Voters' Information, Corruption, and the Efficiency of Local Public Services*

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Abstract

This paper explores the link between voters' information, corruption and efficiency in the context of a career concern model where politically connected local monopolies are in charge of the provision of a local public service. We find that both a corrupt environment and a low level of voters' information on managerial actions induce managers to reduce effort levels, thereby contributing to drive down efficiency. We test our predictions using data on solid waste management services provided by a large sample of Italian municipalities. We estimate a stochastic cost frontier model that provides robust evidence that services provided in more corrupt regions and in regions with low voters' information are substantially less cost efficient. We show that the negative impact of a corrupt environment is weaker for municipalities ruled by left-wing parties, while the positive impact of voters' information is larger if the waste collection service is managed by limited liability companies.

We finally quantify potential cost savings associated to operating in a less corrupt environment and in one in which voters are more informed through a simulation on six major Italian cities. The magnitude of the figures suggests that effective anti-corruption measures, and/or carefully designed incentives for citizens to acquire information, can generate significant economic benefits.

Keywords: corruption, voters' information, efficiency, solid waste
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1 Introduction

In Western countries, many local public services, including water provision, gas distribution and waste collection and disposal, are managed as local monopolies.

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They are typically operated by firms with tight political connections, if not directly by the local government (in-house provision), usually under soft budget constraints.

Local public utilities sharing the above characteristics may be particularly inefficient, due to the interplay of two factors, managerial slack and corruption. Firms with market power are particularly exposed to managerial slack, especially in the absence of effective monitoring devices or appropriate incentive schemes (Nickell, 1996). Markets with an extensive degree of interaction between politicians and firms tend to be associated to higher levels of corruption and patronage (Shleifer and Vishny, 1994). This is empirically documented by Menozzi et al. (2012), in their analysis of the effects of political connections on utilities' performances.[1]

This paper analyzes a framework in which politically connected local monopolies organize the provision of a local public service. It recognizes that the degree of efficiency in managing the service crucially depends on managers' accountability, as well as on the level of corruption of the environment they operate in.

In this non-competitive environment, in addition to the legal threats associated to managerial misbehavior, it is voters' reaction that provides managers with the incentives to refrain from company-damaging activities (such as slacking or engaging in corrupt behavior). Informed voters, when they perceive the company is mismanaged, may hold the politician associated to that manager accountable, and base their re-election decision on that consideration.

We first model the relation between productivity, voters' information, and the presence of a corrupt environment, using a standard career concern approach to political agency. The fact that more voters' information is associated to a higher productivity of the public service is well known (similar results are obtained, among others, by Besley and Burgess, 2002; Ponzetto, 2011; Drago et al., 2014; Nannicini et al., 2013).[2] It results from the interplay of two factors: each manager puts in more effort, and, on average, more talented managers are selected. We enrich this standard setting, by explicitly introducing corruption into it. Following Treisman (2000), we regard corruption as the abuse of public office for private gain. Using Dal Bò and Rossi's (2007) approach, we then characterize a corrupt environment as one where private benefits from diverting managerial effort away from the productive process are substantial[3]. We do

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[1] Menozzi et al. (2012) analyze a sample of Italian local public utilities active in gas, water and electricity distribution. They show that politically connected directors exert a positive and significant effect on employment, while they impact negatively on accounting measures of performance.

[2] For example, Drago et al. (2014) show that an improvement of observability due to the increase in the number of different newspapers available at the local level has the effect of keeping the activity of local governments more accountable. In a similar vein, Nannicini et al. (2013) show that in electoral districts endowed with high levels of social capital (measured by indices of blood donations, electoral participation and by the presence of non-profit organizations) politicians are more accountable and therefore are induced to exert higher effort levels and to reduce misbehaviour.

[3] This definition encompasses both corruption *strictu sensu* (for example, bribes that politicians and managers obtain from providers in exchange for outsourcing contracts) as well as

not model corruption as an activity that directly damages the firm, nor do we delve into the corruptive mechanisms within the firm; instead, we emphasize the notion that managers respond to incentives to corruption, which are determined by the institutional environment in which they operate. We show that, holding voters' information constant, a corrupt environment distorts managerial effort incentives, leading to an increase in the extent of inefficiency. We then derive the implication that inefficiency is greater for local public service providers located in more corrupt regions, besides being greater in regions where voters are less informed on managers' actions.

We test these predictions using a rich unique micro dataset on the solid waste collection and disposal activity in Italy, which includes more than five hundred municipalities observed in the years 2004-2006. We use a stochastic cost frontier approach to analyze the effects of accountability and of a corrupt environment on the costs of providing municipal solid waste (MSW) services. We proxy voters' information by newspapers' readership, while we measure the extent of corruption of the environment by the number of criminal charges against the State, public governments and social institutions. The empirical evidence supports our predictions. We find that both voters' information and corruption have a separate impact, in the expected direction, on the costs of MSW services. Moreover, by enriching our cost frontier specification, we obtain some interesting additional insights. In particular, we find that the impact of voters' information on reducing inefficiency is smaller or even disappears when municipalities organize the service in-house or join a intermunicipal consortium, while operating in a corrupt area is less detrimental to efficiency when municipalities are ruled by left-wing parties.

The relationship between voters' information and the performance of local public governments has rarely been investigated empirically. An exception is Giordano and Tommasino (2013), who identify the determinants of public sector efficiency of the Italian local governments. They show that measures of citizens' political engagement (electoral turnout for referenda and number of newspapers sold) have a positive and significant impact on the efficiency of the provision of local public services such as education, civil justice, healthcare and waste disposal, while measures of social capital do not have any discernible effect. They do not consider the impact of a corrupt environment.

The negative incidence of corruption on efficiency is well documented. Most of the empirical literature relies on cross-country comparisons and makes use of country level measures of corruption such as the Transparency International index or the Corruption Perception index, while very few papers use disaggregated data at the firm or at the local government level.[4] For instance, Dal Bò and Rossi (2007) estimate a labour requirement function on a set of 80 electricity distribution firms active in 13 Latin America countries, and show that firms operating in more corrupt environments tend to be less efficient in terms of

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other forms of political patronage (e.g., the choice to employ workers in excess of the business' needs, in order to build and maintain political support).

[4] See Svensson (2005) and Banerjee et al. (2013) for comprehensive reviews of the literature dealing with corruption.

labour use. Yan and Oum (2014) provide a single country-firm level study. They investigate the effect of a corrupt environment on the cost efficiency of a sample of 55 US commercial airports observed from 2001 to 2009, and find a detrimental effect of corruption on efficiency. Moreover, airports tended to contract out more activities to replace in-house labour under more corrupt environments.

Our paper is the first to analyze, theoretically and empirically, whether both channels (a corrupt environment and voters' information) matter separately in determining the efficiency level of politically connected businesses.

Waste collection is a particularly suitable sector for our analysis. In Italy, waste collection and disposal are mainly carried out under the tight control of local governments. Although citizens have an interest in the efficient management of the MSW activity, due to the impact on the tax burden, it is reasonable to assume that they do not have complete information about technology and are unable to perfectly assess its performance. Also, a corrupt environment may certainly have an impact on the sector, for instance by affecting managerial propensity to negotiate with local governments in order to establish more favorable tariffs and service obligations, thereby diverting the managerial efforts away from cost monitoring and productive tasks.[5]

The remainder of the paper is organized as follows. Section 2 develops the theoretical analysis. Section 3 describes the main features of the dataset, presents the econometric model and shows the main results of the estimates. Section 4 contains our concluding remarks.

2   The model

We model a MSW service operated by a company tightly linked to politics. We capture this notion by assuming that the manager of the firm is selected by the political party in power. In our environment, politicians, after selecting the manager, are unable to motivate him through incentive-based remuneration schemes. In addition, managers' careers are tied to politicians in power, in the sense that managers are reappointed whenever the politician in power is re-elected, and replaced whenever the incumbent politician is ousted; politicians are prevented from firing a manager they have appointed.[6] This is reflective of the Italian organization of the MSW sector. Waste services are typically operated by municipally-owned companies which adopt a spoils system, whereby managers are replaced when the political majority changes; firing a manager is administratively complicated and costly, not only because it may be regarded as an admission of failure, but also because it usually requires a reshuffling of the board of directors, which may present significant political difficulties.

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[5] Also, as discussed in D'Amato et al. (2015), organized crime has developed a strategy to enter the waste cycle, mainly aimed at creating shadow circuits for illegal transport and disposal. In this context, the diffusion of collusive relationships among managers and suppliers aimed at overcharging the firms and at seeking illegal sources of profits is an undisputed matter of fact.

[6] Vlaicu and Whalley (2016) solve a model in which politicians are entitled to fire the managers after each period.

Furthermore, managers of municipally-owned companies are entitled to a fixed wage (R in our model), and were typically not entitled, in the 2004-2006 period, to receive performance-based remunerations.

Each manager operates in an environment characterized by a certain degree of corruption. In corrupt environments, as in Dal Bò and Rossi (2007), managers are privately rewarded for engaging in a range of activities that provide no value to the firm. For instance, they may inappropriately use their position to provide political support to the incumbent politician they are linked to, or they may spend time building social relationships with people or groups outside the firm.

2.1   Setting

We analyze a political/managerial agency model with elections, in which agents are infinitely lived and discount the future at a rate $\delta \in [0,1]$. There is a continuum of self-interested risk neutral voters. Their utility is inversely related to the costs of the MSW operator, which is covered by a subsidy assumed to be funded through taxation. For simplicity, while multiple policy issues enter voters' consideration, we restrict attention to the single issue of managerial performances, to illustrate how managerial effort is shaped by electoral concerns.

The task of the manager consists in mininizing the cost borne by the firm. The manager may provide value to the company, by reducing its cost. We denote as θ_t the value that the manager provides to the company in time t. In particular, θ measures by how much the manager is able to reduce the cost with respect to a benchmark. A negative θ indicates that the cost is above the threshold. In what follows, with a slight abuse of definition, we will designate θ as managerial productivity.

θ_t depends both on managerial talent η_t and on how much effort he puts into managing the company (which we designate as *productive* effort), denoted a^p, according to the following relation:

$$\theta_t = \eta_t + a^p_t$$

Besides exerting effort in the productivity-enhancing activity a^p, the manager also can exert effort in an activity that, while potentially generating a private benefit for the manager, has no direct impact, either positive or negative, on the firm's performance. This effort, which we designate as *unproductive*, is denoted a^u. Effort in the unproductive activity generates a marginal return τ to the manager. τ thus measures how rewarding distorting effort away from the productive activity is; when $\tau = 0$, effort distortion is not rewarding at all. Hence, following Dal Bò and Rossi (2007), we regard τ as a measure of the level of corruption in the institutional environment in which the firm operates.

Observe that the model's main insights would remain unaltered if we assumed that effort in the unproductive activity negatively affects θ; this assumption would capture all managerial actions against the firm in exchange for briberies. Moreover, for the sake of simplicity, benefits from investing in the

unproductive activity are assumed to be a function of the effort in the unproductive activity only (and not of the managerial talent).

Managers keep devoting effort to the unproductive activity, and benefiting from it, even once they are ousted from the firm. This reflects the notion that, in a corrupt environment, managerial positions in politically-related companies allow to develop long-term links and networks which can be exploited even after the manager loses his job. In such cases, $a^p = 0$, $R = 0$ but $a^u \geq 0$.

We assume that a more competent politician selects a more talented manager, on a one-to-one relation. A manager is appointed by the politician when he enters office for the first time, and holds his post until the politician is ousted from power. As illustrated above, this reflects the incentives involved by the Italian institutional setting in the MSW collection sector in the 2004-2006 period.

Politicians, in this model, only play the role of selecting managers. The managerial talent η_t evolves over time according to the following relation:

$$\eta_t = \rho_{t-1} + \rho_t$$

where ρ_{t-1} and ρ_t (which we will refer to as period-specific skills) are i.i.d. random shocks and $\rho \sim N\left(\bar{\rho}, \sigma_\rho^2\right)$. In this formulation (used, for instance, by Alesina and Tabellini, 2008), managerial ability changes gradually over time, capturing the notion that firms operate in a dynamic environment, which requires continuously evolving skills for the manager. It follows that we can rewrite:

$$\theta_t = \rho_{t-1} + \rho_t + a_t^p \tag{1}$$

Managers are career-concerned, and have a fixed per period reward R, which does not depend on effort.

The time-line is as follows. At the beginning of each period t, the $t-1$ specific skill ρ_{t-1} for the incumbent manager becomes common knowledge. However, before exerting efforts a_t^p and a_t^u, the manager does not fully know his talent. In particular, he is unaware of the period t specific skill ρ_t. There is no asymmetric information in this model; in period t, both the manager and voters know ρ_{t-1}, but neither the manager nor voters know ρ_t. At stage two, all voters observe the same noisy signal of managerial productivity:

$$\widehat{\theta}_t = \eta_t + a_t^p + \epsilon_t \tag{2}$$

where ϵ_t is an i.i.d. shock $N\left(0, \sigma_\epsilon^2\right)$, uncorrelated to talent ($E[\eta_t \epsilon_t] = 0$). All voters observe the same signal $\widehat{\theta}_t$. The variance of the noise σ_ϵ^2 reflects the extent of imprecision in the observability of managerial behavior. High σ_ϵ^2 thus indicates less voters' information on managerial behavior. Voters use $\widehat{\theta}_t$ to make their own inference on the level of the time-specific skill $\widehat{\rho}_t$. In period $t+1$, the managerial competence is $\rho_t + \rho_{t+1}$. Thus, voters' expectation on the level of managerial competence at time $t+1$, in case the incumbent manager is reappointed, is $\widehat{\rho}_t + \bar{\rho}$, where the unconditional expectation $\bar{\rho}$ is the best predictor of ρ_{t+1}. If, instead, a new manager is appointed at $t+1$, both ρ_t and

ρ_{t+1} are randomly drawn; in this case, the best predictor at time t of a new manager's competence at $t+1$ is $2\overline{\rho}$. At stage three, elections are held, pitting the incumbent politician to a randomly drawn challenger. Voters recognize that the fate of the manager is tied to that of the politician. They thus re-elect the incumbent politician if the manager he is associated to is, in expectation, more skilled than the manager linked to the challenger, which occurs if $\widehat{\rho}_t > \overline{\rho}$.

In our environment, elections are used to remove badly performing managers. While voters' behavior is geared to the selection of competent managers, rather than to effort elicitation, the incumbent manager is motivated to exert effort in the attempt to boost the perception of his competence in the eyes of the voters. Managerial incentives turn out to be identical to those of the politician in a standard political agency game in which the politician is career concerned (see, for instance, Bonfiglioli and Gancia, 2013).

2.1.1 The voters

The model is solved backwards. Citizens are confronted with an inference problem. While, at the end of period t, they wish to confirm the politician (and, as a consequence, the manager) only if the manager displays a sufficiently high level of competence, they may just observe the noisy managerial productivity signal $\widehat{\theta}_t$.

Citizens form a posterior belief on managerial ability, solving a standard signal extraction problem:

$$\widehat{\rho}_t = E\left(\rho_t | \widehat{\theta}_t\right) = \frac{\sigma_\epsilon^2}{\sigma_\epsilon^2 + \sigma_\rho^2}\overline{\rho} + \frac{\sigma_\rho^2}{\sigma_\epsilon^2 + \sigma_\rho^2}\left(\widehat{\theta}_t - \rho_{t-1} - a_t^{p,e}\right) \tag{3}$$

where $a_t^{p,e}$ is the productive effort level that, under rational expectations, citizens anticipate that will be prevailing in equilibrium.

Observe that, as in any signal extraction problem, citizens weigh the prior $\overline{\rho}$ and the signal $\left(\widehat{\theta}_t - \rho_{t-1} - a_t^{p,e}\right)$ by the variances. The more precise the signal, the higher the weight the citizens attach to it.

Citizens would like the politician (and the manager he is attached to) to be confirmed if their best predictor of the manager's time-specific ability exceeds the average, i.e. if $\widehat{\rho}_t > \overline{\rho}$. This implies that the incumbent political party is confirmed in office (and, as a consequence, the incumbent manager is reappointed) if:

$$\widehat{\theta}_t - \rho_{t-1} - a_t^{p,e} > \overline{\rho} \tag{4}$$

Condition (4) shows that citizens adopt a threshold rule. They determine, through the re-election of the incumbent politician, the reappointment of the incumbent manager, as long as the observed managerial productivity $\widehat{\theta}_t$ exceeds the expected managerial productivity generated by a manager of average skills $\overline{\rho}$.

2.1.2 The manager

The manager's cost is a convex function of the sum of the efforts put in the two tasks:

$$C\left(a_{t}\right) = \frac{\left(a_{t}^{u} + a_{t}^{p}\right)^{2}}{2}$$

The manager trades off costly productive effort both with the probability of retaining his post, and with privately rewarding unproductive effort. The manager chooses effort levels a_{t}^{u} and a_{t}^{p}, having the same information set as voters, that is, knowing ρ_{t-1}, but not knowing ρ_{t}. The managerial objective at time t consists in maximizing V_{t}, the manager's discounted value from occupying the managerial position at time t:

$$\max_{a_{t}^{p}, a_{t}^{u}} V_{t} = R + \tau a_{t}^{u} - \frac{\left(a_{t}^{p} + a_{t}^{u}\right)^{2}}{2} + \tag{5}$$

$$+ \delta \left(\Pr\left(\widehat{\rho}_{t} > \overline{\rho} | a_{t}^{p}\right) V_{t+1} + \left(1 - \Pr\left(\widehat{\rho}_{t} > \overline{\rho} | a_{t}^{p}\right)\right) \frac{\tau \widetilde{a}_{t}^{u} - \frac{\left(\widetilde{a}_{t}^{u}\right)^{2}}{2}}{1 - \delta} \right)$$

where $\widetilde{a}_{t}^{u}$ is the unproductive effort chosen by the manager after he loses his job, when he devotes his entire energy to the unproductive activity.[7] The optimal amount of effort under such circumstances is clearly $\widetilde{a}_{t}^{u} = \tau$, which results from optimally trading off, at each period t, its total benefits $\tau \widetilde{a}_{t}^{u}$ with its total cost $\frac{\left(\widetilde{a}_{t}^{u}\right)^{2}}{2}$. It follows that the uniperiodal outside option profit is $\frac{\tau^{2}}{2}$.

The objective function (5) may thus be rewritten as:

$$\max_{a_{t}^{p}, a_{t}^{u}} V_{t} = R + \tau a_{t}^{u} - \frac{\left(a_{t}^{p} + a_{t}^{u}\right)^{2}}{2} + \tag{6}$$

$$+ \delta \left(\Pr\left(\widehat{\rho}_{t} > \overline{\rho} | a_{t}^{p}\right) V_{t+1} + \left(1 - \Pr\left(\widehat{\rho}_{t} > \overline{\rho} | a_{t}^{p}\right)\right) \frac{\tau^{2}}{2\left(1 - \delta\right)} \right)$$

Given the recursive nature of the problem, $V_{t} = V_{t+1}$, and the optimal choice of effort is determined as:

$$a_{t}^{p}, a_{t}^{u} = \arg\max_{a_{t}^{p}, a_{t}^{u}} V = \arg\max_{a_{t}^{p}, a_{t}^{u}} \left\{ \frac{R + \tau a_{t}^{u} - \frac{\left(a_{t}^{p} + a_{t}^{u}\right)^{2}}{2} + \delta\left(1 - \left(1 - G\left(a_{t}^{p}\right)\right)\right) \frac{\tau^{2}}{2\left(1 - \delta\right)}}{1 - \delta\left(1 - G\left(a_{t}^{p}\right)\right)} \right\}$$

$$\tag{7}$$

where G, the probability of not being reappointed, is jointly normally distributed $N\left(\overline{\rho}, \sigma_{\rho}^{2} + \sigma_{\epsilon}^{2}\right)$, given the independence assumption of ρ and ϵ, and g is its density.

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[7] Clearly, effort put in the unproductive activity when the manager is no longer in charge $\widehat{a}_{t}^{u}$ differs from the unproductive effort when the manager runs the company, a_{t}^{u}.

2.1.3 Equilibrium effort and selection

The optimal choices of a_t^u and a_t^p are determined by differentiating (7):

$$\frac{\partial V}{\partial a_t^u} = \tau - (a_t^p + a_t^u) = 0$$

$$\frac{\partial V}{\partial a_t^p} = \left(-(a_t^p + a_t^u) - \delta\frac{\tau^2}{2(1-\delta)}g\left(\bar{\rho} + a_t^{e,p} - a_t^p\right)\right)(1 - \delta(1-G)) + \tag{8}$$

$$+\delta g\left(\bar{\rho} + a_t^{e,p} - a_t^p\right)\left(R + \tau a_t^u - \frac{(a_t^p + a_t^u)^2}{2} + \delta G\frac{\tau^2}{2(1-\delta)}\right) = 0$$

In equilibrium, voters correctly predict the effort level. As a result, $a_t^p = a_t^{e,p}$ and $G = \frac{1}{2}$. By adopting a conveniently parsimonious notation, we denote $\widetilde{\sigma} \equiv \left(\sigma_\rho^2 + \sigma_\epsilon^2\right)$ and $A = \pi\widetilde{\sigma}\left(2 - \delta\right)^2$. It follows that, after rearranging (8), we obtain:

$$a_t^u = \begin{cases} 0 \text{ if } \tau < \tau^* \\ \tau - \frac{R}{\tau} + \frac{\sqrt{2A}}{2\delta}\text{if } \tau^* < \tau < \tau^{**} \\ \tau \text{ if } \tau > \tau^{**} \end{cases} \tag{9}$$

$$a_t^p = \begin{cases} \frac{\sqrt{2}}{2\delta}\left(\sqrt{\delta^2\left(4R - 2\tau^2\right) + A} - \sqrt{A}\right) \text{ if } \tau < \tau^* \\ \frac{R}{\tau} - \frac{\sqrt{2A}}{2\delta} \text{ if } \tau^* < \tau < \tau^{**} \\ 0 \text{ if } \tau > \tau^{**} \end{cases} \tag{10}$$

where $\tau^*\left(A, \delta, R\right) = \frac{\sqrt{2}}{4\delta}\left(\sqrt{8R\delta^2 + A} - \sqrt{A}\right)$, and $\tau^{**}\left(A, \delta, R\right) = \frac{2\delta R}{\sqrt{2A}}$.

Figure 1 illustrates a simulation of the results. The 45 degree line represents $\widehat{a}_t^u = \tau$, that is, the unproductive effort put in by the manager after he leaves the job. The other two curves show the equilibrium levels of a_t^p and a_t^u. Managerial incentives to undertake the unproductive activity when in office are directly affected by the level of corruption in the environment; a higher return on the unproductive activity τ is associated to a higher unproductive effort a_t^u. This reduces the managerial effort in the productive activity a_t^p through two channels. First, as a result of convexity of the cost function in the sum of the two efforts, the marginal cost of productive effort is increasing in the amount of unproductive effort. Second, the value of productive effort is inversely affected by the outside option for the manager after he loses his job, which, in turn, is proportional to the return on the unproductive effort. As a result, the equilibrium value of a_t^p, as a function of the level of corruption, exhibits a pattern of negative correlation.

When τ is null, the manager has no incentives to engage in the unproductive activity a_t^u, and the result fully reproduces the model without corruption. When τ is positive but small $(0 < \tau < \tau^*)$, returns on the productive activity, while the manager is active, still overwhelm returns on the unproductive activity, so that unproductive effort while the manager is active remains null (while

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unproductive effort is, for such values of τ, positive after the manager is ousted from office). However, productive effort declines with τ, as a result of the higher attractiveness of the outside option.

As τ gets larger ($\tau^* < \tau < \tau^{**}$), the manager distributes his effort across the two activities. In this interval, marginal increments in τ, while increasing unproductive effort a_t^u, reduce productive effort a_t^p. This occurs through both the increase in marginal cost of the productive activity, and the increase in the appeal of the outside option.

For large values of τ ($\tau > \tau^{**}$), returns to the unproductive activity prevail, and the manager allocates his effort to the unproductive activity only, even when in office.

A manager benefits from his appointment being renewed when the returns on a_t^u are not disproportionately higher than those on a_t^p, in particular for $\tau < \tau^{**}$, where τ^{**} is a function of $\tilde{\sigma}, \delta$ and R. In this interval, more patience (larger δ), as well as a higher wage R, magnifies the re-appointment rewards, leading to a rise in a_t^p (and, correspondingly, to a decline in a_t^u); similarly, a surge in the precision of the prior, or of the citizens' inference of the manager's skills (i.e., a decrease in σ_ρ^2 and in σ_ϵ^2 respectively), raises the managerial productive effort, as it induces a more accurate alignment between the manager's effort and his re-appointment. In addition, observe that, for $\tau < \tau^{**}$, $a_t^u < \tilde{a}_t^u = \tau$, that is, unproductive effort is always smaller when the manager is active (and, as a consequence, shares his effort across the two activities), than after he loses his job (and unproductive effort remains his only option); this stems from cost convexity in the sum of efforts. Conversely, when $\tau > \tau^{**}$, re-appointment has no value for the manager; therefore, $a_t^p = 0$, and $a_t^u = \tilde{a}_t^u = \tau$.

Finally, we consider the expected talent of a politician in the stationary equilibrium.

$$E\left(\eta_t\right) = E(\eta_t|\widehat{\rho}_{t-1} < \overline{\rho})\Pr\left(\widehat{\rho}_{t-1} < \overline{\rho}\right) + E(\eta_t|\widehat{\rho}_{t-1} > \overline{\rho})\Pr\left(\widehat{\rho}_{t-1} > \overline{\rho}\right) =$$

$$= 2\overline{\rho} + \frac{\sigma_\rho^2}{\sqrt{2\pi\left(\sigma_\rho^2 + \sigma_\epsilon^2\right)}}$$

Rational expectations on the part of the voters imply that the level of corruption τ does not affect the ability of voters to screen politicians, and, as a result, does not affect their expected talent.

Expected managerial productivity at time t is therefore:

$$E\left(\theta_t\right) \quad = \quad E\left(\eta_t\right) + a_t^p = \tag{11}$$

$$= \begin{cases} \frac{\sqrt{2}}{2\delta}\left(\sqrt{\delta^2\left(4R - 2\tau^2\right) + A} - \sqrt{A}\right) + 2\overline{\rho} + \frac{\sigma_\rho^2}{\sqrt{2\pi\left(\sigma_\rho^2 + \sigma_\epsilon^2\right)}} & \text{if } \tau < \tau^* \\[3mm] \frac{R}{\tau} - \frac{\sqrt{2A}}{2\delta} + 2\overline{\rho} + \frac{\sigma_\rho^2}{\sqrt{2\pi\left(\sigma_\rho^2 + \sigma_\epsilon^2\right)}} & \text{if } \tau^* < \tau < \tau^{**} \\[3mm] 2\overline{\rho} + \frac{\sigma_\rho^2}{\sqrt{2\pi\left(\sigma_\rho^2 + \sigma_\epsilon^2\right)}} & \text{if } \tau > \tau^{**} \end{cases} \tag{12}$$

The results are summarized in the following:

Proposition 1 *The expected managerial productivity (weakly) decreases when the environment is more corrupt (i.e., when parameter τ increases). Also, it declines when voters have a less precise information (i.e., high σ_ϵ^2), and when the dispersion in managerial talent is greater (i.e., high σ_p^2).*

Proof. It is immediate to see, after differentiating (12) and (10), that

$$
\frac{\partial E\left(\theta_t\right)}{\partial \tau} = \left\{
\begin{array}{l}
-\frac{\sqrt{2}\delta\tau}{\sqrt{\delta^2(4R-2\tau^2)+A}} \text{ for } \tau < \tau^* \\
-\frac{R}{\tau^2} \text{ if } \tau^* < \tau < \tau^{**} \\
0 \text{ if } \tau > \tau^{**}
\end{array}
\right. \leq 0
$$

$$
\frac{\partial E\left(\theta_t\right)}{\partial \sigma_\epsilon^2} = \left\{
\begin{array}{l}
-\frac{\sqrt{2A}\left(\sqrt{A+\delta^2(4R-2\tau^2)}-\sqrt{A}\right)}{4\delta\widetilde{\sigma}\sqrt{A+\delta^2(4R-2\tau^2)}} - \frac{1}{4}\frac{\sqrt{2}}{\sqrt{\pi}}\frac{\sigma_\rho^2}{\left(\sigma_\rho^2+\sigma_\epsilon^2\right)^{\frac{3}{2}}} \text{ for } \tau < \tau^* \\
-\frac{\sqrt{2}\pi(2-\delta)^2}{4\delta\sqrt{A}} - \frac{1}{4}\frac{\sqrt{2}}{\sqrt{\pi}}\frac{\sigma_\rho^2}{\left(\sigma_\rho^2+\sigma_\epsilon^2\right)^{\frac{3}{2}}} \text{ if } \tau^* < \tau < \tau^{**} \\
-\frac{1}{4}\frac{\sqrt{2}}{\sqrt{\pi}}\frac{\sigma_\rho^2}{\left(\sigma_\rho^2+\sigma_\epsilon^2\right)^{\frac{3}{2}}} \text{ if } \tau > \tau^{**}
\end{array}
\right. < 0
$$

$$
\frac{\partial a_t^p}{\partial \sigma_\rho^2} = \frac{\partial a_t^p}{\partial \sigma_\epsilon^2} = \left\{
\begin{array}{l}
-\frac{\sqrt{2A}\left(\sqrt{A+\delta^2(4R-2\tau^2)}-\sqrt{A}\right)}{4\delta\widetilde{\sigma}\sqrt{A+\delta^2(4R-2\tau^2)}} \text{ for } \tau < \tau^* \\
-\frac{\sqrt{2}\pi(2-\delta)^2}{4\delta\sqrt{A}} \text{ if } \tau^* < \tau < \tau^{**} \\
0 \text{ if } \tau > \tau^{**}
\end{array}
\right. \leq 0
$$

■

The result that voters' information reduces managerial productivity is consonant with results on the positive relation between observability and political efficiency (Besley and Burgess, 2002; Ponzetto, 2011; Drago et al., 2014; Nannicini et al., 2013). Observe that low voters' information and the presence of a corrupt environment, while being both sources of declines in managerial productivity, operate through two distinct mechanisms: low voters information (higher variance σ_ϵ^2 of the noise) entails a reduction in the total effort put in by the manager, while a corrupt environment induces a diversion of the effort away from the productive activity. Also, voters' information has an impact on managerial expected talent, while the level of corruption does not.

3   Empirical analysis

3.1   The econometric model

We test our theoretical predictions that costs are higher for utilities located in more corrupt regions, and in regions where voters are less informed, by adopting a stochastic cost frontier approach to model the expenditure for collection and disposal of solid waste at the municipal level, and using proxies to analyze the effects of corruption and voters information on the cost.

The econometric model can be expressed in general terms as:

$$\ln TC_{it} = c(y_{it}, p_{it}; \beta) + u_{it} + v_{it} \qquad (13)$$
$$u_{it} \sim N^+(\mu(z_{it}; \delta), \sigma_u^2)$$
$$v_{it} \sim N(0, \sigma_\nu^2)$$

where TC_{it} is the total cost incurred by municipality i at time t, y_{it} is a vector of outputs, p_{it} is a vector of input prices, β is a vector of parameters to be estimated, v_{it} is a standard error term measuring random noise and u_{it} is a non-negative error term, to be interpreted as cost inefficiency. The latter follows a truncated normal distribution whose pre-truncation mean is parameterized on a set of exogenous factors z_{it} – such as our key variables of interest, voters' information and corruption – and a vector of parameters δ to be estimated.

The two sets of parameters (β and δ) are estimated simultaneously.[8]

We adopt a linear specification of the mean value of the inefficiency term, following Kumbhakar et al. (1991) and Battese and Coelli (1995):

$$\mu_{it} = \delta_0 + z'_{it}\delta \qquad (14)$$

Given the sign of δ parameters, a variation of z variables changes the mean of the pre-truncated distribution of u_{it}, thus allowing for an increase/decrease of the estimated cost inefficiency, in line with our theoretical model.[9]

Cost inefficiency u_{it} is estimated as its conditional expectation $\widehat{u}_{it}$, given the fitted value of $\epsilon_{it} = u_{it} + v_{it}$, i.e. $\widehat{u}_{it} = E(u_{it}|\epsilon_{it})$, following Jondrow et al. (1982).[10] $\widehat{u}_{it}$ can then be transformed into a measure of distance from the optimal frontier. The cost inefficiency measure CI_{it}, following Battese and Coelli (1988), is then defined as:

$$CI_{it} = E\left(e^{u_{it}}|\epsilon_{it}\right) \qquad (15)$$

(15) yields inefficiency values greater than (or equal to) 1, readily interpretable as percentage deviations from the minimum attainable cost. Given that the expected inefficiency (i.e. the mean of the pre-truncated distribution) is modeled as a function of a set of variables z, the effect of such variables on the estimated cost inefficiency index depends on the features of the truncated normal

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[8] This is what Wang and Schmidt (2002) refers to as one-step procedure, as opposed to a two-step approach which consists of estimating cost inefficiency without including exogenous factors and subsequently fitting a model in which a set of variables is used to explain the estimated inefficiency. Extensive Monte Carlo simulations provided by Wang and Schmidt (2002) provided evidence in favor of the one-step approach since the two-step procedure is affected by serious biases in both the involved steps.

[9] In principle, other possibilities would be feasible to analyze the impact of social environment characteristics on the level of costs. An alternative would be, for instance, the inclusion of a set of environmental features z_{it} directly in $c(y_{it}, p_{it}, z_{it}; \beta)$, thus allowing for a modification of its shape. This option is, however, not appropriate given our purposes, since it assumes that the social characteristics of the operating environment do not impact directly on the effort of the municipalities or on their negotiation capabilities.

[10] u_{it} cannot be simply derived as a residual, since the composite error includes the statistical noise v_{it} term, which is not observable.

distribution. In general, their marginal effect on cost efficiency CE (i.e., the inverse of cost inefficiency, ranging from 0 to 1) may be computed as (Olsen and Henningsen, 2011):

$$\frac{\partial CE}{\partial z} = (1 - \widehat{\gamma}) \left(\begin{array}{c} \frac{\phi\left(\frac{\mu^*}{\sigma^*} - \sigma^*\right) e^{\left(-\mu^* + \frac{1}{2}\sigma^{*2}\right)}}{\sigma^* \Phi\left(\frac{\mu^*}{\sigma^*}\right)} - \frac{\Phi\left(\frac{\mu^*}{\sigma^*} - \sigma^*\right) \phi\left(\frac{\mu^*}{\sigma^*}\right) e^{\left(-\mu^* + \frac{1}{2}\sigma^{*2}\right)}}{\sigma^* \left(\Phi\left(\frac{\mu^*}{\sigma^*}\right)\right)^2} + \\ - \frac{\Phi\left(\frac{\mu^*}{\sigma^*} - \sigma^*\right) e^{\left(-\mu^* + \frac{1}{2}\sigma^{*2}\right)}}{\Phi\left(\frac{\mu^*}{\sigma^*}\right)} \end{array} \right) \frac{\partial \mu}{\partial z'}$$

(16)

where $\Phi\left(.\right)$ and ϕ denote the cumulative distribution function and the density function of the standard normal distribution, $\mu^* = (1 - \widehat{\gamma})\widehat{\mu} + \widetilde{\gamma}\widehat{\epsilon}$, $\sigma^* = \sqrt{\widehat{\gamma}(1 - \widehat{\gamma})\widehat{\sigma}}$, $\widehat{\sigma} = \widehat{\sigma}_u + \widehat{\sigma}_v$, $\widehat{\gamma} = \frac{\widehat{\sigma}_u}{\widehat{\sigma}}$, $\widehat{\sigma}_u$ is the estimated value of the standard deviation of the inefficiency term, $\widehat{\sigma}_v$ is the estimated value of the standard deviation of random noise, $\widehat{\epsilon}$ is the estimated value of the composed error term ($\widehat{\epsilon} = \widehat{u} + \widehat{v}$), $\widehat{\mu}$ is the estimated expected value of the truncated distribution of the inefficiency term, based on the δ parameters. The marginal effects calculated at the individual observation level measure the (monotonic) variation in the cost efficiency index with respect to a contour change of the z variable.

3.2   Data and variables

The database, which can be considered as fairly representative of the entire population of Italian municipalities, refers to a balanced panel of 529 municipalities (of which 204 are located in the North, 207 in the South, and the remaining 118 in the Center of Italy) observed over the period 2004-2006. Table 1 presents the summary statistics of the variables included in the cost frontier specification. For each municipality, we observe:

-      the total cost (TC), which is the sum of labor, capital and fuel costs incurred to provide the MSW service;

-      the tons of MSW disposed (y_D);

-      the tons of MSW sent for recycling (y_R);

-      the price of labor (p_L), given by the ratio of total salary expenses to the number of full-time equivalent employees;

-      the price of diesel fuel (p_F);

-      the price of capital (p_K), obtained by dividing depreciation costs by the capital stock.

We merged different sources of data. Data on costs and output quantities were obtained from annual MUDs (i.e. annual declarations concerning municipal solid waste collection) and were provided by Ecocerved. As to input prices, we relied on balance sheets of the firms (or internal organizational structures of the municipalities, in case of in-house provision) managing the service in the municipalities. As an exception, the price of diesel fuel was drawn from data released by the local Chambers of Commerce.

Table 1 shows that the average municipality produces almost 21,000 tons of waste, around 20 per cent of which is sent to recycling, with an average cost per ton in the neighborhood of 250 Euros.

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Our database contains information concerning the organizational structure of the MSW service as well as the political orientation of the municipality. The limited liability company is by far the most popular legal form (82 percent of the entire sample), followed by in-house provision (10 percent) and inter-municipal partnership (8 percent). The political environment is captured by data on the political majorities ruling the municipalities. Data indicate that left-wing parties are governing around 29 percent of municipalities, right-wing parties around 18 percent, and "civic or municipal lists", that is independent local political groups which are not affiliated to major nation-wide left-wing or right-wing parties, the remaining 53 percent.[11]

Finally, the cornerstone of the analysis is related to the measurement of voters' information (VOTINFO) and of the level of corruption of the environment. We proxy voters' information by newspapers diffusion (as in Snyder and Stromberg, 2010), measured by the number of newspapers readers for every 1,000 inhabitants (excluding sport newspapers) as in Cartocci (2007).[12] This indicator is available only at the province-level of disaggregation, thus we associated each municipality to its provincial value.[13] This seems a reasonable degree of approximation given that the average dimension of an Italian province is quite small (around 2700 km^2 and 500,000 inhabitants). Moreover, in our dataset, there is a total of 101 provinces (out of 110), thus a suitable cross-section variability is ensured.

A crucial point of the analysis clearly concerns the complex assessment of the level of corruption of the environment. As argued by Golden and Picci (2005), directly measuring corruption is *"an enterprise that is not possible since corruption is a complex set of variable interactions, processes and phenomena with no single metric"* (p. 37). Moreover, as suggested by Olken (2009), the most commonly used measures are based on corruption perceptions, while more effort should be put in constructing more objective corruption indices, which could produce more reliable results: *"Perceptions data should be used for empirical research on the determinants of corruption with considerable caution, and there is little alternative to continuing to collect more objective measures of corruption, difficult though that may be"* (p. 962). Our preferred measure uses publicly available data from the National Institute of Statistics (ISTAT).[14] In particular,

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[11] The name "civic lists" stems from the alleged origin of the candidates - civil society rather than political parties. In the remainder of the paper, we will refer to them as independent parties.

[12] We also used the average voters' turnout during the period 1999-2001 (VOTE), which can be thought as a "visible" form of participation. Regressions which include VOTINFO alone, VOTE alone, both measures, or an average between VOTINFO and VOTE (as in Giordano and Tommasino, 2013) are very similar and are available upon request.

[13] In Italy, a province is an administrative division of intermediate level between a municipality and a region. A province is composed of many municipalities, and usually several provinces form a region.

[14] As a robustness check, we use also the corruption index proposed by Golden and Picci (2005), which is based on the difference between the cumulative amount of resources devoted to public works in each province and the physical quantities of infrastructures actually realized. This "missing expenditure" index, which has been widely used in the literature (see, for example, Pinotti, 2015 and Nannicini et al., 2013), is similar to the one computed by Olken

CORRUPT indicates the number of criminal charges against the State, public governments and social institutions (per 100,000 inhabitants), and consists of an aggregate indicator that includes crimes such as embezzlement, extortion, conspiracy and other crimes against the faith and public order. *CORRUPT* is available at provincial level and it is time-invariant, since we consider the average number of crimes during the period 2004-2006. This measure, used by Del Monte and Papagni (2007) and Abrate et al. (2015), does not reflect actual corruption crimes, but only the crimes reported to the police, and hence it likely underestimates the true phenomenon.[15]

3.3 The cost frontier specification

We parameterize the stochastic cost frontier, in order to identify the relationship between cost efficiency and corruption. We use a translog function, that is a second degree Taylor approximation of an arbitrary cost function, taking the following form:

$$\ln\left(\frac{TC_{it}}{p_{F_{it}}}\right) = \beta_0 + \sum_{r \in (D,R)} \beta_r \ln y_r + \sum_{s \in (L,K)} \beta_s \ln\left(\frac{p_s}{p_{F_{it}}}\right) \tag{17}$$

$$+ \sum_{r \in (D,R)} \sum_{s \in (L,K)} \beta_{rs} \ln y_s \ln\left(\frac{p_{s_{it}}}{p_{F_{it}}}\right) + \frac{1}{2} \sum_{r \in (D,R)} \sum_{l \in (D,R)} \beta_{rl} \ln y_r \ln y_l$$

$$+ \frac{1}{2} \sum_{s \in (L,K)} \sum_{m \in (L,K)} \beta_{sm} \ln\left(\frac{p_{s_{it}}}{p_{F_{it}}}\right) \ln\left(\frac{p_{m_{it}}}{p_{F_{it}}}\right) + u_{it} + v_{it}$$

In Equation (17) the residual is composed of a one-sided (u_{it}) term, which follows a truncated normal distribution with mean μ_{it}, and a symmetric random noise (v_{it}). We further assume that v_{it} and u_{it} are homoskedastic and independent of each other and uncorrelated with the output and input price vectors, y_r and p_s.

The outputs y_r are represented by the volume of MSW disposed (r = D) and the volume of MSW recycled (r = R). On the side of productive factors, prices refers to labor (s = L), capital (s = K) and fuel (s = F).

Cost and input prices are divided by the price of fuel (p_F) to ensure homogeneity of degree one in input prices while $\beta_{sr} = \beta_{rs}$ and $\beta_{sm} = \beta_{ms}$ impose symmetry. Other non imposed properties, in particular concerning the concavity of the cost function in input prices, are checked ex post.

We model the expected value of the pre-truncation normal distribution of cost inefficiency in accordance to the theoretical predictions derived in Section 2. In particular, we test three subsequent models:

(2009), who compared the amount of money spent for road-building projects in Indonesian villages with an independent estimate of the actual cost of project realisazion provided by a team of engineers. Results are very similar.

[15] However, Del Monte and Papagni (2007) defend the quality of this variable as an indicator of corruption by showing that it is highly correlated to the traditional corruption perception index (CPI) which, being based on survey data, is not subject to the above criticism.

MODEL 1:

$$\mu_{it} = \delta_0 + \delta_{VOT} \ln VOTINFO_{it} + \delta_{CORR} \ln CORRUPT_{it} \qquad (18)$$

MODEL 2:

$$\mu_{it} = \delta_0 + \ln VOTINFO_{it} \left(\delta_{VOT} + \delta_{VOT\_CORP} CORP_{it} \right) \qquad (19)$$

$$+ \ln CORRUPT_{it} \left(\delta_{CORR} + \delta_{CORR\_LW} LWPOL_{it} \right)$$
$$+ \delta_{CORP} CORP_{it} + \delta_{LW} LWPOL_{it}$$

MODEL 3:

$$\mu_{it} = \delta_0 + \ln VOTINFO_{it} \left(\delta_{VOT} + \delta_{VOT\_CORP} CORP_{it} \right) \qquad (20)$$

$$+ \ln CORRUPT_{it} \left(\delta_{CORR} + \delta_{CORR\_LW} LWPOL_{it} \right) + \delta_{CORP} CORP_{it} + \delta_{LW} LWPOL_{it}$$
$$+ \delta_S SOUTH_i + \delta_N NORTH_i + \delta_{LONG} LONGIT_i + \delta_{LAT} LATIT_i + \delta_{GDP} GDP_{it} + \delta_T TIME_t$$

Following the indications from the theoretical model developed in Section 2, Model 1 sets the municipality inefficiency as a function of voters' information and corruption. Model 2 enriches the analysis using additional variables that can impact on the way voters' information or corruption are affecting the efficient provision of MSW services. More specifically, it emphasizes the potential interactions between voters' information and the organizational form of service supply, on the one hand, and corruption and political orientation on the other. First, we control for the type of service organization, by adding a dummy identifying municipalities that manage the service through limited responsibility companies ($CORP$). The type of ownership may directly impact on efficiency, even though empirical evidence in this sense is rather mixed (Bel et al., 2010). Furthermore, if the potential impact of accountability varies across different types of service organizations, we may observe an additional indirect effect through the parameter δ_{VOT_CORP}. The underlying assumption is that the efficiency benefits from higher voters information may be diluted or even disappear when services are not provided through a limited liability company (the only one subject to the private law administrative and accounting rules). For instance, under in-house provision, a municipality could use cross-subsidization strategies within the broad municipal budget, which can make it particularly challenging for an observer to assess the actual cost, and hence the actual efficiency, of the service. In a similar vein, for associative consortia it is more difficult to disentangle the responsibilities of each municipality in case of poor performance in the management of the service.

The second control concerns the type of political leadership in the local councils, measured by the dummy variable $LWPOL$. In this case, as well, the political variable is included by itself and in terms of interaction with the level of corruption. The underlying idea is that local administrations leaning to the

left might be more spending-oriented, but at the same time less affected by distorting corruption effects (δ_{CORR_LW} is expected to exhibit a negative sign). To that regard, Hessami (2011) finds cross-country evidence that corruption in the public sector is more likely to prevail when right-wing parties are in power. She interprets her results by considering that: "*members of right-wing parties are more likely to originate from an entrepreneurial background and their party platforms more strongly represent the interests of businessmen*" (p. 2), so that they often (more often than left-wing politicians) end up in a trustful, reciprocal relationship with representatives of the private sector, a link that can also be used to foster illegal activities such as corruption. Moreover, Jimenez and Garcia (2012) find, in a large sample of Spanish municipalities, that, after a politician is involved in a local corruption case, the voting share of left-wing parties is reduced by 2-3 percentage points, while right-wing coalitions even increase their share in subsequent elections. Therefore, left-wing parties appear to have much more to lose if caught involved in corruption activities. Finally, Model 3 adds several control variables in the mean inefficiency ancillary equation, as a further robustness check on the key interest parameters. In particular, the presence of a geographical effect is captured both by means of two macro-area dummies (NORTH and SOUTH) and by the exact latitude (LATIT) and longitude (LONGIT) coordinates of each municipality. In addition, we account for the time trend (TIME) and the GDP per capita of the province, a control meant to proxy for shocks that could affect simultaneously corruption and efficiency.

3.4   Results

The one-step total cost frontier (17), combined either with the inefficiency model (18) or (19) or (20), is estimated using maximum likelihood technique. As a normalization strategy, we have divided all continuous variables (cost, output, input price, voters' information and corruption measures) by their sample geometric mean.[16] This allows directly interpreting first order parameters as cost elasticities at the local approximation point. Table 2 displays the estimated parameters. All first orders parameters of the cost frontier are strongly significant and have the expected positive sign. Output parameters β_D and β_R indicate that a 1% increase in MSW disposed or MSW sent to recycling results, ceteris paribus, in a 0.755 to 0.765% or 0.241 to 0.251% increase in costs respectively. Scale economies at the sample mean can be computed as the inverse of the sum of output elasticities. In this case, the adopted two-output cost frontier specification yields values around unity in all the models, thus suggesting that the average municipality exhibits constant returns to scale. The estimates of labor and capital price elasticities are given by parameters β_L and β_K. According to Shephard's lemma they equal the optimal labor and capital cost shares at the local approximation point. The share of the factor (i.e., fuel) used as numeraire

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[16]The geometric mean is less sensitive to outliers. This is an advantage, even though we careful checked data consistency before estimation.

in (17) can then be obtained residually. All the three models estimate a labor cost share (between 38% and 45%) higher than the capital cost share (between 9% and 15%) and about the same as the fuel cost share (between 40% and 52%). This seems reasonable and in line with the typical cost structure in this service. Second-order parameters give flexibility to the functional form, allowing to estimate pointwise output and input price elasticities. In particular, the parameter β_{DR} is negative and significant, suggesting cost complementarities in the joint provision of disposal and recycling services. The specification of the cost function (17) is simple. Since the main focus of the paper is to analyze the impact of corruption and accountability on cost inefficiency, we are not including additional explanatory variables, such as environmental characteristics (the population served, the area size of the municipality, the number of buildings), frequency of service, and the presence of nearby disposal facilities such as incinerators or landfills.[17]

Turning to cost inefficiency, Table 2 shows that the coefficient associated to voters' information index (δ_{VOT}) in Model 1 is negative and highly statistically significant. Greater propensity to participation by citizens – and therefore less opacity in the relationship between citizens and decision-makers – can substantially reduce cost inefficiency. This is in line with Besley and Burgess (2002), as well as with a large anecdotal evidence pointing at the notion that a greater pressure by public opinion is able to route managers and policy-makers towards more efficient decisions.

As expected, δ_{CORR} is instead positive, suggesting that more widespread corruption negatively affect the efficiency performance of MSW services. On the whole, this leads support to our theoretical section.

Model 2 explores in greater details the effects of voters' information and corruption. In this case, the parameter δ_{VOT} measures the impact of the degree of voters' information in the base case in which waste is collected directly by individual municipalities or through inter-municipal consortia, while the parameter of the interacted term (δ_{VOT_CORP}) should be interpreted as the incremental effect due to the presence of limited liability companies. By itself, the corporatization of waste collection generally reduces cost inefficiency (δ_{CORP} = -0.112). This result is in line with the empirical evidence about the positive effects of corporatization on the performance of local public services provision (Cambini et al., 2011) The marginal impact of accountability in the case of service supply through distinct business organizations is very significant (δ_{VOT_CORP} = -0.260) while δ_{VOT} is not statistically significant. This means that voters' information reduces cost inefficiency only if the service is managed through the establishment of independent companies, while the presence of associations of municipalities or of direct in-house management blur the potential benefits of a higher transparency.[18]

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[17]Results of such estimations are available upon request. For more details concerning the technological features of MSW services see Abrate et al. (2014), who focus on the impact of different recycling shares on refusal collection costs and provide a complete analysis of scale, scope, and density economies.

[18]An additional model estimation, not presented here, also tested for a differential impact

Similarly, we analyze the differential prevalence of corruption across different political majorities. The parameter δ_{CORR_LW} represents the incremental cost inefficiency due to corruption under left-wing political guidance. In Model 2 δ_{CORR} still remains positive and highly statistically significant, while the interaction term δ_{CORR_LW} is inefficiency-reducing. The resulting effect of corruption in municipalities led by left-wing local councils is equal to 0.215 (s.e. = 0.094) and is statistically significantly different from zero at 5% level (p-value = 0.023). This implies that in municipalities ruled by right-wing parties and by independent parties ("civic lists") waste collection services suffer more from cost inefficiency due to corruption. The impact of corruption is twice as large as that recorded for municipalities ruled by left-wing parties. The behavior of left-wing municipal councils is, however, more spending-oriented ($\delta_{LW} = 0.133$). In Model 3, all additional variables included in the inefficiency model are significant. The geographical dummies confirm the well-known North-South division, suggesting a higher (lower) refuse collection costs for Southern (Northern) municipalities, while the time trend is negative and significant at the 1% level across all the models, indicating a cost reducing technological progress. Interesting enough, the coefficient for LONGIT is negative, suggesting that, after having checked for the three macro regions (North, Center and South), eastern municipalities are associated with lower costs.[19] Perhaps surprisingly, the coefficients for GDP is positive. More importantly, the effects of corruption and voters' information are confirmed.

The last rows in Table 2 show the statistics for λ coefficient, which is defined as the ratio between the standard deviation of the inefficiency term (σ_u) and the standard deviation of random noise. The values are statistically significant at 1% level, indicating that the inefficiency term has a significant contribution on total variation of the composed error. Then, the likelihood ratio tests of the unrestricted Model 3 (U) against the restricted (R) Models 1 and 2 indicate that including a large set of explanatory variables of expected inefficiency would be preferable.[20]

Using equation (16), we compute the marginal effects on estimated cost efficiency for our preferred specification (Model 3). Results are displayed in Table 3, which provides a measure of the marginal improvement in the efficiency level that can be achieved by reducing corruption or increasing voters' information. The theoretical maximum cost efficiency (frontier level) is equal to 1: therefore, the efficiency level can be also interpreted as the percentage of efficiency achieved with respect to the maximum. Since the explanatory variables are in logarithm, the magnitude of the values in Table 3 can be interpreted as follows. In the cases

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of in-house and inter-municipal consortia and the results were confirmed: VOTINFO does not have a significant impact on inefficiency both in the case of in-house and inter-municipal partnership.

[19] This implies, for example, that municipalities localized in the North-eastern Veneto region (or Lazio and Apulia, for Center and South, respectively) are more efficient than municipalities localized in Piedmont (Sardinia and Sicily, respectively).

[20] The test statistics -2 (LLFR-LLFU), where LLF is the log-likelihood function of the estimated models, is distributed as a Chi-square with degrees of freedom equal to the number of restrictions imposed.

where the services are provided by limited liability companies, increasing voters' information by 10% would move the efficiency level towards the frontier by approximately 0.5%. Furthermore, decreasing corruption by 10% would increase the efficiency level, on average, by 0.68%, with a more remarkable impact for not left-governed municipalities (0.83%). While these figures describe the average impact, both effects tend to be more pronounced when the estimated efficiency decreases.

3.5   Impact of voters' information and corruption on costs

In this section we provide evidence on the impact of voters' information and corruption changes on cost variation. Based on the cost frontier $c(y_{it}, p_{it}; \beta)$, and on the marginal effects on efficiency computed (16), the effect of changes of z-factors ($\triangle z$) in relation to the actual observed cost can be measured as follows:

$$\frac{\triangle Cost}{\triangle z} = \frac{-\frac{\partial CE}{\partial z} \triangle z e^{(c(y_{it}, p_{it}, \beta))}}{CE^2 + \left(\frac{\partial CE}{\partial z}\right)(\triangle z)(CE)} \tag{21}$$

Table 4 simulates the average cost change due to a reduction or expansion of voters' information and corruption levels, respectively, up to the maximum/minimum level. Accordingly, a reduction in voters' information to the minimum level results in a cost increase of approximately 8.6% of the observed cost while expanding the level of voters' information to the maximum value (within the sample) would allow cost savings in the order of 6%, corresponding to approximately 6 euros per inhabitant. If extended to the whole Italian population, this figure would translate in a total cost savings of almost 400 million euros. A more widespread corruption (to the maximum level) would increase costs of 3.9% in the presence of local governments leaning to the left and up to 11.4% in the group of not left-wing observations. By contrast, programs aimed at curbing corruption would allow, in the not left-wing group, cost savings up to 10.9%, corresponding to approximately 11 euros per inhabitant. These figures are as almost three times those for the group of municipalities ruled by left-wing political parties, and corroborate the previous evidence concerning a lower permeability of the latter to the corruption plague.

Finally, Table 5 details cost simulations for a set of large municipalities (with more than 300,000 inhabitants). With reference to the two mostly populated Italian cities, Rome and Milan, a large reduction in the degree of corruption is expected to result in a relative cost saving of 12-14%, equivalent to around 20-28 euros per inhabitant. Also the second largest Southern city, Palermo, looks like it would be heavily affected by a hypothetical improvement in the degree of corruption. In the same vein, an improvement in the level of voters' information in the two most populous cities is shown to induce a relative cost saving ranging between 2.5 and 3.1%, equivalent to a saving of 4-6 euros per inhabitant. The major benefit would concern, in this case, the Southern municipalities (Palermo and Bari), generally plagued by less transparency in the

decision-making process.

3.6 Robustness checks

In this section, we focus on the causality relation between inefficiency and corruption, addressing the potential endogeneity problem arising from the model specification. First, following Dal Bó and Rossi (2007), we argue that using corruption data at the provincial level and municipal-level data from one particular industry limits the potential endogeneity problems. In fact, while it is likely that existing corruption in a province has an impact on the cost efficiency of a subset of firms such as our waste management providers, it is less likely that the inefficiency of the latter will affect the province's overall corruption level.

However, our corruption proxy might still capture the effect of some other omitted factors (such as, for instance, the corruption crimes not reported to the police). As a result, as a robustness analysis, we instrument our key variables of interest. Our instruments exploit the correlation between history and institutional quality variables such as corruption. The idea is that some critical historical events (such as a foreign domination or the formation of civic traditions) still matter for current institutional settings of a region (such as corruption), but do not plausibly influence current economic performance.

The first set of instruments follows Putnam et al. (1993), who proposed a 9-scale measure of civicness of Italian provinces in the period between 1860 and 1920. In particular, the index has been computed using data on membership in mutual aid societies and in cooperatives, strenght of the mass parties, turnout in the few open elections before the advent of Fascism, longevity of local cultural and recreational organizations.[21]

The second, alternative, instrument we use follows Di Liberto and Sideri (2015). They analyze the link between institutional quality and the economic performance of Italian provinces using, as instruments, the histories of the different foreign dominations that ruled Italian regions (in a time span of seven hundred years before the unification of Italy which occurred in the late 19th century). We use two instruments, $FORDOM_{year}$ and $FORDOM_s$. $FORDOM_{year}$ accounts for the number of years during which each Province has been ruled (the maximum value is for the provinces controlled by the Papal state, who ruled for 700 years). $FORDOM_s$ accounts for the number of different dominators that governed a specific Province at different periods of time in the seven centuries taken into consideration. In particular, it is constructed as a Krugman's specialization index: $FORDOM_s = \sum_i \mid b_i - \bar{b} \mid$, where i identifies the nine possible dominations (the Normans, the Swabians, the Anjou, the Aragonese, the Bourbons, the Papal State, the Savoy, the Austrians and the Republic of

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[21] According to Putnam et al. (1993): "*In the nineteenth and early twentieth centuries, the same Italian regions that sustained cooperatives and choral societies also provided the most support for mutual aid societes and mass parties, and citizens in those same regions were the most eager to make use of their newly granted electoral rights. Elsewhere, by contrast, apathy and ancient vertical bonds of clientelism restrained civic involvement and inhibited voluntary, horizontally organized manifestations of social solidarity*" (p. 149).

Venice), b_i is the percentage of years a specific dominator ruled a province (i.e. b_i =total number of years/700), and $\bar{b}$ is the average b for all provinces. A high value of FORDOM$_s$ means that the province has been ruled by the same regime for a long period of time, while a low value occurs if there have been different dominations over the centuries.[22]

The identification strategy employs a two-step approach to instrument corruption taking Model 3 as the baseline and using alternatively, as first stage instruments, the Putnam's scale of civicness for the early unitary period and the type of historical dominations. In the second stage, the frontier model is run by including the fitted values of corruption (instead of the original ones) among the determinants of inefficiency.

The high value of the first stage F-statistic suggests that both civicness and historical dominance are good instruments for corruption.[23]

The estimates, shown in Table 6, confirm most of the results. In particular, the impact of corruption on inefficiency remains significant in all models and the magnitude of the coefficients is even higher than in Model 3. This means that, if a problem of endogeneity due to omitted variable should exist, it would potentially go in the direction of underestimating the effect of corruption. This results seems consistent with the notion that the proposed measure of corruption (CORRUPT), based on reported corruption crimes only, might partially underestimate the true phenomenon, and thus the cost benefits emerging from our simulations might be regarded as conservative.

The only difference with respect to the evidence discussed in the previous Section consists in the significance of the interaction with left side politicians. This is ensured only when we use civicness as our instrument (while it disappears when we use foreign dominations).

4   Conclusions

Politically connected public services providers may be less efficient than standard competitive firms. The principals (voters) may observe the agents (the service provider managers) only very imperfectly. In addition, the interaction between voters and managers is mediated by politicians, who act both as agents of the voters, and as principals of the public service providers. In this context, managers have incentives to exploit the limited information on their behavior

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[22] Following Di Liberto and Sideri (2015), we considered also as instruments the full set of dummies accounting for the different dominators (or the years matrix in which each dominator has been associated with the number of years of ruling). Results are very similar.

[23] In particular, as a rule of thumb, one could say that an instrument is not weak when the F-statistic is larger than 10. Actually, Stock and Yogo (2005) develop more rigorous tables defining the critical minimum value of F to avoid the problem of weak instruments, depending on the number of instruments. In both Model 4 and 5, the value of F is much larger then such critical values. Moreover, while the high number of instruments used in Model 4 (8 dummy variables) might bring out a suspect of overidentification, this problem is ruled out in Model 5 where the number of instruments is exactly the same as the number of instrumented variables.

by the voters. They may put in less effort, and exploit corruption opportunities, which may be particularly appealing to them thanks to their relations with politicians.

The aim of this paper is to analyze both theoretically and empirically how voters information and a corrupt environment impact on efficiency in the provision of a typical local public service, such as solid waste collection and disposal.

On the theory side, we integrate corruption into a standard career concern model. We separately identify corruption and shirking as sources of inefficiency. We do not model corruption as an activity that directly damages the firm; our choice reflects the notion that managers respond to incentives to corruption, which are determined by the environment in which they operate. We find that inefficiency is larger for operators located in areas where information on their performances is less precise. We also show that inefficiency is larger in more corrupt environments, in which managers' incentives are distorted towards activities that do not benefit the company, while they are privately rewarding. Our theoretical predictions are tested using a rich dataset on solid waste management services provided by Italian municipalities for the years 2004-2006. The results of our cost frontier estimates show that both voters' information, measured by newspapers' readership, and corruption, measured using official data about the criminal activity at provincial level, matter and exhibit a significant impact (negative for corruption, positive for voters' information) on efficiency levels. In addition, we show that the effect of voters' information declines or even disappears when municipalities provide the service in-house or by adhering to intermunicipal consortia, which appear to be less efficient ways of organizing the activity, as compared to entrusting it to a limited liability company. Finally, we find that, while municipalities ruled by left-wing parties exhibit higher inefficiency levels, they are also those in which the impact of corruption on inefficiency is lower.

Our results are robust to the introduction of further explanatory variables of the mean value of the inefficiency term, to the measurement of corruption through the missing-expenditure index introduced by Golden and Picci (2005), and to the use of instrumental variables estimation.

Overall, our findings suggest that effective anti-corruption measures, and/or carefully designed incentives for citizens to acquire information, can have substantail effects on the costs of collecting solid waste, especially for the Southern regions of the country. Our simulations for six Italian major cities show that costs can decrease in the range of 3-14%, if corruption declined to the minimum value observed in the sample, while they can decrease in the range of 2-11%, if accountability increased up to its maximum value.

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Figure 1. Effort levels a^p, a^u and $\widehat{a}^u$ as a function of τ
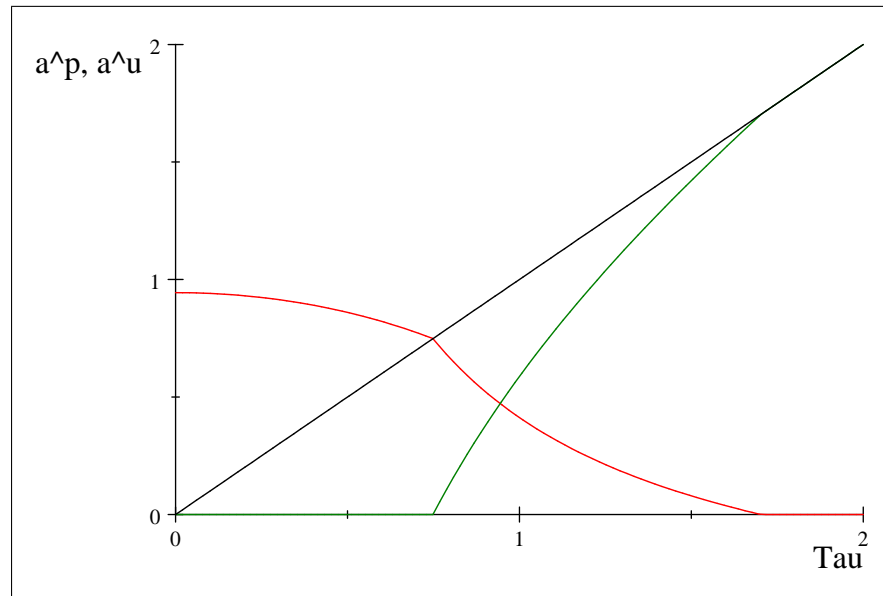
Simulation of the equilibrium values of a^p and a^u as a function of τ, using $\delta = 0.7$, $\pi \widetilde{\sigma} = 0.2$, $R = 1$.

Table 1. Summary statistics

Variable	Description	Mean	Std. dev.	Min	Max
TC	Total cost *(000 €)*	5,436	23,965	46	48,065
y_D	Waste disposed (t)	17,125	71,195	118.44	1,462,128
y_R	Waste recycled (t)	3,770	13,044	8.86	210,211
p_L	Price of labor (€ / Employee)	36,394	5,744	21,000	62,613
p_K	Price of capital (depreciation rate)	0.087	0.013	0.049	0.124
p_F	Price of diesel fuel (€ / liter)	1.023	0.122	0.780	1.370
$CORP$	Limited responsibility company (dummy)	0.819	0.386	0	1
$HOUSE$	In-house provision (dummy)	0.100	0.300	0	1
$INTMUN$	Inter-municipal partnership (dummy)	0.081	0.273	0	1
$LWPOL$	Left wing political orientation (dummy)	0.287	0.453	0	1
$RWPOL$	Right wing political orientation (dummy)	0.178	0.383	0	1
$CIVIC$	Civic or municipal lists (dummy)	0.534	0.499	0	1
$VOTINFO$	Newspaper readers (per 1,000 inhabitants)	74.095	38.519	17.94	175.43
$CORRUPT$	Crimes against public faith (per 100,000 inhab.)	5.492	1.819	1.703	15.113
$LATIT$	Latitude coordinate	42.524	2.661	35.503	46.610
$LONGIT$	Longitude coordinate	12.413	2.789	7.333	18.377
GDP	Per-capita added value	21,782	7,014	11,639	36,542

Table 2. Cost frontier estimates

Variables	Parameters	Model 1	Model 2	Model 3
$\ln y_D$	β_D	0.765***	0.755***	0.758***
		(0.009)	(0.009)	(0.010)
$\ln y_R$	β_R	0.246***	0.251***	0.241***
		(0.007)	(0.007)	(0.009)
$\ln p_L$	β_L	0.449***	0.446***	0.383***
		(0.050)	(0.049)	(0.055)
$\ln p_K$	β_K	0.144***	0.147***	0.093*
		(0.046)	(0.046)	(0.048)
$(\ln y_D)^2$	β_{DD}	0.192***	0.192***	0.174***
		(0.013)	(0.013)	(0.013)
$(\ln y_R)^2$	β_{RR}	0.109***	0.108***	0.097***
		(0.007)	(0.007)	(0.007)
$(\ln p_L)^2$	β_{LL}	-0.043	-0.118	0.207
		(0.384)	(0.381)	(0.370)
$(\ln p_K)^2$	β_{KK}	-1.232***	-1.203***	-0.459
		(0.414)	(0.413)	(0.411)
$(\ln y_D)(\ln y_R)$	β_{DR}	-0.137***	-0.136***	-0.120***
		(0.008)	(0.008)	(0.008)
$(\ln p_L)(\ln y_D)$	β_{LD}	0.071	0.079*	0.059
		(0.048)	(0.048)	(0.048)
$(\ln p_L)(\ln y_R)$	β_{LR}	0.020	0.023	0.024
		(0.036)	(0.036)	(0.035)
$(\ln p_L)(\ln p_K)$	β_{LK}	-0.075	-0.031	-0.335
		(0.318)	(0.319)	(0.310)
$(\ln p_K)(\ln y_D)$	β_{KD}	0.012	0.009	-0.067
		(0.051)	(0.051)	(0.050)
$(\ln p_K)(\ln y_R)$	β_{KR}	-0.046	-0.052	0.008
		(0.034)	(0.034)	(0.033)
Constant	β_0	-0.300***	-0.307***	-0.280***
		(0.031)	(0.039)	(0.042)
Inefficiency model				
$\ln VOTINFO$	δ_{VOT}	-0.253***	-0.040	-0.043
		(0.072)	(0.054)	(0.049)
CORP	δ_{CORP}		-0.112**	-0.028
			(0.057)	(0.030)
$\ln VOTINFO \times CORP$	δ_{VOT_CORP}		-0.260***	-0.178***
			(0.099)	(0.045)
$\ln CORRUPT$	δ_{CORR}	0.399***	0.462***	0.298***
		(0.089)	(0.101)	(0.058)
LWPOL	δ_{LW}		0.133***	0.084***
			(0.040)	(0.024)
$\ln CORRUPT \times LWPOL$	δ_{CORRLW}		-0.247**	-0.206***
			(0.105)	(0.070)
SOUTH	δ_S			0.342***
				(0.059)

NORTH	δ_N			-0.197***
				(0.047)
LONGIT	δ_{LONG}			-0.009***
				(0.001)
LATIT	δ_{LAT}			0.002***
				(0.000)
GDP	δ_{GDP}			0.104***
				(0.033)
TIME	δ_T			-0.063***
				(0.014)
Constant	δ_0	0.002	0.117	0.203***
		(0.115)	(0.092)	(0.065)
Std. Dev. One-sided error term	σ_U	0.214***	0.192***	0.075*
		(0.037)	(0.032)	(0.041)
Std. Dev. Two-sided error term	σ_V	0.250***	0.249***	0.265***
		(0.009)	(0.010)	(0.009)
Lambda	λ	0.856***	0.770***	0.285***
		(0.042)	(0.038)	(0.049)
LLF		-252.097	-237.508	-185.806
LR test		132.580***	103.400***	
Number of observations		1587	1587	1587

Statistically significant at 1% ***, 5% **, 10%*, standard errors in round brackets.

Table 3. Marginal effects on estimated cost efficiency (based on Model 3)

	Mean	Std. Dev.	Min	Max
Voters' information if CORP = 1	0.050	0.014	0.017	0.075
Corruption	-0.068	0.032	-0.125	-0.012
if LWPOL = 1	-0.029	0.006	-0.039	-0.012
if LWPOL = 0	-0.083	0.024	-0.125	-0.029

Table 4. **Impact of voters' information and corruption on costs (based on Model 3)**

		If CORP = 1	If LWPOL = 1	If LWPOL = 0
Average population		45,662	54,152	35,828
Δ corruption (to minimum value)	Cost change (% variation)		-0.039	-0.109
	Cost change (million €)		-0.3	-0.6
	Cost change (€ per inhabit.)		-4.45	-10.99
Δ corruption (to maximum value)	Cost change (% variation)		0.039	0.114
	Cost change (million €)		0.3	0.5
	Cost change (€ per inhabit.)		4.49	11.28
Δ voters' information (to minimum value)	Cost change (% variation)	0.086		
	Cost change (million €)	0.6		
	Cost change (€ per inhabit.)	9.57		
Δ voters' information (to maximum value)	Cost change (% variation)	-0.058		
	Cost change (million €)	-0.3		
	Cost change (€ per inhabit.)	-6.05		

Table 5. Impact of voters' information and corruption on costs for some large municipalities (based on Model 3)

		ROME	MILAN	TURIN	PALERMO	FLORENCE	BARI
Average population		2,711,491	1,297,244	910,437	662,046	366,074	321,747
Geographical region		Center	North	North	South	Center	South
Δ corruption (to minimum value)	Cost change (% variation)	-0.125	-0.141	-0.053	-0.138	-0.091	-0.026
	Cost change (million €)	-53.4	-36.3	-7.5	-14.2	-6.2	-1.2
	Cost change (€ per inhabit.)	-19.69	-27.98	-8.24	-21.43	-16.99	-3.69
Δ corruption (to maximum value)	Cost change (% variation)	0.066	0.107	0.064	0.128	0.067	0.075
	Cost change (million €)	28.4	27.5	9.0	13.2	4.6	3.4
	Cost change (€ per inhabit.)	10.47	21.22	9.86	19.88	12.58	10.57
Δ voters' information (to minimum value)	Cost change (% variation)	0.142	0.154	0.104	0.086	0.141	0.073
	Cost change (million €)	61.9	39.6	15.2	8.9	9.4	3.3
	Cost change (€ per inhabit.)	22.85	30.53	16.71	13.43	25.69	10.22
Δ voters' information (to maximum value)	Cost change (% variation)	-0.025	-0.031	-0.033	-0.083	-0.028	-0.113
	Cost change (million €)	-11.2	-8.0	-4.8	-8.6	-1.9	-5.2
	Cost change (€ per inhabit.)	-4.13	-6.19	-5.23	-12.96	-5.19	-16.06

Table 6. Instrumental variables estimates of the inefficiency model

Variables	Parameters	Model 4	Model 5
		Instruments: Putnam civicness Number of instruments: 8	Instruments: Dominations (1100-1800) Number of instruments: 2
lnVOTINFO	δ_{ACC}	0.014 (0.043)	-0.042 (0.048)
CORP	δ_{CORP}	-0.014 (0.026)	0.001 (0.026)
lnVOTINFO $\times$ CORP	δ_{ACC_CORP}	-0.181*** (0.039)	-0.095** (0.041)
lnCORRUPT	δ_{CORR}	0.522*** (0.055)	0.430*** (0.132)
LWPOL	δ_{LW}	0.075*** (0.018)	0.076*** (0.020)
lnCORRUPT $\times$ LWPOL	δ_{CORRLW}	-0.367*** (0.090)	-0.084 (0.146)
SOUTH	δ_{S}	0.269*** (0.039)	0.242*** (0.043)
NORTH	δ_{N}	-0.090*** (0.035)	-0.072 (0.047)
LONGIT	δ_{LONG}	-0.005*** (0.001)	-0.005*** (0.002)
LATIT	δ_{LAT}	0.002*** (0.000)	0.003*** (0.000)
GDP	δ_{GDP}	0.040** (0.020)	0.027 (0.031)
TIME	δ_{T}	-0.057*** (0.012)	-0.060*** (0.014)
Constant	δ_{0}	0.188*** (0.047)	0.220* (0.123)
First stage F-statistic [instruments only] [a]		$F_{(8, 1568)}$ 71.680	$F_{(2, 1575)}$ 48.300
(p-value)		(0.000)	(0.000)
Number of observations		1587	1587

Statistically significant at 1% ***, 5% **, 10%*, standard errors in round brackets.

[a] The F-statistic tests the validity of instruments: the null hypothesis is that, respectively, Putnam civicness dummies and domination indexes are jointly not significantly different from 0 in the first stage regression. F-statistic must be at least larger than 10 to avoid the problem of weak instruments.