AVCP). Dependent variable in columns 1-4 is days of delay in the execution of public works (defined as the difference between expected end and actual end of the work). Dependent variable in columns 5-6 is the percentage rebate from auction's reserve price and the model is estimated

[26] Also Decarolis (2009) and Decarolis and Palumbo (2011) restrict their sample to Northern regions as a robustness check.

on the whole sample. Duration of civil trials is the average duration in days of a trial in the courts of a province in a given year. Starting value is the starting value of the bidding competition (which usually comes from the CA's engineers computation). Resident population is the population of a province in a given year. Format of auctions: restricted procedure, simplified restricted procedure, design-and-construct, private negotiation. All columns include type of CA (e.g. municipality, region, etc.) as well as main category of the work at stake effects. Columns 1-6 include province and year fixed effects.

3.4.2 The enforcement of penalty clause

The AVCP dataset described above and used for our main estimates, unfortunately, does not contain observations on the enforcement of penalties by CA.

We offer evidence from an alternative source of data: the Consip's (Italian Public Procurement Agency)[27] controls on public bodies' procurement procedures for goods and services. This original set of information is available for 3 years (2005-2007) for a total of 4457 observations. From this dataset, we can observe whether the procurer has deviated from contract terms and whether a penalty has been enforced in case of violation of one of the terms of contract for which a penalty is required. Furthermore, this dataset gives us additional information on the type of contracting authority, the category of goods and services, and the location of the CA.

Descriptive statistics indicate that the percentage of contracts which have been detected as deviating from the contract terms is relatively high (about 36%), of which 82% refers also to delays in the delivery of goods and services. The distribution of deviations across type of CA is quite uniform (36% refers to central administration and bodies of the State, 36.5% to local administration, 40% to schools, universities and research centers, 31% to health services).[28]

We merge this information with the duration of civil trial at province level, and we analyze the relationship between the efficiency of courts and the probability of contractual deviations as a robustness check. This relationship gives us similar evidence than the relationship between delays in the execution of works and efficiency of courts which we studied above. After controlling for type of CA, category of goods and services, province level characteristics, and year fixed-effects, our estimation results (Table 3) highlight that there is a statistically significant, positive but decreasing relationship between the duration of trials and the probability of contractual deviation.[29]

Moreover, the other relationship we are interested in checking in Consip dataset is between duration of trials and enforcement of the penalties, conditional on the violation of the terms of the contract. However, this relationship is more difficult to be analyzed given the low number of cases. In fact, only for 63 a penalty has been enforced out of 1614 cases where a deviation from the contract terms has been detected (i.e. only in about 3% of the cases of deviation). The distribution across type of CA shows that the central administration and bodies of the State has enforced penalties in the 5.2% of the cases, the local administration in the 4.6%, schools, universities and research centers in the 3.3%, and health services in the 1%.[30]

Although, the very low number of observations do not allow us to make significative estimates on the relationship between the enforcement of the penalties and the efficiency of courts, the extremely low level of enforcement is an important evidence, as it highlight that penalties are usually not enforced by the CAs.

[27] Differently from AVCP which is the authority in charge for works, Consip S.p.A. is a public stock company owned by Italy's Ministry of the Economy and Finance (MEF) that operates on behalf of the State and manages the Program for the Rationalization of Public Purchases.

[28] This is classification of type of CA is similar to Bandiera, Prat and Valletti (2009), who also used Consip data.

[29] The model specification is similar to the one estimated on AVCP dataset. However, given the short time spam (3 years) of the Consip dataset, we prefer to augment the specification with province-level controls instead than including province fixed-effects. The control variables at province level include the population; the value added per capita to control for the level fo development; and, the number of voluntary organizations as a measure of social capital.

[30] See Guccio et al. (2008) for an analysis of the deviations (of costs) by type of CA in Italy. Although, they employ a different classification they also find that central administration bodies have higher probability of deviation respect to local administration.

Table 3. Violation of contract terms and duration of trials. Evidence from Consip data

	(1)	(2)	(3)	(4)
Dependent (1/0)	Violation	Violation	Violation	Violation
Duration of trials, days	0.0001	0.00044***	0.0001	0.00041**
	(0.000)	(0.000)	(0.000)	(0.000)
Duration of trials, squared		-0.00000***		-0.00000***
		(0.000)		(0.000)
Resident population	0.01284	0.01341	0.01613	0.01675
	(0.013)	(0.012)	(0.013)	(0.013)
(Log of) value added per capita	0.03653	0.04456	0.02330	0.03121
	(0.051)	(0.048)	(0.052)	(0.049)
Number of voluntary organizations	-0.00151	-0.00121	-0.00163	-0.00132
	(0.003)	(0.003)	(0.003)	(0.003)
Type of CA	Yes	Yes	No	No
Type of CA, detailed	No	No	Yes	Yes
Type of goods and services	Yes	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes
Observations	4457	4457	4457	4457
R^2	0.215	0.218	0.226	0.228

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

The estimated sample is a set of controls run by CONSIP on public bodies' procurement procedures for goods/services in the period 2005-2007. In columns 1-4 dependent variable takes value 1 if the firm has deviated from contracted terms, 0 otherwise. Duration of civil trials is the average duration in days of a trial in the courts of a province in a given year. Resident population is the population of a province in a given year. Log of value added per capita is a measure of richness of a province in a given year. Number of voluntary organizations is a measure of social capital of a province in a given year. All columns include effects for type of goods/services, type of CA and year.

4 Conclusion

To be done.

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5 Appendix

Proof. of (4)

Solving the model by backwards induction, suppose first F delays the contract's execution, the CA collects the penalty, and then **F opens a trial**; in this case the F's payoff, if it wins, will be

$$\pi + v(d,\pi) - G_F;$$

in the case F looses the trial, the payoff results

$$\pi + v\left(d,\pi\right) - p\left(d,\pi\right) - G_F - L(\gamma),$$

with expected payoffs from starting the trial ■

$$\alpha\left(\gamma\right)\left[\pi + v(d,\pi) - G_F\right] + \left(1-\alpha\left(\gamma\right)\right)\left[\pi + v\left(d,\pi\right) - p\left(d,\pi\right) - G_F - L\left(\gamma\right)\right].$$

If **F does not open** a trial, its payoffs will be instead

$$\pi + v\left(d,\pi\right) - p\left(d,\pi\right),$$

so that F will go to court if

Proof.

$$\alpha\left(\gamma\right)\left[\pi + v(d,\pi) - G_F\right] + \left(1-\alpha\left(\gamma\right)\right)\left[\begin{array}{c}\pi + v\left(d,\pi\right) - \\ -p\left(d,\pi\right) - G_F - L\left(\gamma\right)\end{array}\right] \geq \pi + v\left(d,\pi\right) - p\left(d,\pi\right)$$

from which (2) belongs.

If F delays and does not go to trial because (2) is not satisfied, then the CA's expected payoff after collecting the penalty is simply

$$B\left(\pi\right) - s\left(d,\pi\right) + p\left(d,\pi\right),$$

while not exercising the penalty it is

$$B\left(\pi\right) - s\left(d,\pi\right).$$

Thus, for $p\left(d,\pi\right) > 0$, the CA will always exercise the penalty if F does not go to trial. If F delays and goes to trial, i.e. (2) is satisfied, then the CA's expected payoff after collecting the penalty is

$$B\left(\pi\right) - s\left(d,\pi\right) - G_{CA} - \alpha\left(\gamma\right)L\left(\gamma\right) + \left(1-\alpha\left(\gamma\right)\right)p\left(d,\pi\right),$$

while not exercising the penalty it is

$$B\left(\pi\right) - s\left(d,\pi\right).$$

Then, the CA will exercise the penalty only if

$$B\left(\pi\right) - s\left(d,\pi\right) - G_{CA} - \alpha\left(\gamma\right)L\left(\gamma\right) + \left(1-\alpha\left(\gamma\right)\right)p\left(d,\pi\right) \quad \geq \quad B\left(\pi\right) - s\left(d,\pi\right)$$

and (3) belongs.

Hence, if F delays and

$$\alpha\left(\gamma\right) \geq \frac{p\left(d,\pi\right) - G_{CA}}{p\left(d,\pi\right) + L\left(\gamma\right)}, \frac{G_F + L\left(\gamma\right)}{p\left(d,\pi\right) + L\left(\gamma\right)},$$

the CA does not enforce the penalty to avoid the trial. If instead (2)$\leq \alpha\left(\gamma\right) \leq$(3), then the CA enforces the penalties and F goes then to trial, and condition (4) follows. ■

Proof of Proposition 1 Consider the firm's initial decision on whether to strategically delay. Given condition (1), condition (4) outlines three parameter regions as follows:

Parameter Region (A), or low $\alpha(\gamma)$.

In this parameter region (2) is not satisfied, (3) is satisfied and penalties are always enforced by the CA, no trial is started by the firm upon exercize of penalties, and therefore F chooses no strategic delay since $v(d,\pi) \leq p(d,\pi)$.

Parameter Region (B), or intermediate $\alpha(\gamma)$.

Here, both (2) and (3) are satisfied; penalties are enforced and trial started; then the firm chooses positive strategic delay only if

$$\pi + v(d,\pi) - G_F - (1-\alpha(\gamma))(p(d,\pi) + L(\gamma)) > \pi \Leftrightarrow$$

$$\alpha(\gamma) \quad \geq \quad 1 + \frac{G_F - v(d,\pi)}{p(d,\pi) + L(\gamma)}$$

Given that $G_F, L(\gamma), p(d,\pi)$ should be positive or equal to 0, and $0 \geq \alpha(\gamma) \geq 1$, condition (5) results satisfied only if $v(d,\pi) \geq G_F$.

Parameter Region (C), or high $\alpha(\gamma)$.

When $\alpha(\gamma)$ is sufficiently large that (**??**) is satisfied but (3) is not, then penalties are not enforced and F always maximizes delay because $\pi + v(d,\pi) \geq \pi$.

Proof of Corollary 2 Rewriting (2) as

$$C_F = \alpha(\gamma)(p(d,\pi) + L(\gamma)) - G_F - L(\gamma) \geq 0$$

and find the sign of partial derivatives w.r.t. γ, π, L and G_F of the left-hand-side (6). They result as follows

$$\begin{aligned} \frac{\partial C_F}{\partial \gamma} &= \alpha_\gamma(p(d,\pi) + L(\gamma)) - L'(1-\alpha(\gamma)) > 0 \\ \text{if } \alpha_\gamma(p(d,\pi) + L(\gamma)) &> L'(1+\alpha(\gamma)) \end{aligned}$$

$$\begin{aligned} \frac{\partial C_F}{\partial \pi} &= \alpha(\gamma) p_\pi > 0 \\ \frac{\partial C_F}{\partial G_F} &= -1 \leq 0 \\ \frac{\partial C_F}{\partial L} &= \alpha(\gamma) - 1 \leq 0 \end{aligned}$$

The cross derivative will give :

$$\frac{\partial^2 C_F}{\partial \pi \partial \gamma} = \alpha_\gamma p_\pi > 0,$$

as the penalty is defined as an increasing function of π and the probability α of winning the trial F as weakly increasing in γ.

Similarly for

$$C_{CA} = \alpha(\gamma)(p(d,\pi) + L(\gamma)) - p(d,\pi) + G_{CA} \leq 0$$

$\frac{\partial C_{CA}}{\partial \gamma} = \alpha_\gamma (p(d,\pi) + L(\gamma)) + L'\alpha(\gamma) > 0,$
$\frac{\partial C_{CA}}{\partial \pi} = \alpha(\gamma) p_\pi - p_\pi \leq 0,$
$\frac{\partial C_{CA}}{\partial L} = \alpha(\gamma) > 0$,
$\frac{\partial C_{CA}}{\partial G_{CA}} = 1 > 0$
and $\frac{\partial^2 C_{CA}}{\partial \pi \partial \gamma} = \alpha_\gamma p_\pi > 0.$