Public Procurement and the Risk of Severe Weather Events*

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Abstract

This paper studies how severe weather events (SWEs) affect the awarding procedures of public procurement contracts. We draw on a large dataset of Italian public procurement tenders for the construction and the maintenance of buildings and roads in the period 2008-2021. We find that municipalities previously hit by SWEs during the execution of procurement works are more likely to adopt procurement procedures that give them discretion in the selection of participating firms. When the firm winning the contract has already worked with the municipality in the past, such discretion reduces the likelihood of time overruns in work completion. Relational contracts aimed at overcoming the contractual incompleteness caused by SWEs can explain the previous findings. In a simple theoretical setting, we show that the public buyer can reward firms that handled past SWEs well by selecting them as participants in future tenders.

KEYWORDS: public procurement; relational contract; severe weather events

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1 Introduction

Climate change is one of the biggest challenges faced by contemporary societies. The rise in average temperatures, structural changes in several biomes, and increasing frequency of severe weather events (SWEs) create environmental and socioeconomic problems that governments across the world must address. SWEs are particularly harmful because they damage infrastructures, disrupt economic activities, and cause human losses. The US Department of Commerce estimates that severe storms and tropical cyclones cost USD 679.5 billion in the period 2010-2019, a 45% increase on the previous decade. SWEs also increase the level of risk and uncertainty which, in turn, reduces private investments and further stifles economic growth. Public investments can partially offset private funding. However, SWEs also affect public investments: hailstorms, cloudbursts, and tornadoes slow down the completion of public projects generating time and cost overruns that reduce social welfare (Schuldt et al., 2021).

In this paper, we study how public buyers (PBs) that experienced SWEs during the execution of previously awarded contracts, design new procurement tenders to cushion the negative impact of future disruptive events. SWEs can halt the execution of an ongoing contract causing losses for the PB by delayed completion. When to resume work involves moral hazard. Firms executing work can reduce the delay, but this choice comes at a cost. For instance, firms may have to pull resources away from more profitable working sites. Contractual clauses cannot reduce the moral hazard problem for two reasons. First, the contingencies associated with SWEs are too numerous to be included in a contract. Second, third parties (i.e., Courts) cannot either estimate or verify the costs incurred by the firm. This contractual incompleteness generates inefficiencies, such as informational rents and investment hold-ups, that can be partially offset using informal relational contracts.

We first build a theoretical framework and show that PBs can modify the design of procurement tenders to reduce the losses caused by future SWEs. In our framework, a PB wants to procure a new work in each of infinitely many periods. During the execution of the work, SWEs can randomly strike and impose a loss on the PB. The firm executing the work can then undergo a cost to reduce this loss. In each period, the PB can choose one of two possible procurement procedures: either an open or negotiated auction. Open auctions do not restrict the number of participating firms, and the winning price the PB must pay is thus, on average, lower.[1] Negotiated procedures enable the PB to restrict participation in the procurement auction to a subset of selected firms. Due to the reduction in the number of participating firms, the PB pays, on average, a higher amount to procure the work. However, negotiated procedures also enable the PB to enter into a relational contract with the firms. Specifically, the PB can reward a firm that has reduced her losses by including it among the participants in a future negotiated procedure. In the presence of unobservable heterogeneity in firm characteristics and moral hazard, history-dependent selection of participants can incentivize firms to behave in the interests of the PB.[2]

We then empirically investigate the link between the design of procurement procedures and the losses of PBs due to SWEs. We draw on a large Italian dataset on public procurement tenders for the construction and maintenance of roads and buildings over the period 2008-2021. The dataset includes information on the awarding mechanism (open and negotiated procedures), contract volumes, work suspensions and time overruns. We combine this dataset with geo-localized information on SWEs.

We show that when SWEs occur during the execution of procurement contracts, the frequency of time overruns (i.e., a proxy for PB loss) decreases if the PB has used negotiated procedures and has awarded the contract to a firm with which it has previously worked. Moreover, we empirically highlight that PBs, that have previously experienced SWEs, are

[1] A low winning price in an open procedure can be detrimental to the quality of the work, and can therefore reduce social welfare (Cameron, 2000 and Decarolis, 2014).

[2] Levin (2003) studies how self-enforcing relational contracts can overcome moral hazard and hidden information. The importance of relational contracts extends beyond public procurement. See, among others, Baker et al. (2002), Board (2011), Halac (2012) and Macchiavello (2021).

more likely to use negotiated procedures in designing new tenders. Also, in line with the literature (see Section 2), we find that both the use of negotiated procedures and the awarding of contracts to firms that have previously worked for the PB reduce the likelihood of time overruns. This result is compatible with the existence of relational contracts such as those described in our simple theoretical setting.

The remainder of the paper is organized as follows. Section 2 discusses how the paper contributes to the literature. Section 3 illustrates our simple theoretical framework. Section 4 describes the institutional setting and the data used. Section 5 sets out the empirical analysis and discusses results. Section 6 concludes.

2 Literature Review

Our paper contributes to the literature on procurement auction formats and their effect on contract performance (see Dimitri et al., 2006 for a summary of early contributions and applications). The focus of this paper on the PB's choice of the awarding mechanism links our analysis to Lambert-Mogiliansky and Sonin (2006), Burguet and Che (2004) and Burguet (2017). This strand of research studies auctions in which a PB favors some bidders in exchange for monetary transfers. In equilibrium, the PB distorts the procurement procedure in its own interest at the expense of public welfare. Even in the absence of monetary incentives, the preferential treatment of some bidders may still reduce welfare because it discourages other firms from participating in the awarding procedure (Krasnokutskaya and Seim, 2011). However, in our setting, the PB favors a bidder in order to improve contractual outcomes and to better address the consequences of SWEs. Here, negotiated procedures can improve welfare.

We also contribute to the literature on the role of discretion and informal contracts in mechanism design. When certain contingencies are not verifiable, formal contracts —

i.e., externally enforceable contracts that specify a reward/punishment for each act of the contractual parties — often fail to provide the right incentives to agents. In this scenario, self-enforcing relational contracts, based on the repeated interaction of the contracting agents, can overcome moral hazard and hidden information (Levin, 2003).[3] In line with these insights, we show how the aggravation of weather-related risks leads PBs to adopt procedures that help to foster relational contracts.

The literature demonstrates how relational contracts can be beneficial for public procurement. For instance, Cameron (2000) and Decarolis (2014) show that negotiated procedures result in higher quality work than open procedures. Similarly, Coviello et al. (2018) and Carril (2021) find that restricting the number of firms participating in an auction increases the awarding price, but also reduces time and cost overruns. Our paper adds to this literature. It shows that a PB reacts to SWEs by decreasing the share of open compared to negotiated procedures and awarding procurement jobs more often to firms with which it has experience. These patterns are compatible with the existence of relational contracts between a PB and its suppliers.[4] In this respect, we are close to Board (2011) and Calzolari and Spagnolo (2017), studying the role of relational contracts in a setting where a firm repeatedly interacts with its suppliers.

We show that the contractual relationship between PBs and firms is also subject to external (weather-related) shocks. We then establish a link with Macchiavello and Morjaria (2015) and Gil et al. (2022) who investigate how external shocks modify the reputation of a firm's suppliers. We document the impact of exogenous weather events on contract performance and are, to the best of our knowledge, the first to investigate how SWEs affect

[3]In a similar vein, Barron et al. (2020) shows that a combination of formal and relational contracts improves contractual outcomes over the use of each of these instruments in isolation (for this, see Corts and Singh, 2004). Bajari et al. (2009) provides evidence that awarding procedures based on direct negotiation can improve welfare compared to open auctions with multiple participants. This outcome is particularly likely when a firm is required to carry out complex tasks and the contract design is incomplete.

[4]The role of informal self-enforcing relationships and reputation in the contractual setting is notoriously hard to estimate. See, however, Macchiavello and Morjaria (2021, 2023) for recent progresses in this area.

subsequent PB choices in the design of public procurement procedures.

3 Theoretical framework

A PB ("she") interacts with a set $N = \{1, 2, ..., n\}$ of firms ("it", $n \geq 2$) over infinitely many periods $t = 1, 2, ...$ In every period t, the PB wants to procure a work that she values $g > 0$. The payoff from not procuring the work is normalized to 0. The PB and the firms share a common discount factor equal to $\delta \in (0, 1)$.

The set of firms N is constant over time. The same firm can execute procurement contracts in multiple periods. If firm i executes the work in period t, it incurs an *execution cost* equal to $\theta_{i,t} \in \mathbb{R}_{++}$. Execution costs are independent for firms and over periods and are drawn at the beginning of each period from a continuously differentiable cumulative density function F with support $\Theta = [0, \overline{\theta}] \subset \mathbb{R}_+$. The probability density function associated with F is a continuous function f. Firms that execute no work do not incur any cost.

In every period t, a random shock can reduce the PB value g by an amount equal to $\ell > 0$. For instance, a severe weather event can delay the completion of the work. The shock hits with probability $q < 0.5$. We assume that the PB always wants to procure the work independently of the occurrence of the shock and the firm's execution cost. Formally, we assume $g > \overline{\theta} + \ell$.

In addition to execution costs, firms also differ in their *resilience to the shock*, s_{it}. A firm with high resilience to shocks cushions the loss ℓ that the PB suffers when a shock occurs. Hence, s_{it} captures the organizational skills and capital and labor endowments that enable firm i to continue executing the contract even after the shock occurs. The resilience to the shock is a stochastic process that evolves as follows:

$$s_{i,t} = \frac{1}{2}s_{i,t-1} + \frac{1}{2}\varepsilon_{i,t}. \tag{1}$$

$\varepsilon_{i,t}$ is an iid random variable that takes value 0 with probability $(1-\alpha)$ and value 1 with probability α. The value of $\varepsilon_{i,t}$ is realized in period t after the awarding of the procurement contract and before the realization of the shock. Importantly, the resilience to shock is persistent: a firm that has developed the ability to cope well with a shock today carries this ability into the next period. Firms are thus of multidimensional type.

Let w_t be the firm that wins the awarding procedure in period t. If the shock occurs in period t, firm w_t can intervene to eliminate the loss ℓ (action $d_t = 1$). If the firm intervenes, it pays a cost $c > 0$ and the intervention is successful with probability $s_{w_t,t}$. In this case, the PB incurs no loss. If the firm w_t does not intervene (action $d_t = 0$) or it intervenes unsuccessfully, the PB incurs the loss ℓ. When there is a shock at time t and firm w_t intervenes, the PB observes both $s_{w_t,t-1}$ and $\varepsilon_{w_t,t}$. Differently, the PB does not observe these two parameters, and in general does not gain any additional information about firms that do not execute the contract or do not intervene.

The PB can award the procurement contract through one of two possible procedures: a first-price open procurement auction with all firms in set N participating, or a first-price negotiated procurement auction in which a set $R \subset N$ of firms is invited to participate. Let $r < n$ be the number of firms in set R. In a negotiated procedure, the PB also chooses the identity of the participating firms. The restriction to an exogenous set of awarding procedures captures the administrative and procedural constraints faced by the PB. The PB cannot then choose the optimal, cost-minimizing procurement auction; i.e., she cannot take a mechanism design approach.

The procurement auctions are implemented as follows. Each firm i participating in the auction in period t submits a bid $b_{i,t}$. The bid represents the payment the firm is willing to accept to execute the contract. The PB awards the work to the firm that submits the lowest bid, which becomes firm w_t (ties are broken randomly). Firm w_t receives the monetary amount $b_{i,t}$ and pays the execution cost $\theta_{i,t}$. After the award of the auction in period t, $\varepsilon_{i,t}$ is determined and the uncertainty regarding the occurrence of the shock is resolved. Firm w_t then decides whether or not to intervene.

The model described above has multiple equilibria. In particular, there exists an equilibrium in which the PB always runs open auctions and firms never intervene to reduce the loss ℓ. If the PB always runs an open auction, firm w_t has no incentive to intervene at time t. The intervention entails a cost equal to $c > 0$ and no benefit — the PB does not adjust future auctions based on the intervention of firm w_t's, nor on her resilience to the shock. In every period, the PB then selects the transfer-minimizing award mechanism, namely the open one. Standard results in auction theory then imply that the discounted expected payoff of the PB is equal to $\mathcal{V}^B = \left[g - q\ell - \int_0^{\overline{\theta}} \left(nF(\theta)(n-1)(1-F(\theta))^{n-2}\right) f(\theta)d\theta\right] / [1-\delta]$, while the discounted expected payoff of a generic firm i is equal to $\mathcal{U}^B = \left[\int_0^{\overline{\theta}} (1-F(\theta))^{n-1} F(\theta)d\theta\right] / [1-\delta]$.

To improve on this equilibrium, the PB can establish a relational contract with firms. A simple relational contract is as follows: If no shock occurs at time t or if a shock occurs but firm w_t does not intervene, the PB runs an open procedure at time $t+1$. If a shock occurs at time t and firm w_t intervenes, the type of auction at time $t+1$ depends on the realization of $\varepsilon_{w_t,t}$. If the PB learns that $\varepsilon_{w_t,t} = 1$, she also learns that firm w_t can reduce losses at time $t+1$. The PB then runs a negotiated auction at time $t+1$ and she includes firm w_t among the participants. If $\varepsilon w_t, t = 0$, the PB runs an open procedure at time $t+1$. Firm w_t best responds to the behavior of the PB and it intervenes at time t if and only if the cost of intervention c is sufficiently low and $\varepsilon_{w_t,t} = 1$.

The PB uses an open auction in the first period. From then on, the PB and the firms act according to the relational contract described above until the PB deviates from it.[5] If the PB failed to honor the relational contract at least once in the past, firms stop intervening and the PB only runs open procedures. In this case, payoffs revert to $\mathcal{V}^B$ and $\mathcal{U}^B$.

The logic behind the relational equilibrium is simple. When the PB finds out that firm

[5]Deviations from the point of view

w_t has a high resilience to the shock both at time t and at time $t+1$ ($d_t = 1$ and $\varepsilon_{w_t,t} = 1$), the PB rewards the firm by including it in future negotiated procedures through a relational contract. Under this relational equilibrium, when the frequency of shocks q increases, the intervention of firms becomes more likely and the frequency of open procedures consequently decreases.

The previous discussion can be summarized in the following proposition (proof in the Appendix).

Proposition 1. *There exist thresholds $\bar{\ell}$ and $\bar{c}$, such that if the shock is sufficiently disruptive for the PB ($\ell \geq \bar{\ell}$), and the intervention of the firm is not too costly ($c \leq \bar{c}$), the relational equilibrium described above is sustainable. Under this relational contract, the share of open procedures decreases with the frequency of the shocks, q.*

The relational contract described above is not the only feasible one. For instance, if the firm failed to intervene after a shock at time t, the PB could punish it by running a negotiated auction at time $t+1$ excluding firm w_t from the participants. In this case too, the frequency of open procedures would decrease with the increased frequency of shocks. In general, relational contracts use future negotiated procedures to incentivize firms to intervene after a shock. Under a relational contract, the share of open procedures necessarily decreases with the frequency of shocks.[6]

[6]The PB could also establish relational contracts in which the procedure at time at time $t+1$ is negotiated if there was no shock at time t or if there was a shock, firm w_t intervened and $\varepsilon_{w_t,t} = 1$. In this case, open procedures would be chosen if there was a shock at time t and either firm w_t did not intervene, or it intervened and $\varepsilon_{w_t,t} = 0$. In this case, the share of open procedures would not decrease with the frequency of the shock q. Under these relational contracts, however, the expected payments to firms would be higher in all periods without shocks. Because $q < 1/2$, the payoff of the PB under this type of relational contract would then be lower than under the relational contract described above.

4 Setting and data

4.1 Institutional framework

Our analysis focuses on Italian public procurement contracts, regulated by the Italian code of laws called “Codice dei contratti pubblici”, (henceforth, CdCP). The first version of the CdCP came into effect in April 2006 (Legislative Decree no. 163/2006) and underwent profound revision in 2016 (Legislative Decree no.60/2016) and further minor revisions in April 2017 (Legislative Decree no. 56/2017) and in June 2019 (L. 55/2019). The CdCP regulates all aspects of public procurement, including preliminary feasibility studies, rules that guarantee the publication of the call for tender, awarding mechanisms and the monitoring of the work during execution of the contract.

When an Italian PB procures a work, it can adopt procedures with no discretion in the selection of participating firms (i.e., *”procedure aperte”*, open procedures), or it can adopt procedures where she has discretion in the selection of participating firms (i.e., *”procedure competitive con negoziazione”*, negotiated procedures[7] In an open procedure, the PB publishes the details of the proposed procurement and all firms can participate in the auction. In a negotiated procedure, instead, the PB invites a group of firms to submit a bid for the work it wishes to procure and then negotiates specific details with the bidders.[8]

We focus on procurement procedures initiated by municipalities. These procedures are the result of a political decision by elected officials based on the available public resources. Once initiated, public procurement procedures directly involve bureaucrats in both the planning and the execution of works. For each procurement procedure, the PB appoints a public officer (*”Responsabile Unico del Provvedimento”*, henceforth RUP), who manages the various steps

[7]There are other types of procedures. For instance, when the PB stipulates a contract with a value under EUR 40,000, it can directly select the firm (*affidamento diretto*). At the other extreme, if a PB stipulates a contract with a value above EUR 5,000,000, it must adopt a special European procedure (*procedura comunitaria*).

[8]Starting in 2016, a PB that adopts a negotiated procedure must rotate its invitations. Specifically, a PB cannot invite the same firm to two consecutive tenders for the same type of work.

of the procedure. If the procurement contract concerns engineering or architectural work, the RUP must have the necessary technical qualifications. The RUP monitors the correct steps of the awarding procedure and completion of the job. Finally, a procurement manager appointed by the PB (*"Direttore Lavori"*, henceforth DL) manages and monitors the daily execution of the work.

Severe weather events, extenuating circumstances (e.g., earthquakes, riots, public health concerns), or the intervention of the judiciary authority can cause a suspension in the execution of works. These suspensions do not have any direct cost for the PB. Yet, they delay completion of the work, which is an indirect cost for the PB. Firms can speed up the resumption of the work after suspension, but this is costly. For instance, they can increase the number of working hours, or transfer resources from other worksites.

Regional administrative judges monitor the regularity of the awarding procedure. Appeals against the ruling of administrative judges are hear in the *Consiglio di Stato*, a Court located in the national capital, Rome. Legal disputes concerning the execution of the work (in particular, time overruns) are decided by judges, usually located in provincial capitals. Appeals against rulings are heard in regional courts called *Corti d'Appello*.

4.2 Dataset

Our aim is to study how SWEs affect the choices of Italian PBs in designing procurement tenders. Therefore, we assembled a large dataset of Italian procurement tenders in the period 2008-2021. The data are available from the Italian National Anticorruption Agency (henceforth, ANAC)[9]. The database includes information on the main elements of the tender (reserve price, awarding mechanism, entry restrictions), outcomes (winning price, winning firm identity), and contract execution (suspensions, if any,, the reason for the suspension,

[9]Source: https://dati.anticorruzione.it/opendata/ocds_it. Data have been publicly available since 2008.

time overruns and cost overruns).

We focus on a subset of homogeneous procurement tenders. Specifically, we consider tenders for the construction and maintenance of buildings and roads,[10] with a reserve price above EUR 50,000, and a municipality acting as the PB. Works on buildings and roads are among the most exposed to adverse weather conditions: 54% of all suspensions due to adverse weather conditions involve these two types of work. Considering contracts with a reserve price above EUR 50,000 construction and maintenance of buildings and roads accounts for 22.9% of all contracts awarded by Italian municipalities. We include contracts with a reserve price above EUR 50,000 for two reasons. First, if the reserve price is below EUR 40,000, the PB can directly award a contract to a specific firm without involving potential competitors in the process.[11] Second, for procurement tenders with a reserve price below EUR 40,000, the ANAC database contains only a subset of information.[12]

Finally, we consider procurement tenders of municipalities because this allows us to identify a specific geographical area where the procurement works take place. This way, we can associate location-specific weather events to public buyers.

Our final sample includes 124,712 procurement tenders managed by 7,632 municipalities between 2008 and 2021. It covers 62% of the procurement contracts awarded by Italian PBs for the construction and maintenance of buildings and roads during the period under consideration.

We combine the dataset on procurement tenders with information on SWEs obtained through the European Severe Weather Database (henceforth, ESWD). ESWD records detailed quality-controlled information on severe convective storm events in Europe, with their

[10] The type of work is identified using the Common Procurement Vocabulary (CPV).

[11] We choose a larger threshold—EUR 50,000 instead of EUR 40,000—to avoid contract bunching i.e., the splitting up of a single potential contract into multiple smaller contracts to circumvent the legislative discontinuity at EUR 40,000. See Palguta and Pertold (2017), Tas (2022), and Coviello et al. (2022) for evidence of the existence of this type of bunching.

[12] In particular, the database only collects information to track financial flows, and does not also monitor the award and the execution of the work.

date (Dotzek et al., 2009). Data are georeferenced, zero-dimensional (i.e. points), and have been available since 2009.[13].

For each time a PB i announced a public tender, we measure its exposure to past SWEs with the following variable:

$$SWE_{it}^{\Delta} = \#\text{ of severe weather events in the } \Delta \text{ years prior to time } t \quad (2)$$

SWE_{it}^{Δ} counts the number of past SWEs in a time window of Δ years ending at time t. In the main analysis, the width of Δ is set at three years, but in the Appendix we report results for other widths, ranging from one to five years. We define the variable SWE_{it}^{Δ} on a rolling basis because events that occurred in more recent years can have a stronger impact on the choice of the PB, and PBs may have experienced SWEs before the year in which data from the ESWD starts.

The summary statistics of the variable SWE_{it}^{Δ} for the different lengths of the window Δ are set out in Table 1.[14] On average, if we consider the window with width $\Delta = 3$, a PB announcing a new tender experienced 0.68 severe weather events in the relevant time period.

[Table 1 about here]

Because we consider SWEs over a rolling window with width equal to three years, our final sample includes information on procurement tenders announced in the period 2012-2021. The final database includes 90,794 observations. Table 2 provides the summary statistics for all variables contained in our main analysis.

[Table 2 about here]

[13]In our analysis, we only consider events confirmed by a reliable source (quality level QC1 or above). The reporting criteria of an event are available at `https://www.eswd.eu/docs/ESWD_criteria_en.pdf`. Heavy rain is the most frequent event included in our dataset. The definition of heavy rain used in the ESWD is the following: *"Rain falling in such large amounts, that significant damage is caused, or no damage is known, but exceptionally high precipitation amounts have been observed within a period of at most 24 hours."* Operationally, it means that rainfall exceeds a fixed threshold for precipitations over a given time period.

[14]Data on procurement tenders and on severe weather events are available respectively from 2008 and 2009 As we increase the width of the rolling window Δ, the number of observations decreases.

The average reserve price (i.e., the PB's maximum posted willingness to pay for the tendered work) is 323,000 euro, and almost all the tenders (96.6%) include a reserve price under 1 million euros. On average, PBs manage about 12 procurement tenders for the construction and maintenance of buildings and roads every year. The average yearly share of procedures without an ex-ante restriction on the set participants ("Open procedures") is 18.4%, and it amounts to almost two procedures per year. The share of open procedures varies with the size of the work. The average share of open procedures is below 20% for tenders with reserve price of under one million euros, and is close to 80% for tenders with reserve price of over one million euros.[15]. This discontinuity captures stricter administrative requirements for the use of negotiated procedures, when the reserve price exceeds the one million euro threshold.[16] The median number of firms participating in an open auction is 15, while the median number of firms participating in a negotiated procedure is three.

Procurement tenders are mostly concentrated in northern Italy (53%). Municipalities in southern Italy (including Sicily and Sardinia) account for 30% of the total number of tenders, with the remaining 17% in central Italy. Five of the twenty Italian regions benefit from special financial and administrative independence (*"Regioni a statuto speciale"*). These regions manage 16.6% of the total number of tenders. Lastly, 18.3% of the procurement tenders are managed by a PB in a local capital (*"capoluogo di provincia"* or *"città metropolitana"*), i.e., a vast geographical area which tends to be highly populated.

Our dataset also includes information on the political cycle of PBs. In particular, the variable *Mayor tenure* measures the number of years since the last election. Also, we include information on the mayor's education (about 60% of Italian mayors in our dataset have a

[15] See Figure B-i, Appendix B1 for further information.

[16] Open procedures are the default mechanism used in the Italian public procurement process. Nevertheless, open procedures generate additional administrative and time costs for public buyers. Therefore, the law gradually simplifies the use of negotiations as the value of the reserve price decreases. This is implemented through a set of different thresholds. Below each of these thresholds, PBs have larger leeway in the use of negotiated procedures. The one million euro threshold plays an important role.

Bachelor or Master degree [17]

Two thirds of the procurement tenders in our dataset include information on the winning firm. In 26.5% of these cases, the winning firm had previously worked for the PB managing the tender. We call these firms *incumbents*. In our dataset, a firm awarded a tender by a given PB on average had executed 8.8 contracts in the past. Of these 8.8 contracts, 4.7 were in the territory of the PB. This result suggests how firms tend to specialize in certain geographical areas. The contractual duration of procurement works is on average 278 days, evenly distributed (the 10th, 50th and 90th percentiles are respectively equal to 90, 229 and 513 days). The actual duration is often longer: the average duration is 357 days, and time overruns - measured as a delay in completing the work - occur in 62.6% of cases.[18]

In addition to measuring the occurrence of SWEs before the start of the tender (SWE^{Δ}_{it}), we also measure the occurrence of SWEs during the execution of the work. Specifically, we let CS_{it} be a binary variable equal to one if at least one SWE occurs between the start of the procurement tender (time t) and the date of completion.

5 Empirical analysis

5.1 The Role of Past SWEs

In this section, we show that the exposure to past SWEs affects the choice of the awarding mechanism for new contracts. For this purpose, we define the dummy variable OP_{it}, equal to 1 if auction i started at time t is an open procedure. Our baseline regression model is:

$$OP_{it} = \alpha + \delta SWE^{3}_{it} + \beta C_{it} + \lambda_i + \tau_{it} + \varepsilon_{it}, \quad (3)$$

[17] Data on the mayors come from the Italian Ministry of the Interior. Source: https://elezioni.interno.gov.it/opendata

[18] The distributions of contractual duration and time overruns (in days) are reported in Figure B-ii in Appendix B1

The key identifying assumption to estimate δ in the regression model (3) is the exogeneity of SWE^3_{it}: past SWEs are random events that do not depend on the PB's past choices of the awarding mechanism. Although SWEs are random, they can exhibit spatial autocorrelation (across municipalities that are geographically similar), and time autocorrelation (within the same municipality). We control for the spatial autocorrelation, through the variable τ_{it}. These are fixed effects at NUTS 2 level (20 Italian regions) interacted by time (40 quarters, from 2012 to 2021) and by PB altitude.[19] We control for time autocorrelation clustering standard errors at the PB level.

Regression model (3) also include PB fixed effects (λ_i, 7,478 municipalities), and a vector of controls that captures some specific features of the tender (C_{it}). These controls include fixed effects for the work type (the construction and maintenance of buildings and roads is further divided into 55 different types of work), and three controls for the size of the work: the log-reserve price (*Ln Reserve Price*), a dummy variable equal to 1 if the reserve price exceeds one million euros (*1M*), and the interaction between the previous two variables (*Ln Reserve Price*$\times$ *1M*). We control for the EUR 1 million threshold to capture discontinuity in the use of open procedures at this threshold (see Figure B-i).

Table 3 (column 1) shows the estimate of (3).[20]If an additional SWE strikes a territory, the PB managing thesuch territory is then less likely to use open procedures when she designs new tenders. This finding is statistically significant at the 1% level. In addition, the use of open procedures is more likely for larger tenders (*Ln Reserve Price* variable).

Table 3 (columns 2-5) shows the results of additional estimations to test the robustness of our findings. The negative and significant coefficient of SWE^3_{it} holds true in all our models.

Column 2 runs a probit model where PB fixed effects are replaced with two variables: a dummy equal to 1 if the PB is the administrative center of a district (*County seat*), and

[19]We measure altitude with 3 binary variables accounting for territories at low (valleys and plains), medium (hills) or high (mountains) altitude, as defined by the Italian National Institute of Statistics.

[20]533 singleton observations are dropped.

the natural logarithm of the population (*Ln Population*). Column 3 shows whether the main driver of our finding is the loosening of administrative restrictions for the use of negotiated procedures due to natural disasters (e.g., earthquakes, large floods, avalanches). In such extreme circumstances, the Italian Government can grant PBs a higher level of discretion in managing procurement procedures.[21] PBs can then use their discretion to increase the use of negotiated procedures, speed up the procurement process, and promptly intervene to remedy damage. As a result, geographical and temporary regulatory changes (and not the effects of SWEs on the choice of the awarding procedure) can increase the PB's use of negotiated procedures. To address this potential confounding channel, Column 3 repeats our analysis for a smaller sample excluding all procurement contracts in areas where additional discretion was provided after the occurrence of a natural disaster.

Column 4 investigates possible spillover effects from SWEs in municipalities close by. To account for this scenario, we construct a set of variables $SWEN_{it}^{\Delta}$ as follows: for each procurement tender i announced at time t, $SWEN_{it}^{\Delta}$ counts the number of SWEs that occurred in the previous Δ years ($\Delta \in \{1, 2, 3, 4, 5\}$) in municipalities that share a land border with the territory of the PBs managing tender i.[22] Exclude from the analysis are 112 observations from municipalities located in islands and other isolated territories. Table B-1 in the Appendix provides the descriptive statistics of variables $SWEN_{it}^{\Delta}$. For each width Δ, the average value of $SWEN_{it}^{\Delta}$ is about 4 times larger than SWE_{it}^{Δ}. We then run the regression model 3 adding the variable $SWEN_{it}^{3}$ among the controls. The coefficient associated with this variable is not significant, while the coefficient associated with SWE_{it}^{3} remains significant. The reduction in the share of open procedures is thus mostly driven by SWEs striking the territory of the PB.[23]

[21]The central government grants this additional discretion through specific decrees, recorded in a dataset provided by the Italian Civil Defense (Protezione Civile). Data are available here: https://www.protezionecivile.gov.it/it/dipartimento/amministrazione-trasparente/interventi-straordinari-e-di-emergenza.

[22]On average, each municipality borders 7 others.

[23]This finding is in line with the theoretical model in Section 3. Even though a PB can observe interventions

Finally, Column 5 investigates whether mayors' characteristic influence the awarding mechanism chosen by the PB (see Bucciol et al., 2020; Coviello and Gagliarducci, 2017, for evidence of this). This is particularly likely to occur in small municipalities with few professional bureaucrats where the mayor is more involved in day-to-day management. We account for the characteristics of the mayor by adding two additional controls to regression model 3: years in office since the last election, and a set of dummies that capture the mayor's educational level. Table 2 sets out the descriptive statistics of these variables. The tenure in office of the mayor is statistically associated (at the 10% level) with a reduction in the probability of using open procedures.[24] The educational level of the mayor is not correlated with the use of open procedures.

In our analysis, we define the exposure to SWEs based on a time window with width of three years. Table B-2 in the Appendix investigates the robustness of our findings to alternative measures of exposure. First, we let the width Δ in SWE_{it}^{Δ} range between 1 year and 5 years. For this purpose, we restrict the dataset to tenders in the period 2014-2021 because 2014 is the first year in which SWE_{it}^{5} were observed. Irrespective of the width of the window, Columns 1-5 show that open procedures are less likely after SWEs. Second, we construct a set of variables counting the number of past SWEs in PB territories using multiple windows with the same width (1 year), but different starting times: 1 year before (SWE_{it}^{0-1}), 2 years before (SWE_{it}^{1-2}), 3 years before (SWE_{it}^{2-3}), 4 years before (SWE_{it}^{3-4}), and 5 years before (SWE_{it}^{4-5}). Column 6 in Table B-2 shows that the impact of past SWEs remains negative and statistically significant over time.

in adjacent municipalities, it has no information about the realization of ε. If the PB rewards interventions in adjacent municipalities with negotiated procedures, firms with low resilience to the shock have an incentive to intervene. In equilibrium, the PB would then prefer not to invite the firm to a negotiated procedure.

[24] The negative correlation between tenure in office and the use of open procedures is therefore consistent with Coviello and Gagliarducci (2017) who show that longer mayoral terms in office reduce the number of participants in procurement auctions.

5.2 The relational contract mechanism

The previous section shows that the occurrence of SWEs in the past reduces the frequency of open procedures in the future. We now analyze how this reduction can modify the likelihood of time overruns, i.e., those events for which the actual duration of a procurement contract exceeds the contractual one. Time overruns are an important indicator of performance during the execution of a contract. Reductions in the frequency of time overruns are consistent with the presence of relational contracts between the PB and firms. The model in Section 3 suggests that the prospects of future negotiated procedures incentivize winning bidders to intervene to reduce the delays caused by SWEs striking during the execution of the work. In this section, the empirical analysis shows that the selection of a negotiated procedure decreases the probability of time overruns and that this effect is stronger if an incumbent (i.e., a firm that has previously worked for the PB awarding the contract) is awarded the contract.

Specifically, we estimate the following regression model:

$$TO_{it} = \alpha + \delta_1 CS_{it} + \delta_2 SWE^3_{it} + \delta_3 IW_{it} + \delta_4 OP_{it} + \beta_1 D_{it} + \lambda_i + \tau_{it} + \varepsilon_{it}, \quad (4)$$

where TO_{it}, CS_{it} and IW_{it} are three binary variables equal to 1 if the contract ended with a time overrun, if a SWE occurred during contract execution, and if the tender was awarded to an incumbent, respectively, and zero otherwise. D_{it} is a vector of contract specific variables including the log-reserve price, the contract duration (in days), and fixed effects for the various types of procurement contract (55 different types of work related to buildings and road construction). λ_i and τ_{it} are defined as in equation (3).

The results are shown in Table 4, Column 1.[25] We find no statistically significant correlation between past severe weather events (SWE^3_{it}) and time overruns (TO_{it}). This is intuitive.

[25] The number of observations in Table 4 is smaller than in Table 3 because information on time overruns is available only for a subset of the procurement tenders in our dataset.

Past SWEs occurred before the awarding of a contract and cannot therefore directly affect its execution. SWEs during the contract are positively correlated to time overruns: the coefficient of CS_{it} is positive and statistically significant at the 1% level. OP_{it} and IW_{it} are respectively positively and negatively associated with TO_{it}. These results are consistent with the theory setting in section 3: relational contracts take place through negotiated procedures ($OP = 0$) involving incumbent firms ($IW = 1$). This finding holds true for all the other models we run as described below (Columns 2 to 4 in Table 4).

To the baseline regression Column 2 adds the interaction between the type of awarding procedure and the presence of an incumbent winner ($OP_{it} \times IW_{it}$). This regression model provides key insights, supporting the presence of relational contracts in the setting considered (and sketched in Section 3). In particular, the regression model defines a baseline case, where the PB uses a negotiated procedure and awards the work to a new firm (i.e. $OP_{it} = IW_{it} = 0$). It then compares this baseline scenario to three alternatives, varying either the procedure used (open rather than negotiated), or the identity of the winner (an incumbent rather than a new firm), or both these dimensions at the same time. Of the four possible scenarios, we find that the probability of time overruns is the lowest when PBs award a tender to an incumbent firm through a negotiated procedure: the coefficient of the variable IW_{it} denotes a reduction in TO_{it} equal to 0.046 ($p < 0.001$) with respect to the baseline. The probability of time overruns is the highest when PBs award a procurement contract through an open procedure: the linear combination of OP_{it}, IW_{it} and $IW_{it} \times OP_{it}$ denotes an increase in TO_{it} equal to 0.055 ($p < 0.001$) with respect to the baseline when the award is made to an incumbent, and the coefficient of the variable OP_{it} alone denotes a similar increase in TO_{it} when the award is made to a new contractor. Finally, note that where a contract is awarded through an open procedure, no significant difference between the incumbent and other contractors is evident in terms of time overruns: the linear combination between IW_{it} and $IW_{it} \times OP_{it}$, is not significant ($p = 0.351$).

The findings discussed above are consistent with the relational contract described in Section 3. The PB relies on negotiated procedures to select firms that exhibited high resilience to shocks in the past and are thus more likely to reduce the losses (i.e., the time overruns) in the future. Also, firms signal their interest in entering into future negotiated procedures with the PB by performing well (i.e., by completing the work on time).

Column 3 builds on Column 2 and provides specific evidence that relational contracts can reduce losses due to SWEs. In particular, Column 3 adds to the regression model in Column 2 further interactions between shocks during the contract and (i) the type of awarding mechanism chosen by the PB ($CS_{it} \times OP_{it}$), and (ii) the victory of an incumbent firm ($CS_{it} \times IW_{it}$). SWEs during the contract increase the likelihood of time overruns. Conditional on a SWE occurring during the contract ($CS_{it} = 1$), there are four possible combinations of OP_{it} and IW_{it}. We rank these combinations based on the ascending likelihood of time overruns (all coefficients discussed below are statistically significant at the 1% level). When an incumbent firm wins a negotiated procedure ($OP_{it} = 0$, $IW_{it} = 1$), the likelihood of time overruns increases by 0.107. If the firm winning a negotiated procedure is not an incumbent ($OP_{it} = 0$, $IW_{it} = 0$), the likelihood of time overruns increases by 0.135. When the procedure is open ($OP_{it} = 1$), the increase in the likelihood of time overruns is equal to 0.220 if the firm executing the work is an incumbent ($IW_{it} = 1$) and otherwise 0.196 ($IW_{it} = 0$). All pairwise comparisons in coefficients are significant at the 5% confidence interval, except for the last two coefficients, not statistically significant. In line with the theoretical framework discussed in Section 3, the effect of CS_{it} on TO_{it} is the lowest when PBs rely on negotiated procedures and an incumbent firm wins the auction. The effect is the highest when PBs use open procedures, irrespective of the identity of the winner.

Finally, Column 4 tests for an alternative explanation to relational contracts: PBs could learn from past SWEs to manage procurement contracts subject to shocks and this could decrease time overruns in the presence of SWEs during the contract. To account for this possibility, Column 4 includes the interaction between SWEs during the contract (CS_{it}) and past shocks (SWE_{it}^3). In the casepresence of a contemporaneous shock during the contract, past experience plays no significant role in explaining TO_{it}. The linear combination between SWE_{it}^3 and $CS_{it} \times SWE_{it}^3$ is not statistically significant ($p = 0.866$). Moreover, in the presence of shocks during the contract ($CS_{it} = 1$) with a fixed number of SWEs, awarding the contract to an incumbent firm through a negotiated procedure reduces the probability of time overruns.[26] No such effect exists when the PB uses an open procedure.[27]

5.3 Sequentiality in the procurement process

In the previous sections we show that in areas where SWEs occurred, for new tenders PBs adopt negotiated more often than open procedures. Furthermore, where an incumbent firm wins, negotiated procedures have the lowest probability of time overruns during the execution of the work.

In this section, we test the robustness of our results when we consider the interplay between the three phases of a public procurement procedure: the design and publication of the tender, the award of the contract and the execution of the work. This interplay occurs through a sequential (one-way) rather than simultaneous (two-way) relationship between the three variables (the design of the tender, OP_{it}, the identity of the winning firm, IW_{it}, and time overruns, TO_{it}). For example, the outcome of the awarding step can influence the likelihood of time overruns, but the converse is not true. Therefore, we estimate the following three

[26] The linear combination between IW_{it} and $CS_{it} \times IW_{it}$ is equal to -0.030 with a p-value equal to $p = 0.025$.

[27] The p-value of the linear combination between IW_{it}, $CS_{it} \times IW_{it}$, and $IW_{it} \times OP_{it}$ is 0.371.

equations, where a, b, c denote the first, second, and third step of the procurement process:

$$
\begin{aligned}
OP_{it} &= \alpha^a + \beta^a \boldsymbol{X}^a_{it} + \lambda^a_i + \tau^a_{it} + \epsilon^a_{it} \\
IW_{it} &= \alpha^b + \delta^b OP_{it} + \beta^b \boldsymbol{X}^b_{it} + \tau^b_i t + \lambda^b_i + \epsilon^b_{it} \\
TO_{it} &= \alpha^c + \delta^{c1} OP_{it} + \delta^{c2} IW_{it} + \beta^c \boldsymbol{X}^c_{it} + \lambda^c_i + \tau^c_{it} + \epsilon^c_{it}
\end{aligned}
\tag{5}
$$

Ordinary Least Squares (OLS) is an appropriate model for each stage if there is no correlation between the error terms of the three linear models. Nonetheless, the error terms of the three steps may be correlated, for instance due to some specific PB characteristic. We account for this possibility by estimating 5 through a Generalized Structural Equation Model (GSEM). All stages are modelled with a probit model, and standard errors take into account that OP_{it} (in the second and third stages) and IW_{it} (in the third stage) are predicted from previous regressions.[28].

In (5), $\boldsymbol{X}^a_{it}$, $\boldsymbol{X}^b_{it}$, $\boldsymbol{X}^c_{it}$ are vectors of controls that always include the log of the reserve price (*Ln Reserve Price*) and fixed effects for work types (55 different works related to building and road constructions). $\boldsymbol{X}^a_{it}$ includes SWE^3_{it} and the same variables used in the baseline regression shown in Tab 3, Column 1. $\boldsymbol{X}^b_{it}$ adds an awarding-stage specific control, *Past contracts*. This variable counts the number of previous contracts awarded to the winning firm within the PB province with the exception of those awarded by the PB itself.[29] Finally, as far as the third stage of (5) is concerned, we replicate the analysis in Table 4, Column 1,

[28] A 3SLS instrumental variable approach would also result in a consistent estimate of 5. However, the number of instruments (including 7,478 PB FEs and 2,400 FEs given by the PB region interacted by altitude and time) would be too high for this approach to be computationally feasible. Alternatively, we could rely on bootstrapping. However, the latter approach, would not explicitly model the sequential relation between the three stages.

[29] To learn about the variables to include in $\boldsymbol{X}^b_{it}$, we estimate IW using a set of specifications similar to Table 3. Unlike model 3, we exclude the variable *1M* and its interaction with *Ln Reserve Price* because the administrative threshold at EUR 1 million affects solely the tender design. Finally, we add OP_{it} and $Pastcontracts_{it}$. Table B-3 in the Appendix sets out the results. The use of an open procedure is negatively associated with the likelihood of an incumbent firm winning the tender. The variable *Past contracts* is always positive and highly significant, while, at least in Column 1 (our baseline specification), SWE^3_{it} is not. In general, we only have information on the winning firm in 60,109 observations compared with the 90,259 observations when estimating *OP*.

but exclude SWE^3_{it} used in the first stage.

Computational constraints limit the use of fixed effects compared to Tables 3 and 4. Specifically, τ_{it} is now a vector of binary variables indicating the NUTS 2 level (20 Italian regions) interacted by year (10 years, from 2012 to 2021). λ_i are random intercepts at the PB level. Unlike a model with PB fixed effects, these intercepts are assumed to follow a normal distribution $N(0, \sigma^i)$, with $i \in \{a, b, c\}$.

Columns 5-7 in Table 4 show the result of the GSEM estimation of (5).[30] The qualitative findings of the sequential estimation in the third stage are the same as the linear model in Column 1: shocks during the contract (CS_{it}) increase the likelihood of time overruns, which is reduced in the event of the victory of an incumbent firm (IW_{it}). The use of an open procedure (OP_{it}) increases the likelihood of time overruns. Moving backward to the second stage, open procedures are negatively associated with the probability that an incumbent firm winning the tender. This is compatible with a mechanism in which the PB uses a negotiated procedure to reduce the number of firms participating in a tender, consequently improving the winning odds of incumbent firms. The use by the PB of negotiated procedures to improve the winning odds of some specific firms is consistent with the existing literature (Coviello et al., 2018). Finally, the results in the first stage are similar to those presented in Table 3: the occurrence of past SWES reduces the use of open procedures.

The GSEM procedure properly accounts for the sequential steps in the procurement process and reduces the role of confounding effects in the simultaneous empirical analysis. As such, it provides further and more robust evidence about the role of negotiated procedures and relational contracts on time overruns.

[30] The model identification relies on two elements. First, SWEs that occur before the tender publication date (and that determine SWE^3_{it}), can affect the PB decision to use an open procedure, but not directly the selection of the auction winner, nor time overruns. Second, CS_{it} are exogenous shocks that occur during the execution of the contract and cannot be predicted by the PB or the bidders.

6 Conclusions

Severe weather events (SWEs) have become increasingly frequent due to climate change. These events often determine very destructive effects on territories. In addition, SWEs are particularly harmful for the public procurement of works because they are unpredictable and increase the negative consequences of incomplete contracts. Moreover, SWEs often damage the existing infrastructure and delay the completion of ongoing works.

In this paper, we theoretically and empirically show how public buyers (PBs) adjust the design of procurement tenders in response to SWEs. We first build a theoretical framework, where a PB interacts with a set of firms to procure multiple works over time. SWEs strike randomly and determine losses for the PB. The firm executing the work can reduce these losses. Specifically, we find those conditions under which relational contracts — namely, informal and not externally enforceable arrangements between PBs and firms — are self-enforcing and cushion the losses caused by SWEs. The relational contracts hinge on the PB using negotiated procedures to award procurement contracts. In a negotiated procedure, the PB selects ex-ante the firms that can bid; this is different from open procedures, where any firm interested can participate. To support relational contracts, the PB rewards firms that reduced losses in the past by including them among the participants in future negotiated procedures. This history-dependent incentive scheme encourages firms to reduce the losses to a PB if a SWE strikes.

We then test our predictions using a large dataset on Italian procurement contracts over the period 2008-2021, cross-referenced with geo-localized information on SWEs We find that PBs with previous experience of SWEs are more likely to use negotiated than open procedures. Adopting a negotiated procedure and awarding the contract to a firm that had previously worked for the PB reduces time overruns in the execution of the work, hence PB losses. These empirical findings support the validity of relational contracts between PBs and firms, showing that the ”relationship value” (Macchiavello and Morjaria, 2023) increases with the frequency of SWEs. Our findings are robust to different specifications and hold true even when we test for alternative mechanisms (i.e., PBs that learn from past SWEs can reduce losses).

Our analysis contributes to the debate on the role of discretion in public procurement. In our setting, the PB chooses between open and negotiated awarding procedures weighing the gains from a lower payment against the losses from the short-run opportunism of the winning firm. To the best of our knowledge, we are the first to highlight how SWEs shape this intertemporal trade-off and to evaluate it from an empirical point of view.

Several factors other than SWEs can affect the relational contracts between PBs and firms, and thus affect the dynamic value of these contracts. Discovering these factors, assessing their relevance, and accounting for them in the design of public procurement regulations are natural avenues for future research.

References

Bajari, P., R. McMillan, and S. Tadelis (2009). Auctions versus negotiations in procurement: an empirical analysis. *The Journal of Law, Economics, & Organization 25*(2), 372–399.

Baker, G., R. Gibbons, and K. J. Murphy (2002). Relational contracts and the theory of the firm. *The Quarterly Journal of Economics 117*(1), 39–84.

Barron, D., R. Gibbons, R. Gil, and K. J. Murphy (2020). Relational adaptation under reel authority. *Management Science 66*(5), 1868–1889.

Board, S. (2011). Relational contracts and the value of loyalty. *American Economic Review 101*(7), 3349–67.

Bucciol, A., R. Camboni, and P. Valbonesi (2020). Purchasing medical devices: The role of buyer competence and discretion. *Journal of Health Economics 74*, 1–17.

Burguet, R. (2017). Procurement design with corruption. *American Economic Journal: Microeconomics 9*(2), 315–41.

Burguet, R. and Y.-K. Che (2004). Competitive procurement with corruption. *RAND Journal of Economics*, 50–68.

Calzolari, G. and G. Spagnolo (2017). Relational contracts, procurement competition, and supplier collusion. *University of Bologna Discussion Papers*.

Cameron, L. J. (2000). Limiting buyer discretion: effects on performance and price in long-term contracts. *American Economic Review 90*(1), 265–281.

Carril, R. (2021). Rules versus discretion in public procurement. *Economics Working Papers 1765*.

Corts, K. S. and J. Singh (2004). The effect of repeated interaction on contract choice: Evidence from offshore drilling. *Journal of Law, Economics, and Organization 20*(1), 230–260.

Coviello, D. and S. Gagliarducci (2017). Tenure in office and public procurement. *American Economic Journal: Economic Policy 9*(3), 59–105.

Coviello, D., A. Guglielmo, C. Lotti, and G. Spagnolo (2022). Procurement with manipulation.

Coviello, D., A. Guglielmo, and G. Spagnolo (2018). The effect of discretion on procurement performance. *Management Science 64*(2), 715–738.

Decarolis, F. (2014). Awarding price, contract performance, and bids screening: Evidence from procurement auctions. *American Economic Journal: Applied Economics 6*(1), 108–32.

Dimitri, N., G. Piga, and G. Spagnolo (2006). *Handbook of procurement*. Cambridge University Press.

Dotzek, N., P. Groenemeijer, B. Feuerstein, and M. A. Holzer (2009). Overview of essl's severe convective storms research using the european severe weather database eswd. *Atmospheric Research 93*, 575–586.

Gil, R., M. Kim, and G. Zanarone (2022). Relationships under stress: Relational outsourcing in the us airline industry after the 2008 financial crisis. *Management Science 68*(2), 1256–1277.

Halac, M. (2012). Relational contracts and the value of relationships. *American Economic Review 102*(2), 750–79.

Krasnokutskaya, E. and K. Seim (2011). Bid preference programs and participation in highway procurement auctions. *American Economic Review 101*(6), 2653–86.

Lambert-Mogiliansky, A. and K. Sonin (2006). Collusive market sharing and corruption in procurement. *Journal of Economics & Management Strategy 15*(4), 883–908.

Levin, J. (2003). Relational incentive contracts. *American Economic Review 93*(3), 835–857.

Macchiavello, R. (2021). Relational contracts and development. *Annual Review of Economics 14*.

Macchiavello, R. and A. Morjaria (2015). The value of relationships: evidence from a supply shock to kenyan rose exports. *American Economic Review 105*(9), 2911–45.

Macchiavello, R. and A. Morjaria (2021). Competition and relational contracts in the rwanda coffee chain. *The Quarterly Journal of Economics 136*(2), 1089–1143.

Macchiavello, R. and A. Morjaria (2023). Relational contracts: Recent empirical advancements and open questions. (30978).

Palguta, J. and F. Pertold (2017). Manipulation of procurement contracts: Evidence from the introduction of discretionary thresholds. *American Economic Journal: Economic Policy 9*(2), 293–315.

Schuldt, S. J., M. R. Nicholson, Y. A. Adams, and J. D. Delorit (2021). Weather-related construction delays in a changing climate: a systematic state-of-the-art review. *Sustainability 13*(5), 2861.

Tas, B. K. O. (2022). Bunching below thresholds to manipulate public procurement. *Empirical Economics*, 1–17.

Table 1: Descriptive Statistics of exposure to past SWEs

	Mean	Sd	P10	P50	P90	Count
SWE_{it}^{1}	0.314	0.939	0	0	1	110,977
SWE_{it}^{2}	0.603	1.629	0	0	2	100,643
SWE_{it}^{3}	0.864	2.208	0	0	2	90,792
SWE_{it}^{4}	1.095	2.689	0	0	3	82,266
SWE_{it}^{5}	1.340	3.258	0	0	3	74,923

Notes: SWE_{it}^{Δ} records the number of SWEs that occurred in the territory of municipality i in the Δ years prior to time t, the date at which a tender is made public. Δ ranges from 1 to 5 years. The total number of observations decrease with the number of years Δ because data on SWEs are available from 2009 only.

Table 2: Descriptive Statistics: contracts and PB's characteristics: 2012-2021

	Mean	Sd	P10	P50	P90	Count
Open Procedure (OP)	0.184	0.388	0	0	1	90,792
Reserve Price (000 euro)	323	1,233	62	132	609	90,792
1M	0.044	0.206	0	0	0	90,792
Geographical area:						
North-West	0.294	0.456	0	0	1	90,792
North-East	0.239	0.427	0	0	1	90,792
Center	0.168	0.373	0	0	1	90,792
South	0.196	0.397	0	0	1	90,792
Sicily and Sardinia	0.103	0.304	0	0	1	90,792
Altitude:						
Plain, 0-299mt	0.660	0.474	0	1	1	90,792
Hill, 300-599mt	0.142	0.349	0	0	1	90,792
Mountain, above 600mt	0.198	0.398	0	0	1	90,792
Population (th.)	104	372	1	8	157	90,792
County seat	0.183	0.387	0	0	1	90,792
Mayor tenure (years)	2.726	1.441	1	3	5	90,792
Mayor's education:						
Primary	0.003	0.051	0	0	0	90,792
Lower secondary	0.052	0.222	0	0	0	90,792
Upper secondary	0.358	0.479	0	0	1	90,792
Bachelor or Master	0.578	0.494	0	1	1	90,792
Ph.D.	0.009	0.094	0	0	0	90,792
Winning firm:						
Incumbent Winner (IW)	0.265	0.442	0	0	1	60,109
N. past contr. in PB's county:						
Overall:	4.770	12.926	0	1	13	60,109
Excluding PB:	3.603	7.217	0	1	11	60,109
Contract duration (days)	278	210	90	229	513	31,000
TO	0.626	0.484	0	1	1	31,000
CS	0.220	0.415	0	0	1	31,000

Notes: OP is a dummy variable that is equal to 1 if the PB chooses an open procedure, and it is equal to 0 if the PB chooses a negotiated procedure. *Reserve Price* is the reserve price (measured in thousands of euros) set by the Public Buyer (PB). Our data also include dummy variables that take a value equal to 1 if: the reserve price exceeds 1 million euro (*1M*); the PB is the administrative center of a county (*County seat*); the winning firm had previously won at least one contract with the PB (*Winning firm: Incumbent Winner*). The variables *Population* records the population of the municipality at the time the auction took place, in thousands inhabitants. The variable *Mayor tenure* counts the tenure of the mayor, in years, from the latest election. The variable *Winning firm: N. past contracts in PB's county* counts the number of past contracts awarded to the winning firm within the county of the PB, either *Overall*, or excluding the contracts awarded by the PB itself (*Excluding PB*). *Geographical area*, *Altitude*, and *Mayor's education* are sets of dummy variables recording the location of the PB at the NUTS 1 level, the altitude of the municipality, and the education of the mayor, respectively. *Contract duration* measures the contractual duration of the work, in days. *TO* and *CS* are dummy variables equal to 1 if, during the contract execution, there was, respectively, a time overrun or a disaster.

Table 3: Open Procedure - Baseline model 2012-2021

	(1)	(2)	(3)	(4)	(5)
	OLS	*Probit*	*OLS*	*OLS*	*OLS*
	OP	OP	OP	OP	OP
SWE_{it}^3	-0.011***	-0.046***	-0.012***	-0.011***	-0.011***
	(0.004)	(0.016)	(0.004)	(0.004)	(0.004)
Ln Population		0.014			
		(0.023)			
County seat		0.113			
		(0.077)			
$SWEN_{it}^3$				$2{\cdot}10^{-4}$	
				$(3{\cdot}10^{-4})$	
Mayor tenure					-0.002*
					(0.001)
Ln Reserve Price	0.101***	0.514***	0.107***	0.101***	0.101***
	(0.004)	(0.014)	(0.005)	(0.004)	(0.004)
1M	0.255	1.693	0.396	0.248	0.257
	(0.272)	(1.035)	(0.313)	(0.272)	(0.272)
Ln Res. Price X 1M	0.003	-0.062	-0.007	0.003	0.003
	(0.019)	(0.072)	(0.022)	(0.019)	(0.019)
Constant	-1.036***	-7.010***	-1.092***	-1.038***	-1.030***
	(0.045)	(0.249)	(0.053)	(0.045)	(0.046)
Work type FE	YES	YES	YES	YES	YES
NUTS-2 X Q. Year X Alt. FE	YES	YES	YES	YES	YES
PB FE	YES	NO	YES	YES	YES
Mayor's education FE	NO	NO	NO	NO	YES
Observations	90,259	84,171	69,260	90,149	90,259
Adjusted R-squared	0.422		0.439	0.422	0.422

Notes. Col. (2) reports the result of a probit model. Col. (1) and (3) to (5) report the results of linear models. In col. (3) and col. (4) we exclude from the sample observations either in places and times where a state of emergency had been declared, or in islands and exclaves, respectively. The other remarks of Table 1 and 2 applies. Clustered standard errors, at the PB level, in parentheses. Significance levels are denoted as follows: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 4: Time Overrun - Baseline model 2012-2021

	Linear models				3-stages GSEM		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	OLS	*OLS*	*OLS*	*OLS*	*Probit*	*Probit*	*Probit*
	TO	TO	TO	TO	OP	IW	TO
SWE^3_{it}	-0.002	-0.002	-0.002	-0.008	-0.047***		
	(0.004)	(0.004)	(0.004)	(0.005)	(0.016)		
OP	0.060***	0.046***	0.043***	0.043***		-0.272***	0.215***
	(0.012)	(0.012)	(0.014)	(0.014)		(0.026)	(0.036)
IW	-0.039***	-0.046***	-0.053***	-0.052***			-0.108***
	(0.007)	(0.007)	(0.008)	(0.008)			(0.020)
IW X OP		0.056***	0.047**	0.047**			
		(0.020)	(0.018)	(0.019)			
CS	0.155***	0.155***	0.143***	0.135***			0.444***
	(0.012)	(0.012)	(0.012)	(0.012)			(0.034)
CS X IW			0.027*	0.022			
			(0.015)	(0.015)			
CS X OP			0.014	0.015			
			(0.023)	(0.023)			
CS X SWE^3_{it}				0.008**			
				(0.004)			
Contract duration	$-3{\cdot}10^{-4}$***	$-3{\cdot}10^{-4}$***	$-3{\cdot}10^{-4}$***	$-3{\cdot}10^{-4}$***			-0.001***
	$(2 \cdot 10^{-5})$	$(2 \cdot 10^{-5})$	$(2 \cdot 10^{-5})$	$(2\ 10^{-5})$			$(6 \cdot 10^{-5})$
1M					2.240*		
					(1.287)		
Ln Res. Price X 1M					-0.093		
					(0.090)		
Past contracts						0.040***	
						(0.002)	
Ln Reserve Price	0.146***	0.145***	0.145***	0.145***	0.589***	-0.035***	0.455***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.020)	(0.010)	(0.019)
Constant	-1.065***	-1.061***	-1.056***	-1.052***	-8.406***	-0.929***	-4.325***
	(0.067)	(0.067)	(0.067)	(0.067)	(0.252)	(0.151)	(0.273)
Work type FE	YES	YES	YES	YES	YES	YES	YES
NUTS-2 X Q. Year X Alt. FE	YES	YES	YES	YES	NO	NO	NO
NUTS-2 X Year FE	NO	NO	NO	NO	YES	YES	YES
PB FE	YES	YES	YES	YES	NO	NO	NO
Var(PB RE)	-	-	-	-	0.545	0.232	0.145
					(0.022)	(0.012)	(0.011)
Observations	29,230	29,230	29,230	29,230	90,792	60,109	30,947
Adjusted R-squared	0.179	0.179	0.179	0.179			

Notes. Col. (1) to (4) report the results of linear models. The result of a three-stage estimation for a system of sequential equations is reported in col. (5), first stage, (6), second stage, and (7), third stage. In col. (6) and (7), OP and IW, respectively, are the linear prediction obtained in the previous stage. *OP* and *IW* denotes, respectively, Open Procedure and Incumbent Winner. *CS* is a dummy variable equal to 1 in case at least one disaster happened in the PB's territory during the execution of the contract. *Past contracts* counts the number of past contracts awarded to the winning firm within the county of the PB and excluding the contracts awarded by the PB itself. The other remarks of Table 1, 2 and 3 applies. Standard errors (clustered at the PB level in col. (1) to (5), and bootstrapped using 100 replications in col. (6) and (7)) in parentheses. Significance levels are denoted as follows: $^{*}\ p < 0.1$, $^{**}\ p < 0.05$, $^{***}\ p < 0.01$.

Appendix

A Proof of Proposition 1

Let the set of firms participating to the auction be $K = 1, 2, ..., k$. The expected stage payoff of the PB in period t is:

$$v_t((b_{i,t})_{i\in K}, d_{w_t,t}, s_{w_t,t}) = \begin{cases} g - q\ell(1 - s_{w_t,t}d_t) - \min_{i\in K} b_{i,t} & \text{if the PB procures the work} \\ 0 & \text{otherwise.} \end{cases}$$

The expected stage payoff of firm $i \in K$ is instead equal to

$$u_i((b_{i,t})_{i\in K}, d_{i,t}) = \begin{cases} \frac{b_{i,t}-\theta_{i,t}-cd_{i,t}}{|\min_{j\in K} b_{j,t}|} & \text{if the PB procures the work and } b_{i,t} = \min_{j\in K} b_{j,t} \\ 0 & \text{otherwise.} \end{cases}$$

Firms that do not participate ($i \in N \backslash K$) receive a stage payoff equal to 0.

Consider period t. The bid of firm i at time t does not depend on $s_{i,t} = \frac{s_{i,t-1}+\varepsilon_{i,t}}{2}$. Variable $\varepsilon_{i,t}$ is realized after the awarding of the procurement work, hence after the firms' bids. The bid does not depend on $s_{i,t-1}$ either. $s_{i,t-1}$ does not affect the resilience to the shock of firm i at time $t + 1$. The PB has thus no incentive to condition the type of auction at time $t + 1$ based on $s_{i,t-1}$. As a result, firms have no incentive to adjust their bids based on $s_{i,t-1}$. We conclude that the bidding strategy at time t depends on $\theta_{i,t}$ only. Standard results in auction theory then imply that, in the unique symmetric equilibrium, the bidding strategy of firm i is

$$\beta(\theta) = \theta + \frac{\int_{\theta}^{\overline{\theta}} (1 - F(x))^{k-1}\, dx}{(1 - F(\theta))^{k-1}}. \tag{A-1}$$

and the expected stage-game payoff from the auction of a firm with execution cost θ is:

$$U_{t,k}(\theta) = \int_{\theta}^{\overline{\theta}} (1 - F(x))^{k-1} \, dx. \tag{A-2}$$

Payoff (A-2) is decreasing in k for each θ. The firm's expected payoff from participating to a negotiated auction is then higher than its payoff from participating to an open auction, which, in turn, is higher than the expected payoff from being excluded from the auction: for every θ, $U_{t,r}(\theta) > U_{t,n}(\theta) > 0$.

The PB's expected stage payoff from the procurement auction is equal to the value g minus the second lowest valuation:

$$V_{t,k} = g - \int_{0}^{\overline{\theta}} \left[kF(\theta)(k-1)(1 - F(\theta))^{k-2} \right] f(\theta) d\theta. \tag{A-3}$$

If the number of firms that participate to an open auction, n, is large enough, the expected stage payoff of the PB is higher in an open procedure than in a negotiated one ($V_{t,r} < V_{t,n}$). The discounted payoff of a firm that runs open procedures only is equal to $\mathcal{V}^B = V_{t,n}/(1-\delta)$.

Consider the relational contract described in the main text and assume that no deviations from the equilibrium path occurred in the past. The PB's expected payoff from period t onward depends on what happened at time $t-1$ and on the occurrence of the shock at time t. If no shock happened at time $t-1$, the PB runs an open procedure without having any information on the set of participating firms. Let the continuation payoff in this case be $\mathcal{V}^{RC}$. If a shock happened at time $t-1$ and firm w_{t-1} did not intervene, the PB runs an open procedure knowing that one of the firm is characterized by $\varepsilon_{w_{t-1},t-1} = 0$. Let the continuation payoff in this case be $\mathcal{Z}^{RC}$. Finally, if a shock happened at time $t-1$ and firm w_{t-1} intervened, the PB runs a negotiated procedure including firm w_{t-1} that has $\varepsilon_{w_{t-1},t-1} = 1$. Let the continuation payoff in this case be $\mathcal{W}^{RC}$.

The three continuation payoffs described above solve the following system of equations:

$$\mathcal{V}^{RC} = V_{i,n} - \left(1 - \frac{\alpha(1+\alpha)}{2}\right) q\ell + \delta\left[(1-q)\mathcal{V}^{RC} + q(1-\alpha)\mathcal{Z}^{RC} + q\alpha\mathcal{W}^{RC}\right]$$
$$\mathcal{Z}^{RC} = V_{i,n} - \left(1 - \frac{\alpha(1+\alpha)}{2} + \frac{\alpha^2}{2n}\right) q\ell + \delta\left[(1-q)\mathcal{V}^{RC} + q(1-\alpha)\mathcal{Z}^{RC} + q\alpha\mathcal{W}^{RC}\right]$$
$$\mathcal{W}^{RC} = V_{i,r} - \left(1 - \frac{\alpha(1+\alpha)}{2} - \frac{\alpha(1-\alpha)}{2r}\right) q\ell + \delta\left[(1-q)\mathcal{V}^{RC} + q(1-\alpha)\mathcal{Z}^{RC} + q\alpha\mathcal{W}^{RC}\right]$$

Solving this system we obtain:

$$\mathcal{V}^{RC} = \mathcal{V}^{B} + \frac{\alpha}{(1-\delta)}\left[\frac{(1+\alpha)}{2} + \delta\frac{q\alpha(1-\alpha)}{2}\frac{n-r}{nr}\right] q\ell -$$
$$\frac{\delta}{1-\delta} q\alpha \int_0^{\overline{\theta}} \left[rF(\theta)(r-1)(1-F(\theta))^{r-2} - nF(\theta)(n-1)(1-F(\theta))^{n-2}\right] f(\theta)d\theta$$
$$\mathcal{Z}^{RC} = \mathcal{V}^{B} + \frac{\alpha}{(1-\delta)}\left[\frac{(1+\alpha)}{2} + \delta\frac{q\alpha(1-\alpha)}{2}\frac{n-r}{nr} - (1-\delta)\frac{\alpha}{2n}\right] q\ell -$$
$$\frac{\delta}{1-\delta} q\alpha \int_0^{\overline{\theta}} \left[rF(\theta)(r-1)(1-F(\theta))^{r-2} - nF(\theta)(n-1)(1-F(\theta))^{n-2}\right] f(\theta)d\theta$$
$$\mathcal{W}^{RC} = \mathcal{V}^{B} + \frac{\alpha}{(1-\delta)}\left[\frac{(1+\alpha)}{2} + \delta\frac{q\alpha(1-\alpha)}{2}\frac{n-r}{nr} + (1-\delta)\frac{1-\alpha}{2r}\right] q\ell -$$
$$\left(1 + \frac{\delta}{1-\delta} q\alpha\right) \int_0^{\overline{\theta}} \left[rF(\theta)(r-1)(1-F(\theta))^{r-2} - nF(\theta)(n-1)(1-F(\theta))^{n-2}\right] f(\theta)d\theta.$$

The firm intervenes to eliminate the loss at time t if and only if (i) $\varepsilon_{w_{t-1},t-1} = 1$, and (ii) the discounted expected payoff the firm gets by participating to a negotiated auction at time $t+1$ exceeds the cost of eliminating the loss at time t; that is, if and only if

$$c \leq \delta \int_0^{\overline{\theta}} \left[(1-F(x))^{r-1} - (1-F(x))^{n-1}\right] dx := \overline{c}.$$

To sustain the relational contract described in the main text, the PB must: (i) run a negotiated auction at time t and include firm w_{t-1} when she knows that $\varepsilon_{w_{t-1},t-1} = 1$, (ii) run an open auction at time t when she knows $\varepsilon_{w_{t-1},t-1} = 0$, (iii) run an open auction when she has no information on the firms' resilience to shock. If the PB deviates from the behavior prescribed by the relational contract, the game reverts to an equilibrium where firms never intervene and the PB always runs open auctions.

The second condition discussed above holds when the third does. Thus, the conditions above hold if $\mathcal{Z}^{RC} \geq \mathcal{V}^B$ and $\mathcal{W}^{RC} \geq \mathcal{V}^B$, or equivalently if $\ell \geq \overline{\ell} := \max\{\overline{\ell_1}, \overline{\ell_2}\}$, where

$$\overline{\ell_1} = \frac{\delta \int_0^{\overline{\theta}} \left[rF(\theta)(r-1)(1-F(\theta))^{r-2} - nF(\theta)(n-1)(1-F(\theta))^{n-2}\right] f(\theta)d\theta}{\left[\frac{(1+\alpha)}{2} + \delta\frac{q\alpha(1-\alpha)}{2}\frac{n-r}{nr} - (1-\delta)\frac{\alpha}{2n}\right]}$$

$$\overline{\ell_2} = \frac{(1-\delta+\delta q\alpha) \int_0^{\overline{\theta}} \left[rF(\theta)(r-1)(1-F(\theta))^{r-2} - nF(\theta)(n-1)(1-F(\theta))^{n-2}\right] f(\theta)d\theta}{\alpha\left[\frac{(1+\alpha)}{2} + \delta\frac{q\alpha(1-\alpha)}{2}\frac{n-r}{nr} + (1-\delta)\frac{1-\alpha}{2r}\right] q}$$

The statement of the proposition follows from some simple observations on $\bar{c}$ and $\overline{\ell}$. First, $\bar{c}$ does not depend on ℓ, nor on q. Second, both $\overline{\ell_1}$ and $\overline{\ell_2}$ are decreasing in q. Hence, $\overline{\ell}$ is decreasing in q as well. Third, under the relational contracts, firms are more likely to intervene when shocks occur more often (q goes up). As a result, when the frequency of shocks increases, the likelihood of open procedures decreases.

B Additional Graphs and Regressions

Figure B-i: Share of Open Procedures for Different Reserve Prices

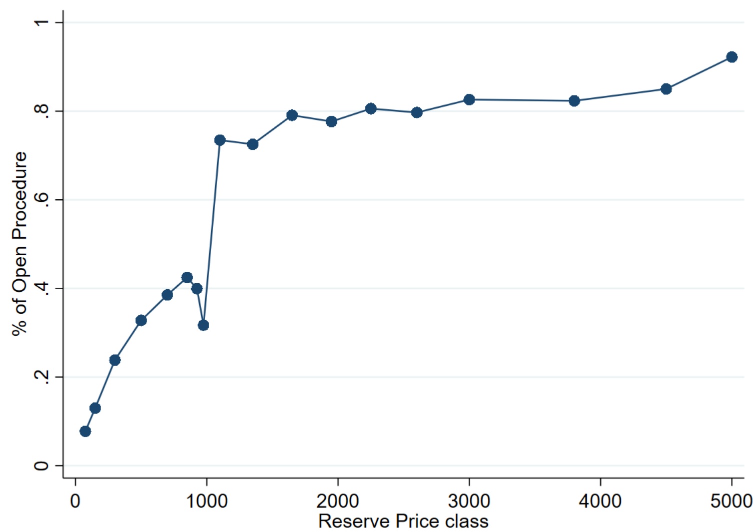

Figure B-ii: Distributions of contract duration and delays

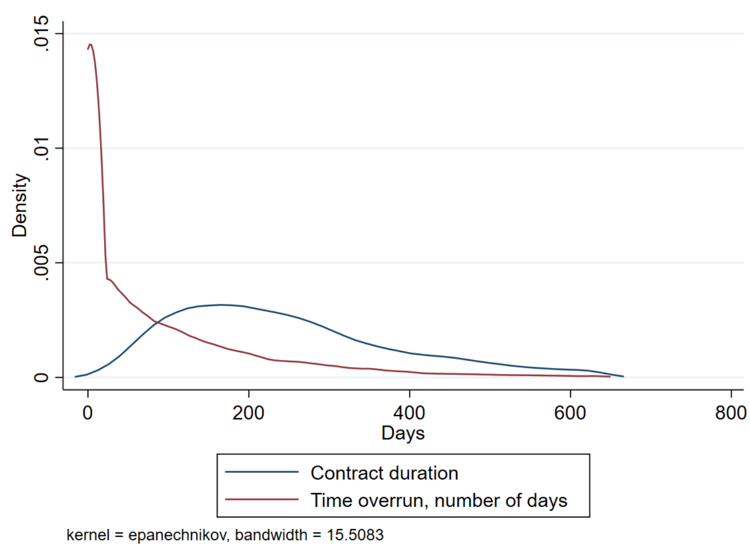

Table B-1: Descriptive Statistics: Past disasters in neighbouring municipalities

N. past disasters:	Mean	Sd	P10	P50	P90	Count
$SWEN_{it}^{1}$	1.267	6.614	0	0	4	90,680
$SWEN_{it}^{2}$	2.390	10.613	0	0	7	90,680
$SWEN_{it}^{3}$	3.061	12.346	0	0	8	90,680
$SWEN_{it}^{4}$	3.448	12.613	0	0	9	90,680
$SWEN_{it}^{5}$	3.802	12.777	0	0	10	90,680

Notes. $SWEN_{it}^{\Delta}$ records the number of past disasters due to severe weather events in the territory of a neighbouring municipality of the PB managing the procurement contract. Past disasters are recorded in the last 1 to 5 years ($\Delta \in [1, 5]$) from contract date. The dataset includes observations in the 2012-2021 period, excluding islands and exclaves.

Table B-2: Open Procedure and Incumbent Winner - Different Time Horizons, 2014-2021

	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	*OLS*	*OLS*	*OLS*	*OLS*	*OLS*
	OP	OP	OP	OP	OP	OP
SWE_{it}^{1}	-0.018***					
	(0.006)					
SWE_{it}^{2}		-0.015***				
		(0.005)				
SWE_{it}^{3}			-0.013***			
			(0.004)			
SWE_{it}^{4}				-0.014***		
				(0.004)		
SWE_{it}^{5}					-0.015***	
					(0.005)	
SWE_{it}^{0-1}						-0.017***
						(0.005)
SWE_{it}^{1-2}						-0.013*
						(0.006)
SWE_{it}^{2-3}						-0.011*
						(0.006)
SWE_{it}^{3-4}						-0.017*
						(0.009)
SWE_{it}^{4-5}						-0.020**
						(0.009)
Ln Reserve Price	0.098***	0.098***	0.098***	0.098***	0.098***	0.098***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
R. Price Above 1M (1M)	-0.181	-0.177	-0.181	-0.169	-0.169	-0.167
	(0.293)	(0.292)	(0.293)	(0.291)	(0.290)	(0.288)
Ln Res. Price X 1M	0.032	0.032	0.032	0.031	0.031	0.031
	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)
Constant	-1.006***	-1.003***	-1.002***	-1.000***	-0.997***	-0.996***
	(0.046)	(0.047)	(0.047)	(0.046)	(0.047)	(0.046)
Work type FE	YES	YES	YES	YES	YES	YES
Time X NUTS-2 X Altit. FE	YES	YES	YES	YES	YES	YES
PB FE	NO	YES	YES	YES	YES	YES
Observations	74,212	74,212	74,212	74,212	74,212	74,212
Adjusted R-squared	0.414	0.414	0.414	0.414	0.415	0.415

Notes. Col. (1) to (6) report the results of linear models. SWE_{it}^{0-1}, SWE_{it}^{1-2}, SWE_{it}^{2-3}, SWE_{it}^{3-4}, and SWE_{it}^{4-5} count the number of past SWEs in the PB's territory using rolling windows with constant length (1 year) and different position relative to the contract date: 0 to 1 year, 1 to 2 years, 2 to 3 years, 3 to 4 years, and 4 to 5 years, respectively. Remarks of Table 1, 2 and 3 apply. Clustered standard errors, at the PB level, in parentheses. Significance levels are denoted as follows: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table B-3: Incumbent Winner - Baseline model 2012-2021

	(1) *OLS* IW	(2) *Probit* IW	(3) *OLS* IW	(4) *OLS* IW	(5) *OLS* IW
SWE^3_{it}	0.004	0.037***	0.009**	0.005*	0.004
	(0.003)	(0.006)	(0.003)	(0.003)	(0.003)
OP	-0.061***	-0.276***	-0.067***	-0.062***	-0.061***
	(0.007)	(0.025)	(0.008)	(0.007)	(0.007)
Ln Population		0.214***			
		(0.010)			
County seat		0.220***			
		(0.043)			
$SWEN^3_{it}$				-0.001	
				$(4{\cdot}10^{-4})$	
Mayor tenure (years)					-0.000
					(0.001)
Past contracts	0.012***	0.038***	0.012***	0.012***	0.012***
	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)
Ln Reserve Price	-0.014***	-0.054***	-0.015***	-0.014***	-0.014***
	(0.003)	(0.010)	(0.003)	(0.003)	(0.003)
Constant	0.405***	-2.486***	0.410***	0.406***	0.406***
	(0.036)	(0.207)	(0.040)	(0.036)	(0.036)
Work type FE	YES	YES	YES	YES	YES
Time X NUTS-2 X Altit. FE	YES	YES	YES	YES	YES
PB FE	YES	NO	YES	YES	YES
Mayor's education FE	NO	NO	NO	NO	YES
Observations	58,944	57,324	45,591	58,897	58,944
Adjusted R-squared	0.193		0.190	0.194	0.193

Notes. Col. (2) reports the result of a probit model. Col. (1) and (3) to (5) report the results of linear models. In col. (3) and col. (4) we exclude from the sample observations either in places and times where a state of emergency had been declared, or in islands and exclaves, respectively. The variable *Past contracts* counts the number of past contracts awarded to the winning firm within the county of the PB and excluding the contracts awarded by the PB itself. The other remarks of Table 1 and 2 applies. Clustered standard errors, at the PB level, in parentheses. Significance levels are denoted as follows: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.