Corruption, Accountability and Efficiency. An Application to Municipal Solid Waste Services*

Graziano Abrate†, Federico Boffa‡, Fabrizio Erbetta §, Davide Vannoni¶‖

May 20, 2014

Abstract

This paper explores the link between accountability, 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 corruption 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. The results of the estimation of a stochastic cost frontier model provide robust evidence that high corruption levels and low accountability substantially increase cost inefficiency. We then show that the negative impact of corruption is weaker for municipalities ruled by left-wing parties, while the positive impact of accountability is larger if the waste collection service is managed by limited liability companies.

Finally, we quantify potential cost savings associated to a reduction in corruption and to an increase in accountability with a simulation on six major Italian cities. The magnitude of the figures indicates the significant economic benefits from anti-corruption and pro-accountability policies.

Keywords: corruption, accountability efficiency, solid waste

JEL Classification: D24, D72, D73, L25, Q53.

†University of Piemonte Orientale and HERMES. email: graziano.abrate@eco.unipmn.it

‡Free University of Bolzano, School of Economics and Managment, and Institut d'Economia de Barcelona. email: federico.boffa@unimc.it

§University of Piemonte Orientale and HERMES. email: fabrizio.erbetta@eco.unipmn.it

¶University of Torino and Collegio Carlo Alberto. email: davide.vannoni@unito.it

‖*Corresponding Author*: Department of Economics, Mathematics and Statistics, Corso Unione Sovietica 218 bis, 10134 Torino, Italy. email: davide.vannoni@unito.it

1 Introduction

In Western countries, many local public services, including water provision, gas distribution and waste collection and disposal, are managed as local monopolies. 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 managerial accountability and corruption as crucial determinants of the level of efficiency in managing the service. The notion of accountability adopted throughout our paper strictly relates to the amount and precision of voters' information on the behavior of the managers in charge of the provision of local public services. The level of information in turn depends both on the incentives for the local monopolies to release it, and on the incentives for voters to acquire it.

We first model the relation between accountability and productivity, using a standard career concern approach to political agency. We show that better accountability is associated to a higher productivity of the public service, as a result of the interplay of two factors: each manager exerts more effort, and, on average, more talented managers are selected. We then enrich our setting, by explicitly introducing corruption. Following the World Bank's definition (World Bank, 1997), 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[2]. We show that corruption distorts managerial effort incentives, leading to an increase in the extent of inefficiency. We derive the implication that inefficiency is greater for waste operators lo-

---

[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 firm employment, while they impact negatively on accounting measures of performance.

[2] 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 other rent-seeking activities connected to political patronage (for example, the choice of employing an excessive number of workers in order to build and maintain political support). Other favors may consist in granting higher current or future regulated profits for the firm willing to satisfy the politician's requirements. For instance, targeted hiring may be a condition for the politician to keep using the same firm as its contractor.

cated in more corrupt regions, and 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 corruption on the costs of providing municipal solid waste (MSW) services throughout Italy. We measure accountability by newspapers' readership and electoral participation, and corruption by the number of criminal charges against the State, public governments and social institutions (as a robustness check, we use also the corruption index proposed by Golden and Picci (2005)). The empirical evidence supports our predictions. We find that both accountability and corruption have an 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 accountability on reducing inefficiency is smaller or even disappears when municipalities organize the service in-house or join a intermunicipal consortium, while corruption is less of harm to efficiency when municipalities are ruled by left-wing parties.

The positive relation between managerial accountability and performance is the counterpart, in a framework of politically connected local monopolies with a soft budget constraint, of the established results on the positive effect of observability and social capital on politicians' accountability obtained in a political agency framework (see, among others, Besley and Burgess, 2002; Ponzetto, 2011; Drago et al., 2014; Nannicini et al., 2013).[3] 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.

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 elec-

---

[3] 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.

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

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

Waste collection is a particularly suitable sector to study the effects of political accountability and corruption on efficiency. In Italy, waste collection and disposal are mainly carried out by publicly-owned firms under the 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 economic performance. This is especially true in contexts plagued by widespread corruption and entrenched presence of criminal organizations. As discussed in D'Amato et al. (2011), entry of organized crime in the waste cycle is 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. Also, in more corrupt environments, managers are more likely to engage in negotiating activities 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.

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 municipal solid waste 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.[5] This is reflective of the Italian organization of the MSW sector. Waste services are typically operated by municipality-owned companies which adopt a spoils system, whereby managers are replaced when the political majority changes; firing

---

[5] Vlaicu and Whalley (2012) solve a model in which politicians are entitled to fire the managers after each period.

4

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. Furthermore, managers of municipality owned companies are entitled to a fixed wage, and were typically not allowed, in the 2004-2006 period, to receive performance-based remunerations.

The manager manages a firm that employs, in each period t, a single input, labor.[6] Following Dal Bò and Rossi (2007), the simple following equation relates labor input L_t, which is assumed to be perfectly flexible, to output y_t through the (possibly time-varying) productivity parameter $\theta_t > 0$.

$$y_t = \theta_t L_t$$

The company is contractually required to collect the garbage shot by the citizens, assumed to be fixed at the level $\overline{y}_t$. This mirrors the institutional setting of the MSW market, where consumers pay a fixed tax $\overline{p}$ for the services, unrelated to the actual amount of waste generated by the household (although possibly a function of a set of variables that affect the expected amount of waste generated), and the company receives a subsidy from the municipality that covers all of its cost; the only external incentive to efficiency for the firm is therefore ultimately provided by voters' behavior.

The cost function faced by the MSW operator, for a given output $\overline{y}$, assumed to be invariant across periods, is then:

$$C_t\left(\overline{y}\right) = \frac{\overline{y}}{\theta_t} w_t$$

where w is the wage paid to each unit of labor. Finally, as a result of the zero-profit condition, $S_t = \frac{\overline{y}}{\theta_t} w_t$, where S_t is the subsidy granted to the firm at time t.

2.1 Baseline model

2.1.1 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 therefore in minimizing the cost $\frac{\overline{y}}{\theta_t} w_t$. As w_t and $\overline{y}$ are exogenous parameters, this amounts to maximizing productivity θ_t.

---

[6]This is a simplifying assumption. Results would be unaltered if we allowed for multiple inputs.

The relation between the managerial type η_t (which could be interpreted as competence or talent), managerial effort a_t and productivity θ_t is described as follows:

$$\theta_t = \eta_t + a_t \qquad (1)$$

Managers are selected by politicians. 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:

$$\theta_t = \rho_{t-1} + \rho_t + a_t \qquad (2)$$

We assume, following Alesina and Tabellini (2007), that performances θ_t are observable, but not contractible. This is typical of the relations between voters and politicians. Managers are career-concerned, and have a fixed per period reward R, which does not depend on effort.

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 effort a_t, the manager does not fully know her talent. In particular, she 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 each period t, the time-line of the game is as follows. At stage one, the manager exerts effort a_t knowing ρ_{t-1}, and without knowing his time-specific skill ρ_t. At stage two, voters observe a noisy signal of productivity:

$$\widehat{\theta}_t = \eta_t + a_t + \epsilon_t \qquad (3)$$

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 may be interpreted as 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 in $t+1$, both ρ_t and

ρ_{t+1} are randomly drawn; therefore, at t, the best predictor of a new manager's competence at $t+1$ is in this case $2\overline{\rho}$. 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 $\widehat{\rho}_t > \overline{\rho}$.

Observe that the incentives for the manager, in our model, 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). 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.

2.1.2 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 productivity signal $\widehat{\theta}_t$.

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

$$\widehat{\rho}_t = E\left(\rho_t|\widehat{\theta}_t\right) = \frac{\sigma_\epsilon^2}{\sigma_\epsilon^2 + \sigma_\rho^2}\overline{\rho} + \frac{\sigma_\rho^2}{\sigma_\epsilon^2 + \sigma_\rho^2}\left(\widehat{\theta}_t - \rho_{t-1} - a_t^e\right) \tag{4}$$

where a_t^e is the 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 $\left(\widehat{\theta}_t - \rho_{t-1} - a_t^e\right)$ 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 $\widehat{\rho}_t \geq \overline{\rho}$. This implies that the incumbent political party is confirmed in office (and, as a consequence, the incumbent manager is reappointed) if:

$$\widehat{\theta}_t - \rho_{t-1} - a_t^e > \overline{\rho} \tag{5}$$

Condition (5) 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 productivity generated by a manager of average skills $\overline{\rho}$.

7

2.1.3 The manager

The effort by the manager has a convex cost:

$$C\left(a_t\right) = \frac{a_t^2}{2} \tag{6}$$

The manager trades off costly effort with probability of retaining her post. She chooses effort a_t, having the same information set as voters, that is, knowing ρ_{t-1}, but not knowing ρ_t. The maximization problem takes therefore the following form:

$$\max_{a_t} V_t = R - \frac{a_t^2}{2} + \delta \Pr\left(\widehat{\rho}_t > \overline{\rho}|a_t\right) V_{t+1} \tag{7}$$

where δ is the discount factor, R is the uni-periodal reward of holding the managerial position, and V_t (V_{t+1}) is the manager's discounted value from occupying the managerial position at time t $(t+1$, respectively). Denote the probability of being reappointed for period $t+1$ as $\gamma \equiv \gamma\left(a_t\right) \equiv \Pr\left(\widehat{\rho}_t > \overline{\rho}|a_t\right)$. Given the recursive nature of the problem, $V_t = V_{t+1}$. Therefore, the discounted value V of the managerial post is:

$$V = \frac{R - \frac{a_t^2}{2}}{1 - \delta\gamma} \tag{8}$$

By combining (4) and (5), the probability γ of being reappointed for a given level of effort a_t may be expressed as:

$$\begin{aligned} \gamma &\equiv & \Pr\left(\widehat{\rho}_t > \overline{\rho}|a_t\right) = \Pr\left(\theta_t - \rho_{t-1} - a_t^e > \overline{\rho}|a_t\right) = \\ &= & \Pr\left(\rho_t + \epsilon_t > \overline{\rho} - a_t + a_t^e\right) = 1 - G\left(\overline{\rho} - a_t + a_t^e\right) \end{aligned} \tag{9}$$

where G, the probability of not being reappointed $(\gamma = 1 - G)$ 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.

Rearranging (8), and using (9), we get:

$$a_t = \arg\max_{a_t} V = \arg\max_{a_t}\left\{\frac{R - \frac{a_t^2}{2}}{1 - \delta\left(1 - G\left(a_t\right)\right)}\right\} \tag{10}$$

2.1.4 Equilibrium effort and selection

In equilibrium, voters are rational and correctly predict the effort level. As a result, $a_t = a_t^e$. Differentiating (10), we obtain the optimal choice of effort as:

$$\frac{\partial V}{\partial a_t} = \delta \frac{R - \frac{a_t^2}{2}}{1 - \delta\gamma} \frac{1}{\sqrt{2\pi\left(\sigma_\rho^2 + \sigma_\epsilon^2\right)}} - a_t = 0$$

Observe that, in equilibrium, rational expectations imply $\gamma = \frac{1}{2}$. By using a conveniently parsimonious notation, we denote $\widetilde{\sigma} \equiv \left(\sigma_\rho^2 + \sigma_\epsilon^2\right)$ and $A = \pi\widetilde{\sigma}\left(2 - \delta\right)^2$. Solving for a_t, one gets:

$$a_t = \frac{\sqrt{2}}{2\delta} \left(\sqrt{4R\delta^2 + A} - \sqrt{A} \right) \tag{11}$$

Effort does not depend on the manager's type; managerial effort serves the purpose of enhancing the perception of the politician's period-specific component of competence, which is not known to the manager when he selects effort.

Reappointment is valuable for the incumbent manager; this motivates his incentives to convey the perception of high competence. A higher uni-periodal reward R, as well as a higher discount factor, amplify the value of reappointment, thereby scaling up managerial effort.

Effort is negatively related to the variance of the noise σ_ϵ^2. An increase in σ_ϵ^2, by reducing the precision of the productivity signal, reduces its sensitivity to effort, and, as a result, the marginal benefit of effort.[7]

Finally, we consider the expected talent of a politician in the stationary equilibrium. Observe that in equilibrium at time t, a new politician (hence a new manager) is in charge with probability $\frac{1}{2}$. This occurs when the politician is replaced as a result of the elections run at time $t-1$, since $\widehat{\rho}_{t-1} < \overline{\rho}$. In such case, the manager's expected talent at t is just the unconditional average period-specific skill for both periods. Hence, $E\left(\eta_t | \widehat{\rho}_{t-1} < \overline{\rho}\right) = 2\overline{\rho}$. With probability $\frac{1}{2}$, instead, the politician is reappointed, and the manager retains her post. This happens when $\widehat{\rho}_{t-1} > \overline{\rho}$. Using (4), and observing that the distribution of the posterior belief $\widehat{\rho}$ is normal with mean $\overline{\rho}$ and variance $\frac{\sigma_\rho^4}{\sigma_\rho^2 + \sigma_\epsilon^2}$, standard properties of the truncated normal distribution yield: $E\left(\rho_{t-1} | \widehat{\rho}_{t-1} > \overline{\rho}\right) = \overline{\rho} + \frac{2\sigma_\rho^2}{\sqrt{2\pi\left(\sigma_\rho^2 + \sigma_\epsilon^2\right)}}$.
Hence, when the incumbent is not replaced after period $t-1$, her expected talent at period t is: $E\left(\eta_t | \widehat{\rho}_{t-1} > \overline{\rho}\right) = 2\overline{\rho} + \frac{2\sigma_\rho^2}{\sqrt{2\pi\left(\sigma_\rho^2 + \sigma_\epsilon^2\right)}}$. It follows that the expected talent at period t is

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

$$= 2\overline{\rho}\left(\frac{1}{2}\right) + \left(2\overline{\rho} + \frac{2\sigma_\rho^2}{\sqrt{2\pi\left(\sigma_\rho^2 + \sigma_\epsilon^2\right)}}\right)\frac{1}{2} =$$

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

Expected ability is negatively related to the variance of the noise σ_ϵ^2. The precision of the signal improves the screening value of the election; the more

---

[7]Effort is also negatively related to the variance of skills σ_ρ^2. However, σ_ρ^2 operates on effort choice through a different channel with respect to the noise σ_ϵ^2. A more dispersed distribution of skills (higher σ_ρ^2), in a setting in which managers do not know their type when selecting the effort level, reduces the probability that a marginal increase in effort allows to cross the productivity threshold $\overline{\theta}$ required for reappointment (which occurs as long as $\widehat{\rho}_t \geq \overline{\theta}$). As a result, larger σ_ρ^2 implies lower marginal benefits of effort.

precise observability of managerial behavior on the part of the voters, the more likely good managers are retained, and bad managers are replaced[8].

Expected productivity at time t is therefore:

$$
\begin{aligned}
E\left(\theta_t\right) &= E\left(\eta_t\right) + a_t = \\
&= 2\overline{\rho} + \frac{\sigma_\rho^2}{\sqrt{2\pi\left(\sigma_\rho^2 + \sigma_\epsilon^2\right)}} + \frac{\sqrt{2}}{2\delta}\left(\sqrt{4R\delta^2 + A} - \sqrt{A}\right)
\end{aligned} \tag{12}
$$

The expected productivity of the local public service is affected by the precision of the signal through two distinct channels. More voters information on managerial behavior increases managerial effort, by making the reappointment more sensitive to actual performances, and it also increases the expected talent of managers, by facilitating voters' screening based on expected talent.

The results are summarized in the following:

Proposition 1 *Expected productivity of the local public service provision at time t is positively related to the precision of the signal, i.e., it is negatively related to the variance of the noise σ_ϵ^2.*

Proof. Considering (12), it is straightforward to show that $\frac{\partial E(\theta_t)}{\partial \sigma_\epsilon^2} = \frac{\partial E(\eta_t)}{\partial \sigma_\epsilon^2} + \frac{\partial a_t}{\partial \sigma_\epsilon^2}$, where $\frac{\partial E(\eta_t)}{\partial \sigma_\epsilon^2} = \frac{\partial\left(\frac{\sigma_\rho^2}{\sqrt{2\pi\left(\sigma_\rho^2 + \sigma_\epsilon^2\right)}}\right)}{\partial \sigma_\epsilon^2} < 0$ and $\frac{\partial a_t}{\partial \sigma_\epsilon^2} = \frac{\partial a_t}{\partial A}\frac{\partial A}{\partial \sigma_\epsilon^2} < 0$, since $\frac{\partial a_t}{\partial A} = \frac{\sqrt{2}}{4\delta}\left(\frac{1}{\sqrt{4R\delta^2 + A}} - \frac{1}{\sqrt{A}}\right) < 0$ and $\frac{\partial A}{\partial \sigma_\epsilon^2} > 0$ ∎

Also, observe that productivity θ_t in the stationary equilibrium is positively related to the discount factor δ and to the revenue awarded to the manager R. The effect of the variance of skills σ_ρ^2 on productivity is more nuanced, as it results from the combination of two countervailing effects. A higher σ_ρ^2 leads to less effort, but to a better screening of politicians. The prevailing effect depends on the model parameters (δ and R).

Our results are in line with the predictions of a variety of political agency models (see, for instance, Alesina and Tabellini, 2007), which establish that politicians' performances decrease in the precision of the signal of the effectiveness of their activity.

The positive relation between signal precision and productivity, implied by $\frac{\partial \theta_t}{\partial \sigma_\epsilon^2} < 0$, is the crucial comparative statics result for our analysis. Better voter information implies better performances.

2.2 Explicit corruption

Following Dal Bò and Rossi (2007), we now introduce an explicit characterization of a corrupt environment. In corrupt environments, managers are privately

---

[8]In contrast to our result on effort, the variance of the skill σ_ρ^2 increases the expected politician's talent, as a larger dispersion of the skills facilitates voters' task of screening politicians in the election.

rewarded for engaging in a range of activities that provide no value to the firm (which we will refer to as unproductive activities). 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.

We extend the framework illustrated in the baseline version by allowing for two different destinations of effort, a productivity-enhancing activity p, and a different type of activity u, which we refer to as unproductive. While effort in the productivity-enhancing activity a^p directly benefits the firm (its effect is analogous to that of a in Section 2.1, effort in the unproductive activity a^u has no direct impact, either positive or negative, on the firm's performance. The model's main insights would remain unaltered if we assumed that effort in the unproductive activity negatively affects the firm's productivity; 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).

Effort in the unproductive activity generates a marginal return τ to the manager. When $\tau = 0$, the problem is exactly analogous to that illustrated in the previous section. Following Dal Bò and Rossi (2007), we assume that τ increases as the degree of corruption increases. This assumption characterizes a corrupt environment as one in which managers obtain substantial rewards from putting effort in tasks that are unrelated to the firm's operation.

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 continue to assume that a more competent politician selects a more talented manager, and managers are tied to the politician in power in a way identical to that illustrated in section 2.1. Productivity at each period t depends on the manager's talent $\eta_t = \rho_{t-1} + \rho_t$ and on his effort a_t^p (while the unproductive effort a_t^u has no direct effect), as follows:

$$\theta_t = \eta_t + a_t^p$$

The time-line at each period t is analogous to that illustrated in the game in section 2.1. At stage one, a manager exerts effort a_t^p and a_u^p, knowing ρ_{t-1}, but without knowing her time-specific skill ρ_t. At stage two, all voters observe the same noisy signal of productivity:

$$\widehat{\theta}_t = \eta_t + a_t^p + \epsilon_t \tag{13}$$

where ϵ_t is an i.i.d. shock $N\left(0, \sigma_\epsilon^2\right)$, uncorrelated to talent ($E[\eta_t \epsilon_t] = 0$). Voters use $\widehat{\theta}_t$ to make their own inference on the level of the time-specific skill $\widehat{\rho}_t$. At stage three, the incumbent is faced by a random challenger in an election. Voters re-elect the incumbent politician if the manager he is associated to is,

11

in expectation, more skilled than the manager linked to the challenger, which occurs if $\widehat{\rho}_t > \overline{\rho}$.

2.2.1 The voters and the manager

Voters' posterior belief on managerial ability is now:

$$\widehat{\rho}_t = E\left(\rho_t | \widehat{\theta}_t\right) = \frac{\sigma_\epsilon^2}{\sigma_\epsilon^2 + \sigma_\rho^2}\overline{\rho} + \frac{\sigma_\rho^2}{\sigma_\epsilon^2 + \sigma_\rho^2}\left(\widehat{\theta}_t - \rho_{t-1} - a_t^{p,e}\right) \tag{14}$$

where $a_t^{p,e}$ is the anticipated productive effort level.

The managers' 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 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 function at time t is the following:

$$\max_{a_t^p, a_t^u} V_t = R + \tau a_t^u - \frac{\left(a_t^p + a_t^u\right)^2}{2} + \tag{15}$$

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

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.[9] 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 (15) may thus be rewritten as:

$$\max_{a_t^p, a_t^u} V_t = R + \tau a_t^u - \frac{\left(a_t^p + a_t^u\right)^2}{2} + \tag{16}$$

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

Given the recursive nature of the problem, $V_t = V_{t+1}$. Hence:

$$V = \frac{R + \tau a_t^u - \frac{\left(a_t^p + a_t^u\right)^2}{2} + \delta\left(1 - \gamma\right)\frac{\tau^2}{2(1-\delta)}}{1 - \delta\gamma} \tag{17}$$

---

[9] 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.

Rearranging (17) and using (9), the optimal choice of effort is determined as:

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

2.2.2 Equilibrium effort

The optimal choices of a_t^u and a_t^p are determined respectively as:

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

$$\frac{\partial V}{\partial a_t^p} = \left(-(a_t^p + a_t^u) - \delta \frac{\tau^2}{2(1-\delta)} g\left(\bar{\rho} + a_t^{e,p} - a_t^p\right) \right)(1 - \delta\gamma) + \qquad (18)$$

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

In equilibrium, voters correctly predict the effort level. As a result, $a_t^p = a_t^{e,p}$ and $\gamma = G = \frac{1}{2}$. Denoting $A = \pi\widetilde{\sigma}(2-\delta)^2$, it follows that, after rearranging (18), we obtain:

$$a_t^u = \begin{cases} 0 \text{ if } \tau < \tau^* \\ \tau - \frac{R}{\tau} + \frac{\sqrt{2A}}{2\delta} \text{ if } \tau^* < \tau < \tau^{**} \\ \tau \text{ if } \tau > \tau^{**} \end{cases} \qquad (19)$$

$$a_t^p = \begin{cases} \frac{\sqrt{2}}{2\delta}\left(\sqrt{\delta^2(4R - 2\tau^2) + A} - \sqrt{A} \right) \text{ if } \tau < \tau^* \\ \frac{R}{\tau} - \frac{\sqrt{2A}}{2\delta} \text{ if } \tau^* < \tau < \tau^{**} \\ 0 \text{ if } \tau > \tau^{**} \end{cases} \qquad (20)$$

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

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; 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.

13

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 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 her 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 $\widetilde{\sigma}, \delta$ 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 analogy with the results obtained in section 2.1. In addition, observe that, for $\tau < \tau^{**}$, $a_t^u < \widetilde{a}_t^u = \tau$, 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 $a_t^u = \widetilde{a}_t^u = \tau$.

Finally, we consider the expected talent of a politician in the stationary equilibrium. Observe that the problem exactly reproduces our baseline model. Hence:

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

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

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 productivity at time t is therefore:

$$E\left(\theta_t\right) \;=\; E\left(\eta_t\right) + a_t^p = \tag{21}$$

$$= \begin{cases} \frac{\sqrt{2}}{2\delta}\left(\sqrt{\delta^2\left(4R-2\tau^2\right)+A}-\sqrt{A}\right)+2\overline{\rho}+\frac{\sigma_\rho^2}{\sqrt{2\pi\left(\sigma_\rho^2+\sigma_\epsilon^2\right)}} \text{ if } \tau < \tau^* \\[2mm] \frac{R}{\tau}-\frac{\sqrt{2A}}{2\delta}+2\overline{\rho}+\frac{\sigma_\rho^2}{\sqrt{2\pi\left(\sigma_\rho^2+\sigma_\epsilon^2\right)}} \text{ if } \tau^* < \tau < \tau^{**} \\[2mm] 2\overline{\rho}+\frac{\sigma_\rho^2}{\sqrt{2\pi\left(\sigma_\rho^2+\sigma_\epsilon^2\right)}} \text{ if } \tau > \tau^{**} \end{cases} \tag{22}$$

Results are summarized in the following:

Proposition 2 *The expected productivity of the local public service (weakly) decreases as the corruption parameter τ increases. Also, consonantly with the baseline model in Section 2.1, expected productivity declines with σ_ϵ^2, while equilibrium productive effort decreases with σ_ϵ^2 and σ_ρ^2.*

Proof. It is immediate to see, after differentiating (22) and (20), that

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

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

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

∎

Observe that low voters' information and corruption, while being both sources of declines in 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 corruption induces a diversion of the effort away from the productive activity. Also, while voters' information has an impact on managerial expected talent, the level of corruption does not.

3   Empirical analysis

3.1   The econometric model

We test our theoretical predictions that costs are greater 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:

$$\ln TC_{it} = c(y_{it}, p_{it}; \beta) + u_{it} + v_{it} \tag{23}$$
$$u_{it} \sim N^+(\mu(z_{it}; \delta), \sigma_u^2)$$
$$v_{it} \sim N(0, \sigma_\nu^2)$$

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, accountability and corruption – and a vector of parameters δ to be estimated.

The two sets of parameters (β and δ) are estimated simultaneously. 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.[10]

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

$$\mu(z_{it}; \delta) = \delta_0 + z'_{it}\delta \tag{24}$$

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.[11]

Cost inefficiency cannot be simply derived as a residual, since the composite error includes the statistical noise v_{it} term, which is not observable. Jondrow et al. (1982) therefore suggest to estimate u_{it} as its conditional expectation $\widehat{u}_{it}$, given the fitted value of $\epsilon_{it} = u_{it} + v_{it}$, i.e. $\widehat{u}_{it} = E(u_{it}|\epsilon_{it})$. The latter can then be transformed into a measure of distance from the optimal frontier following Battese and Coelli (1988), who define the cost inefficiency measure, CI_{it}, as:

$$CI_{it} = E(e^{u_{it}}|\epsilon_{it}) \tag{25}$$

---

[10] 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.

[11] 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.

(25) 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 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):

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

(26)

where $\Phi(.)$ and ϕ denote the cumulative distribution function and the density function of the standard normal distribution, $\mu^* = (1 - \widehat{\gamma})\widehat{\mu} + \widehat{\gamma}\widehat{\epsilon}$, $\sigma^* = \sqrt{\widehat{\gamma}(1 - \widehat{\gamma})\widehat{\sigma}}$, $\widehat{\sigma} = \widehat{\sigma}_u + \widehat{\sigma}_v$, $\widehat{\gamma} = \frac{\widehat{\sigma}_u}{\widehat{\sigma}}$, $\widehat{\sigma}_u$ 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 localized in the North, 207 are localized in the South, and the remaining 118 are localized in the Centre 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.

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 (chosen by 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.[12]

Finally, the cornerstone of the analysis is related to the measurement of accountability and corruption. We regard accountability as related to the amount and precision of voters' information. The equilibrium level of voters information depends on the supply and on the demand of information. Hence, our measure of information combines a proxy for the supply of information and one for demand of information. We proxy demand for information by newspapers diffusion (as in Snyder and Stromberg, 2010), while we proxy demand of information by average voters' turnout, reflective of citizens' attitude to search for information and participate to the community life. Both proxies are provided by Cartocci (2007), in his geographical map of social capital in Italy, and in particular they consist in:

-       the number of newspapers readers (NEWS) for every 1,000 inhabitants (excluding sport newspapers), defined as an "invisible" form of participation;

-       the average voters' turnout during the period 1999-2001 (VOTE), described as a "visible" form of participation.[13]

Both indicators are available only at the province-level of disaggregation, thus we associated each municipality to its provincial value.[14] 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 are a total of 101 provinces (out of 110), thus a suitable cross-section variability is ensured.

Giordano and Tommasino (2013) construct an index of political interest taking into account both newspaper diffusion and electoral participation. We

---

[12] 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.

[13] In particular, the average turnout is computed from 5 elections: 3 referenda (1999, 2000, 2001), 1 election of the National Parliament, 1 election of the European Parliament.

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

follow a similar approach, defining a single accountability index ($ACCOUNT$) as the average between $NEWS$ and $VOTE$.

A crucial point of the analysis clearly concerns the complex assessment of corruption. 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). In particular, $CORRUPT$ 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, which has been used by Del Monte and Papagni (2007), does not reflect actual corruption crimes, but only the crimes reported to the police, and hence it has the drawback of underestimating the true phenomenon.[15]

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.[16]

3.3 The cost frontier specification

In order to identify the relationship between cost efficiency in the collection of solid waste and corruption, we need to parameterize the stochastic cost frontier. A popular functional form in this type of studies is the translog function, that is a second degree Taylor approximation of an arbitrary cost function. In our case, we specify a two output, three input cost frontier, taking the following form:

$$\ln \left(\frac{TC_{it}}{p_{F_{it}}} \right) = \beta_0 + \sum_{r \in (D,R)} \beta_r \ln y_r + \sum_{s \in (L,K)} \beta_s \ln \left(\frac{p_s}{p_{F_{it}}} \right) \tag{27}$$

---

[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.

[16] This "missing expenditure" index, which has been widely used in the literature (see, for example, Pinotti, 2012 and Nannicini et al., 2013), is similar to the one computed by Olken (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 realisation provided by a team of engineers.

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

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

In Equation (27) 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:

MODEL 1:

$$\mu_{it} = \delta_0 + \delta_{ACC} \ln ACCOUNT_{it} \tag{28}$$

MODEL 2:

$$\mu_{it} = \delta_0 + \delta_{ACC} \ln ACCOUNT_{it} + \delta_{CORR} \ln CORRUPT_{it} \tag{29}$$

MODEL 3:

$$\mu_{it} = \delta_0 + \ln ACCOUNT_{it} \left(\delta_{ACC} + \delta_{ACC\_CORP} CORP_{it}\right) \tag{30}$$
$$+ \ln CORRUPT_{it} \left(\delta_{CORR} + \delta_{CORR\_LW} LWPOL_{it}\right)$$
$$+ \delta_{CORP} CORP_{it} + \delta_{LW} LWPOL_{it}$$

In Model 1, we consider only the accountability index as a determinant of municipality inefficiency, as a test for our baseline model developed in Section 2.1. In Model 2, a corruption index is added as a separate variable in the mean inefficiency ancillary equation, accounting for the theoretical predictions of Section 2.2. Model 3 enriches the analysis using additional variables that can impact on the way accountability or corruption are affecting the efficient provision of MSW services.

More specifically, Model 3 emphasizes the potential interactions between accountability 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. 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_{ACC_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 ideas is that local administrations animated by a left-wing political orientation might be more spending-oriented, but at the same time they may be 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, right-wing voters appear to be much more loyal than left-wing voters, so that left-wing parties have much more to lose if caught involved in corruption activities.

3.4 Results

The one-step total cost frontier (27), combined either with the inefficiency model (28) or (29) or (30), is estimated using maximum likelihood technique. As a normalization strategy, we have divided all continuous variables (cost, output, input price, accountability and corruption measures) by their sample geometric mean.[17] This allows directly interpreting first order parameters as cost elasticities at the local approximation point. Table 2 displays the estimated parameters.

---

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

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 0.753 to 0.767% or 0.243 to 0.253% 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 in (27) can then be obtained residually. All the three models estimate a labor cost share (about 45%) higher than the capital cost share (between 10% and 14%) and about the same as the fuel cost share (between 41% and 45%). 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.[18]

Turning to cost inefficiency, Table 2 shows that the coefficient of the accountability index (δ_{ACC}) 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.

By including the corruption variable (Model 2), the magnitude of δ_{ACC} is reduced, although it remains negative and highly statistically significant. As expected, the corruption index parameter (δ_{CORR}) is instead positive, suggesting that more widespread bribing practices negatively affect the efficiency performance of MSW services. On the whole, this leads support both to the baseline version of our theoretical model, and to its enriched version that includes corruption.

Model 3 explores in greater details the effects of accountability and corruption. In this case, the parameter δ_{ACC} measures the impact of the degree of

---

[18]The specification of the cost function (27) is simple but contains all the relevant information to fit precisely observed costs. Since the main focus of this study is to analyze the impact of corruption and accountability on cost inefficiency, we do not present here the estimates of cost function specifications which have been enriched of explanatory variables such as environmental characteristics (the population served, the area size of the municipality, the number of buildings), the presence of nearby disposal facilities such as incinerators or landfills, and so on. Results of such estimations are available upon request. For more details concerning the technological features of MSW services see Abrate et al. (2014a), who focus on the impact of different recycling shares on refusal collection costs and provide a complete analysis of scale and scope economies, and Abrate et al. (2014b), who investigate into depth the issue of density economies.

accountability 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_{ACC_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} = -0.127). 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_{ACC_CORP} = -0.469) while δ_{ACC} is not statistically significant. The effect of accountability if corporatization occurs may be computed as $\delta_{ACC} + \delta_{ACC\_CORP}$, yielding a coefficient equal to -0.508 (s.e. = 0.165), which is statistically significant at 1%. This means that accountability 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.[19]

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 3 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 0.201 (s.e. = 0.091) and is statistically significantly different from zero at 5% level (p-value = 0.027). 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 (δ_{LW} = 0.136).

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 (26), 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

---

[19] An additional model estimation, not presented here, also tested for a differential impact of in-house and inter-municipal consortia and the results were confirmed: accountability does not have a significant impact on inefficiency both in the case of in-house and inter-municipal partnership.

[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.

that can be achieved by reducing corruption or increasing accountability.[21] 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 where the services are provided by limited liability companies, increasing accountability by 10% would move the efficiency level towards the frontier by approximately 0.8%. Furthermore, decreasing corruption by 10% would increase the efficiency level, on average, by 0.64%, with a more remarkable impact for not left-governed municipalities (0.76%).

Figures 2 and 3 depict the relationship, based on Model 3, between marginal effects of accountability and corruption and the conditional expectation of cost efficiency. Figure 2 shows that the effect due to a marginal improvement in accountability is enhanced when estimated efficiency decreases. This means that the effort to induce less opacity in the relationship between citizens and decision-makers would be more advantageous if the level of efficiency is lower. In a specular way, Figure 3 shows a general tendency of corruption to worsen cost efficiency, especially for those municipalities not leaded by left-wing parties and already suffering from higher inefficiency (i.e low levels of cost efficiency, particularly if below 0.7).

3.5   Impact of accountability and corruption on costs

In this section we provide evidence on the impact of accountability and corruption changes on cost variation. Based on the cost frontier model, the over-cost measure (g) could be determined as the ratio between the estimated inefficiency term, u_{it}, and the predicted optimal cost, $c(y_{it}, p_{it}; \beta)$. Since the inefficiency term has been modeled as a function of several exogenous factors, the over-cost rate will also depend on such factors, i.e. $g \equiv g(z)$. A variation in external factors, therefore, will bring about a change in the rate itself. Such difference can be expressed as:

$$\Delta g(z) = \frac{1}{\frac{\partial CE}{\partial z}}[\Delta z] \tag{31}$$

where $\frac{\partial CE}{\partial z}$ is the marginal effect computed in (26). In order to evaluate the effect of changes of z-factors in relation to the actual observed cost, we formulated (31) as follows:

$$\%\Delta Cost = \Delta g(z) \cdot c(y_{it}, p_{it}; \beta)/TC_{it} \tag{32}$$

Figures 4 and 5 illustrate the potential cost change due to a reduction or expansion of accountability and corruption levels, respectively, up to the maxi-

---

[21] Table 3 and Figure 2 refer only to cases where the services are provided by limited liability companies. As already noticed, the effect of accountability is not significant when the service is organized in-house or by relying to intermunicipal consortia.

mum/minimum and first/third quartile values observed in the sample.[22]

A reduction in accountability to the minimum level results in a cost increase up to approximately 15% of the observed cost (10% if first quartile level is considered). On the other hand, an expansion of the level of accountability to the maximum (or to third quartile) would allow a cost saving of up to 20%, with a median value slightly less than 5%, corresponding to approximately 300,000 euros in absolute terms. Given the average population of municipalities in our sample, this means an average impact of about 8.5 euros per inhabitant: if extended to the whole Italian population, the total cost savings would be around 500 million euros.

A more widespread corruption (to the maximum level) would increase costs up to 10% (5% when considering the third quartile) in the presence of local governments with left-wing political orientation and up to 17% (7%) 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 25% (10% if the first quartile is considered), with a median value of 10%, corresponding to approximately 500,000 euros, i.e. 14 euros per inhabitant. These figures are roughly twice as 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.

Figure 6 illustrates cost change simulations for the three main macro regions of the country The results show a greater sensitivity of Southern Italy to policies designed to improve social conditions in terms of corruption and accountability, as well as to a worsening of the level of corruption. For instance, a reduction in corruption up to the lowest observed value would imply a median cost saving of 530,000 (300,000) euros, corresponding to about 13.6 (8.5) euros per inhabitant, for municipalities located in the South (in the North, respectively) However, a deterioration in the accountability level would have a differentially larger impact in Northern and Central Italy, where the level of participation by citizens is, on average, higher.

Finally, in Table 4 we present 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 of the degree of corruption is expected to result in a relative cost saving of 10-11%, equivalent to around 18-20 euros per inhabitant. The second largest Southern city, Palermo, looks like the municipality which is mostly affected by changes in the degree of corruption. In the same vein, an improvement in the level of accountability in the two most populous cities is shown to induce a relative cost saving ranging between 2.4 and 2.6%, equivalent to a saving of 4-5 euros per inhabitant. The major benefit would concern, in this case, the Southern municipalities (Palermo and Bari), generally affected by less transparency of the decision-making process.

---

[22]While the simulation with respect to corruption is distinct for the cases of municipalities governed by left-wing and not left-wing local councils (Figure 5), the simulation with respect to accountability refers only to the category of municipalities that have entrusted the service to limited liability companies (Figure 4), since the marginal effect of the alternative group is not statistically significant.

3.6 Robustness checks

In this section we address some identification issues, such as the potential endogeneity of $CORRUPT$ and the omitted variable bias, that could affect the validity of the above reported results. Following Dal Bó and Rossi (2007), we argue that using corruption data at the provincial level and municipal-level data from one particular industry should reduce 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. Moreover, in order to check whether our results are robust to changes in the modeling of the expected value of the inefficiency term, we estimate several models including additional control variables, such as geographical dummies (DNORTH and DSOUTH), aiming at capturing the extent to which the location in the North or the South of the Country has, in itself, a differential impact with respect to the omitted class represented by Center Italy, a time trend (TIME) and a different corruption index ($CORR_{GP}$), in order to make sure our results are not an artifact of a particular measure of corruption. This alternative measure, which has been proposed by Golden and Picci (2005), is available for all Italian provinces and reflects *"the difference between the amount of physically existing public infrastructure (roads, schools, hospitals, etc.) and the amount of money cumulatively allocated by government to create this public works"* (Golden and Picci, 2005, p. 37). The underlying idea is that corruption raises the costs of building public infrastructures, so that $CORR_{GP}$ is computed as the (logarithm of the) ratio between the building cost and the actual value of public investment. As recognized by Golden and Picci (2005), the measure captures some inefficiencies as well as various illegal activities that comprise genuine corruption. However, the fact that public sector costs were found to vary geographically in ways quite different from private sector costs *"offers persuasive, if indirect, confirmation that the measure of corruption we create is valid, reflecting the extensive graft and fraud that are especially common to public sector contracting, rather than mere inefficiencies."* (p. 38).

The geographical dummies are not generally significant (with the exception of model A in which DSOUTH assumes a positive value, thus suggesting a higher refuse collection costs for Southern municipalities), while the time trend is negative and significant at the 1% level across all the models, indicating a cost reducing technological progress.

The results confirm the cost-reducing impact of the degree of accountability in the cases where solid waste services are provided by corporations (δ_{ACC_CORP} ranges from -0.180 to -0.341 and is always statistically significant at the 1% level). Moreover, in all models, corruption contributes to deteriorate cost efficiency, even when it is measured by $CORR_{GP}$, either included individually or along with CORRUPT. Models C and D confirm that the index of corruption adopted in the baseline model is still significant even after controlling for a variable, i.e. $CORR_{GP}$, reflecting cost over-charge ratios. The dampening effect played by the specific left-wing political orientation (i.e. the negative and sig-

nificant sign of δ_{CORRLW} and δ_{GPLW}), is confirmed except for Extended Model D, while LWPOL still exhibits a positive and significant coefficient, thereby underpinning the previous evidence that municipalities ruled by left wing local councils have a more marked attitude to increase expenditures. Finally, δ_{CORP} holds its negative sign and is statistically significant in all specifications except for Extended Model A.

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 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 accountability, in the sense of voters information, and corruption 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 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 unproductive activities. 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 accountability, measured by newspapers' readership and electoral participation, and corruption, measured using official data about the criminal activity existing in the area where the refuse collection service is provided, matter and exhibit a statistically significant impact (negative for corruption, positive for accountability) on efficiency levels. In addition, we show that the effects of accountability decline or even disappear 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 and to the measurement of corruption through the missing-expenditure index introduced by Golden and Picci (2005). Overall, our findings suggest that fighting corruption and making the behavior

27

of managers of local public utilities more accountable have non trivial 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. The magnitude of the cost savings suggests the significant economic benefits that could be generated by anti-corruption and pro-accountability policies.

5   References

Abrate G., Erbetta, F., Fraquelli G., Vannoni D. 2014a. "The Costs of Disposal and Recycling: An Application to Italian Municipal Solid Waste Services", *Regional Studies*, 48, 5, 896-909.

Abrate G., Erbetta, F., Fraquelli G., Vannoni D. 2014b. "Size and Density Economies in Refuse Collection", Kinnaman T., Takeuchi K. (eds.), *Handbook on Waste Management*, Edward Elgar.

Alesina A., Tabellini G. 2007. "Bureaucrats or Politicians? Part I: A Single Policy Task", *The American Economic Review,* 97, 1, 169-79

Alesina A., Tabellini G. 2008. "Bureaucrats or Politicians? Part II: Multiple Policy Task", *Journal of Public Economics,* 92, 426–447

Banerjee A., Mullainathan S., Hanna R. 2013. "Corruption", Ch.27 in Gibbons R., Roberts J. (eds) *Handbook of Organizational Economics*, 1109-1147.

Battese G., Coelli T. 1988. "Prediction of Firm-level Technical Efficiencies: With a Generalized Frontier Production Function and Panel Data", *Journal of Econometrics,* 38:387-399.

Battese G., Coelli T. 1995. "A Model for Technical Inefficiency Effects in a Stochastic Frontier Production Model for Panel Data", *Empirical Economics*, 20, 325-332.

Bel G., Fageda, X., Warner M. E. 2010. "Is Private Production of Public Services Cheaper than Public Production? A Meta-Regression Analysis of Solid Waste and Water Services", *Journal of Policy Analysis and Management*, 29, 3, 553-577.

Besley T., Burgess R. 2002. "The Political Economy of Government Responsiveness: Theory and Evidence from India", *Quarterly Journal of Economics,* 117(4):1415–51.

Bonfiglioli A., Gancia G. 2013. "Uncertainty, Electoral Incentives and Political Myopia", *The Economic Journal*, 123, 568, 373-400.

Cambini C., Filippini M., Piacenza M., Vannoni D. 2011 "Corporatization and Firm Performance: Evidence from Publicly-Provided Local Utilities", *Review of Law and Economics*, 7, 1, 196-217.

Cartocci R. 2007 "*Mappe del Tesoro. Atlante del Capitale Sociale in Italia*", Il Mulino, Bologna.

D'Amato A., Mazzanti, M., Nicolli F. 2011. "Waste Sustainability, Environmental Management and Mafia Rents: Analysing Geographical and Economic

Dimensions", *CEIS Research Papers*, 213.

Dal Bó E., Rossi M.A. 2007. "Corruption and Inefficiency: Theory and Evidence from Electric Utilities", *Journal of Public Economics,* 91: 939-62.

Del Monte A., Papagni E. 2007. "The Determinants of Corruption in Italy: Regional Panel Data Analysis", *European Journal of Political Economy,* 23: 379-96.

Drago F., Nannicini T., Sobbrio F. 2014. "Meet the Press: How Voters and Politicians Respond to Newspaper Entry and Exit", *American Economic Journal: Applied Economics*, forthcoming.

Giordano P., Tommasino P. 2013. "Public Sector Efficiency and Political Culture", *FinanzArchiv: Public Finance Analysis*, 69, 3, 289-316.

Golden M.A., Picci L. 2005. "Proposal for a New Measure of Corruption, Illustrated with Italian Data." *Economics and Politics*, 17 (1), 37-75.

Hessami Z. 2011. "On the Link between Government Ideology and Corruption in the Public Sector", *mimeo*, University of Konstanz, Germany.

Jimenez J-L., Garcia C. 2011. "Corruption and Local Politics: Does it Pay to be a Crook?", *Research Institute of Applied Economics Working Papers*, 2, Universitat de Barcelona, Barcelona.

Jondrow J., Lovell, K., Materov, I., Schmidt P. 1982. "On the Estimation of Technical Inefficiency in the Stochastic Frontier Production Function Model", *Journal of Econometrics*, 19, 233-238.

Kumbhakar S.C., Ghosh, S, McGuckin J.T. 1991. "A Generalized Production Frontier Approach for Estimating Determinants of Inefficiency in US Dairy Farms", *Journal of Business and Economic Statistics*, 9, 279-286.

Menozzi A., Urtiaga, M. G., Vannoni D. 2012. "Board Composition, Political Connections and Performance in State-Owned Enterprises", *Industrial and Corporate Change*, 21, (3), 671-98.

Nannicini T., Stella A., Tabellini G., Troiano U. 2013. "Social Capital and Political Accountability", *American Economic Journal: Economic Policy*, 5, 2, 222-250.

Nickell S. 1996. "Competition and Corporate Performance", *Journal of Political Economy,* 104, 4, 724-46.

Olken B.A. 2009. "Corruption perceptions vs. Corruption Reality", *Journal of Public Economics*, 93, 950-964.

Olsen J.V., Henningsen A. 2011. "Investment Utilisation, Adjustment Costs, and Technical Efficiency in Danish Pig Farms," *IFRO Working Paper*, University of Copenhagen, Department of Food and Resource Economics, 13.

Pinotti P. 2012. "The Economic Consequences of Organized Crime: Evidence from Southern Italy", *Bank of Italy Working Papers*, 868, April.

Ponzetto G.A.M. 2011. "Heterogeneous Information and Trade Policy", *CEPR Discussion Paper* No. 8726.

Shleifer A., Vishny R. 1994. "Politicians and Firms", *The Quarterly Journal of Economics,* 109, 4, 995-1025

Snyder J.M., Strömberg D. 2010. "Press Coverage and Political Accountability," *Journal of Political Economy*, 118(2), 355-408.

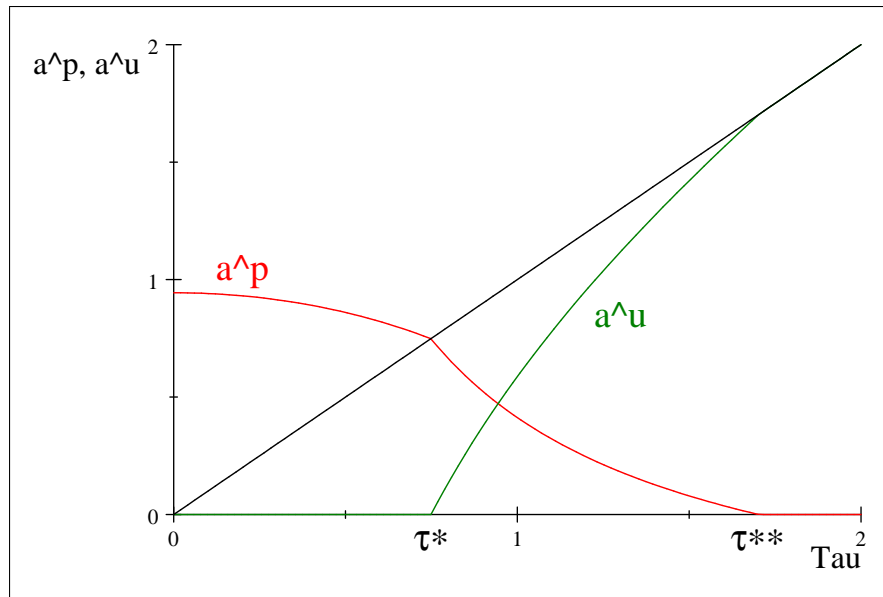Svensson J. 2005. "Eight Questions About Corruption", *Journal of Economic Perspectives,* 19 (3): 19-42.

Vlaicu R, Whalley A. 2012. "Hierarchical Accountability in Government: Theory and Evidence", *mimeo.*

Wang, H., Schmidt P. 2002. "One Step and Two Step Estimation of the Effects of Exogenous Variables on Technical Efficiency Levels", *Journal of Productivity Analysis*, 18, 129-144.

World Bank, 1997. "Helping Countries Combat Corruption: The Role of the World Bank", *Poverty Reduction and Economic Management*, The World Bank, September.

Yan J., Oum T.H. 2014. "Effects of Government Corruption on the Efficiency of U.S. Commercial Airports", *Journal of Urban Economics*, 80, 119-132.

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 liability 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 Lists" or independent local parties (dummy)	0.534	0.499	0	1
$NEWS$	Newspapers readers (per 1,000 inhabitants)	74.095	38.519	17.94	175.43
$VOTE$	Average voters' turnout (%)	53.246	6.750	37.4	68.2
$ACCOUNT$	Accountability : ($NEWS + VOTE$)/2	63.671	21.645	29.32	114.06
$CORRUPT$	Crimes against public faith (per 100,000 inhabitants)	5.492	1.819	1.703	15.113

Table 2. Cost frontier estimates

Variables	Parameters	Model 1	Model 2	Model 3
lny_D	β_D	0.767***	0.763***	0.753***
		(0.009)	(0.009)	(0.009)
lny_R	β_R	0.243***	0.247***	0.253***
		(0.007)	(0.007)	(0.007)
lnp_L	β_L	0.447***	0.454***	0.452***
		(0.050)	(0.050)	(0.050)
lnp_K	β_K	0.104**	0.141***	0.142***
		(0.046)	(0.046)	(0.046)
$(lny_D)2$	β_{DD}	0.194***	0.191***	0.191***
		(0.013)	(0.013)	(0.013)
$(lny_R)2$	β_{RR}	0.108***	0.108***	0.108***
		(0.007)	(0.007)	(0.007)
$(lnp_L)2$	β_{LL}	-0.175	-0.095	-0.178
		(0.396)	(0.385)	(0.383)
$(lnp_K)2$	β_{KK}	-1.378***	-1.317***	-1.297***
		(0.423)	(0.416)	(0.418)
$(lny_D)(lny_R)$	β_{DR}	-0.138***	-0.136***	-0.135***
		(0.008)	(0.008)	(0.008)
$(lnp_L)(lny_D)$	β_{LD}	0.100**	0.076	0.086*
		(0.049)	(0.048)	(0.048)
$(lnp_L)(lny_R)$	β_{LR}	-0.012	0.016	0.018
		(0.036)	(0.036)	(0.036)
$(lnp_L)(lnp_K)$	β_{LK}	0.079	0.001	0.062
		(0.329)	(0.321)	(0.324)
$(lnp_K)(lny_D)$	β_{KD}	0.000	0.012	0.007
		(0.052)	(0.051)	(0.051)
$(lnp_K)(lny_R)$	β_{KR}	-0.040	-0.046	-0.050
		(0.035)	(0.034)	(0.034)
Constant	β_0	-0.253***	-0.304***	-0.307***
		(0.024)	(0.033)	(0.042)
ln ACCOUNT	δ_{ACC}	-1.153**	-0.413***	-0.039
		(0.549)	(0.121)	(0.089)
CORP	δ_{CORP}			-0.127**
				(0.061)
ln ACCOUNT × CORP	δ_{ACC_CORP}			-0.469***
				(0.177)
ln CORRUPT	δ_{CORR}		0.379***	0.444***
			(0.087)	(0.099)
LWPOL	δ_{LW}			0.136***
				(0.041)
ln CORRUPT × LWPOL	δ_{CORRLW}			-0.243**
				(0.105)
Constant	δ_0	-0.587	0.018	0.133
		(0.504)	(0.116)	(0.092)
Std Dev. One-Sided error term	σ_u	0.328***	0.214***	0.191***
		(0.089)	(0.036)	(0.031)
Std Dev. Two-Sided error term	σ_v	0.256***	0.249***	0.249***
		(0.008)	(0.009)	(0.010)
Lambda	λ	1.280***	0.860***	0.767***
		(0.090)	(0.041)	(0.037)
LLF		-276.011	-252.978	-236.661
LR test		78.700***	32.630***	

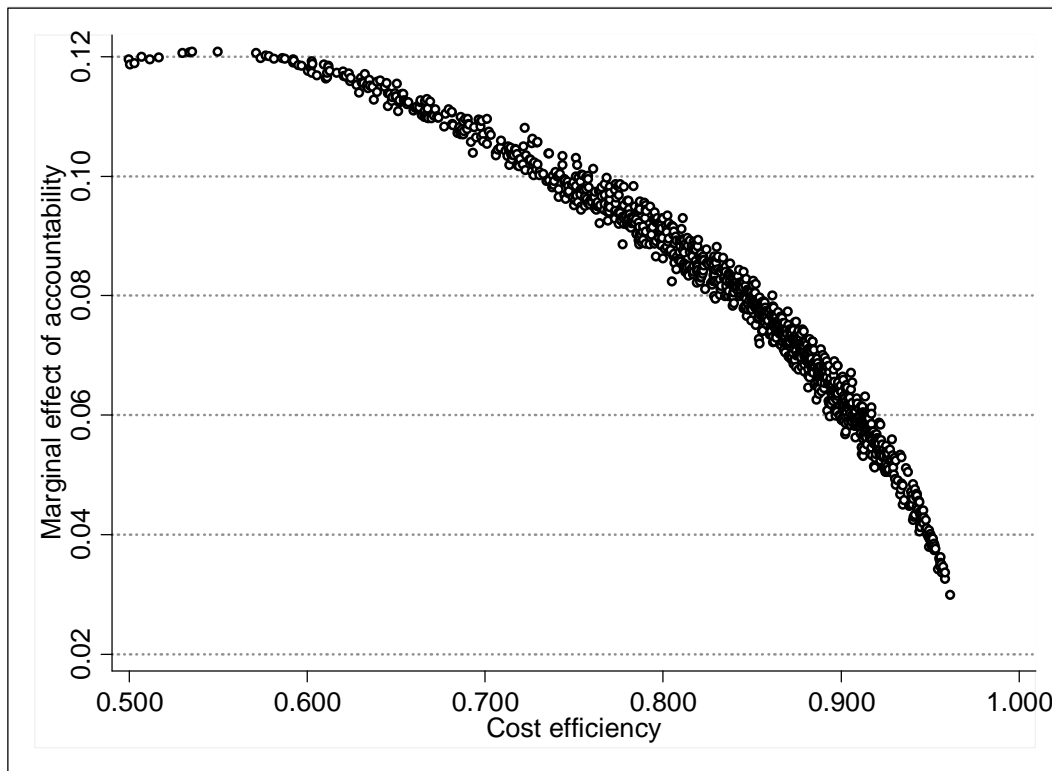Statistically significant at 1% ***, 5% **, 10%*, standard errors in round brackets.

Table 3. Marginal effects on estimated cost efficiency

	Mean	Std. Dev.	Min	Max
Accountability	0.079	0.020	0.030	0.121
if CORP = 1				
Corruption	-0.064	0.025	-0.114	-0.016
if LWPOL = 1	-0.036	0.008	-0.052	-0.016
if LWPOL = 0	-0.076	0.020	-0.114	-0.028

Note: the marginal effects measure the variation of the cost efficiency index with respect to a contour change of the explanatory variable, according to Equation (20): $\dfrac{\partial CE}{\partial \ln ACCOUNT}$ and $\dfrac{\partial CE}{\partial \ln CORRUPT}$.
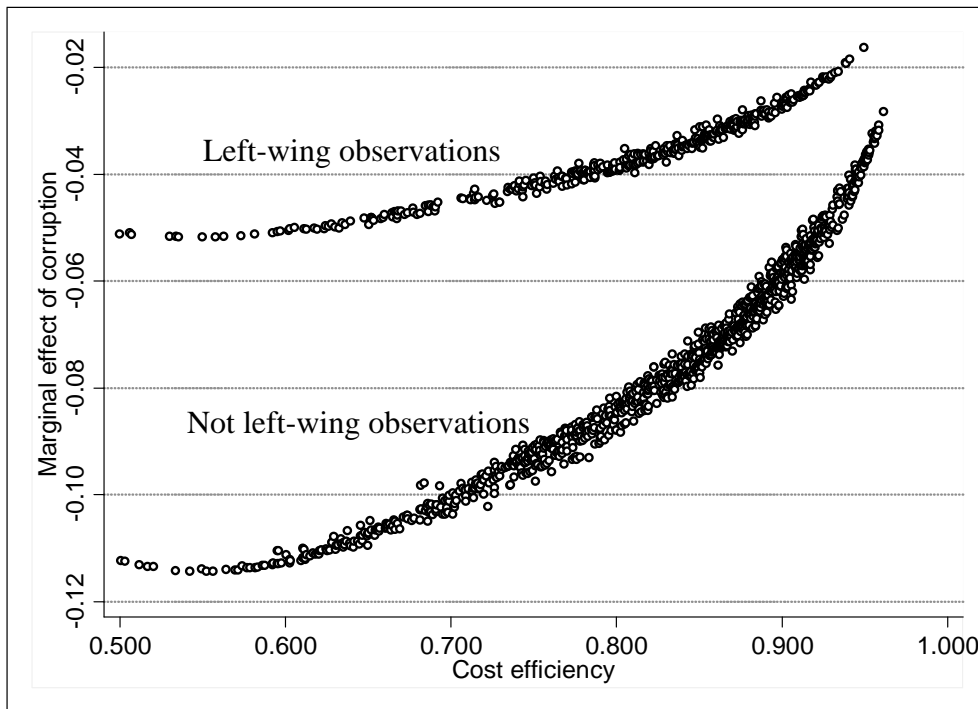
The cost efficiency can range from 0 (minimum level) to 1 (maximum level, i.e. frontier level).

Figure 2. Relation between marginal effect of accountability and estimated cost efficiency
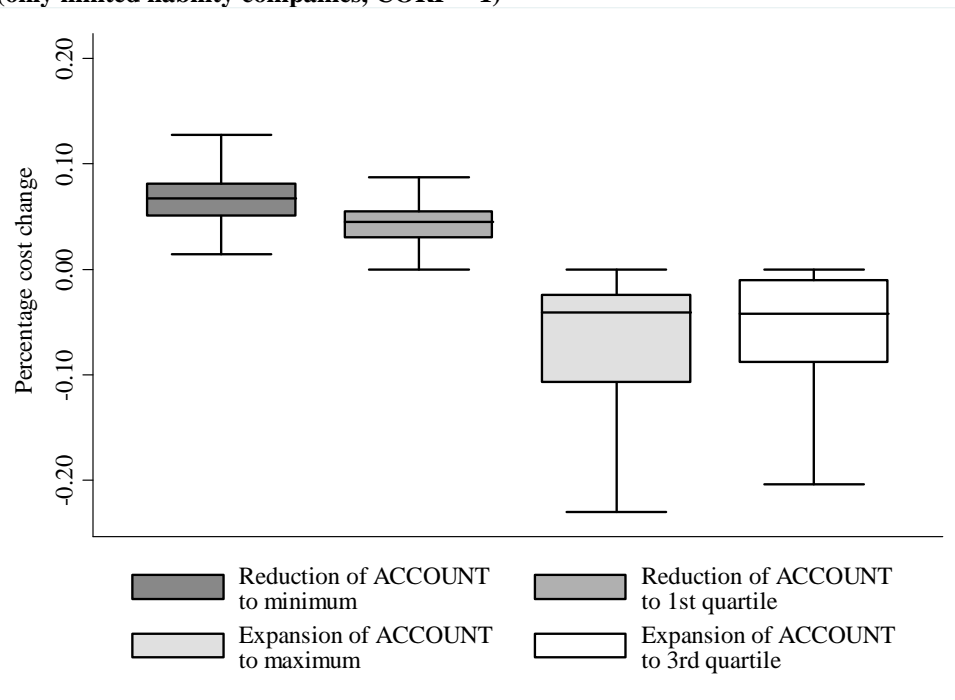

Note: the marginal effects are computed according to Equation (20) $\dfrac{\partial CE}{\partial \ln ACCOUNT}$ only in the case of the presence of limited liability companies. The marginal effect is positive because accountability improves cost efficiency: the theoretical maximum (frontier level) is achieved when the cost efficiency is equal to 1.

Figure 3. Relation between marginal effect of corruption and estimated cost efficiency
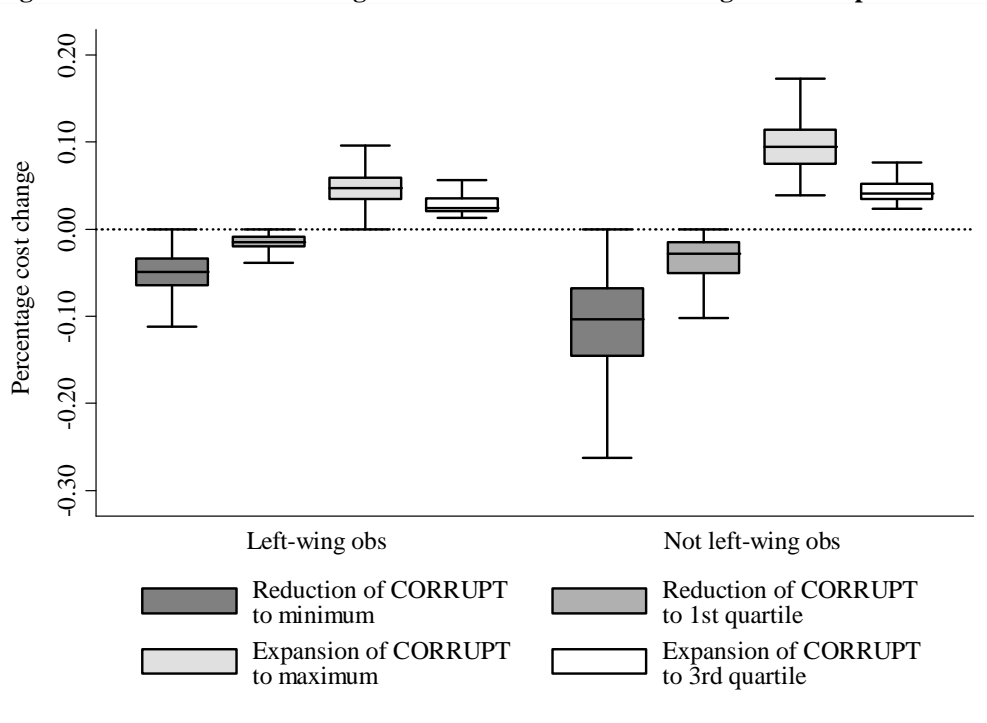

Note: the marginal effects are computed according to Equation (20) $\dfrac{\partial CE}{\partial \ln CORRUPT}$ (for both left-wing and not left-wing municipalities). The marginal effect is negative because reducing corruption improves cost efficiency. The maximum (frontier level) is achieved when the cost efficiency is equal to 1.

Figure 4. Simulation of % changes of costs associated with changes in accountability (only limited liability companies, CORP = 1)

The bottom and top of each box represent the 25th (Q1) and 75th (Q3) percentiles, the line inside the box represents the median, the ends of the whiskers (the upper and lower adjacent values of the distribution) are computed as Q1-1.5×(Q3-Q1) and Q3+1.5×(Q3-Q1), respectively.

Figure 5. Simulation of % changes of costs associated with changes in corruption
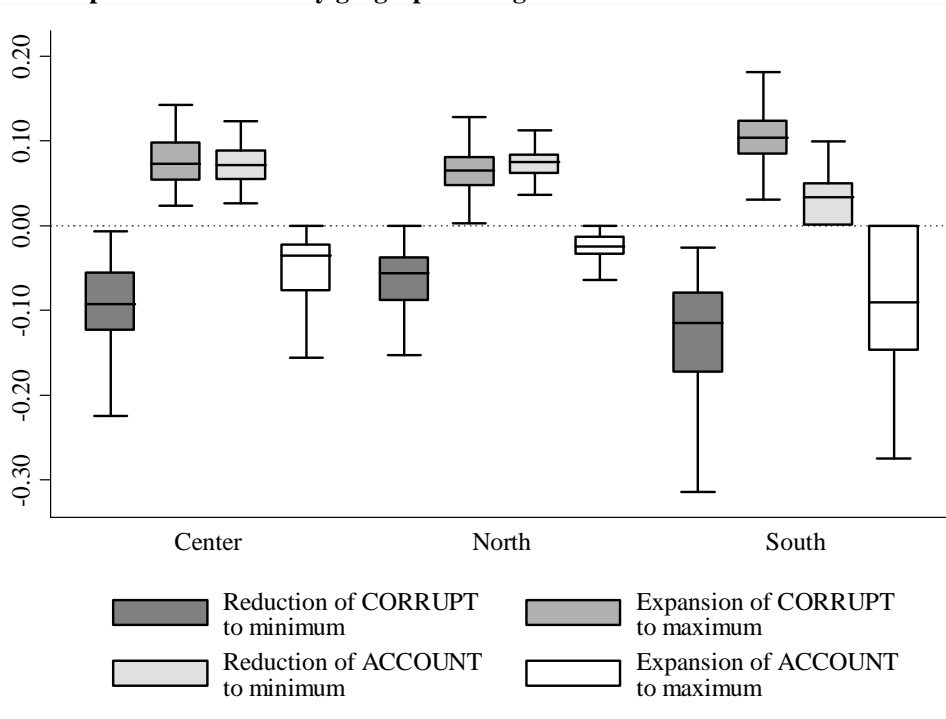

The bottom and top of each box represent the 25th (Q1) and 75th (Q3) percentiles, the line inside the box represents the median, the ends of the whiskers (the upper and lower adjacent values of the distribution) are computed as Q1-1.5×(Q3-Q1) and Q3+1.5×(Q3-Q1), respectively.

Figure 6. Simulation of % changes of costs associated with changes in accountability and corruption. Breakdown by geographical region

The bottom and top of each box represent the 25th (Q1) and 75th (Q3) percentiles, the line inside the box represents the median, the ends of the whiskers (the upper and lower adjacent values of the distribution) are computed as Q1-1.5×(Q3-Q1) and Q3+1.5×(Q3-Q1), respectively.

Table 4. Impact of accountability and corruption on costs for some large municipalities

		ROME 2,711,491 Center	MILAN 1,297,244 North	TURIN 910,437 North	PALERMO 662,046 South	FLORENCE 366,074 Center	BARI 321,747 South
Average population Geographical region							
Δ Corruption (to minimum value)	Cost change (% variation)	-0.112	-0.102	-0.055	-0.142	-0.080	-0.030
	Cost change (million €)	-48.4	-26.4	-7.8	-14.6	-5.4	-1.4
	Cost change (€ per inhabit.)	-17.85	-20.35	-8.60	-22.05	-14.83	-4.25
Δ Corruption (to maximum value)	Cost change (% variation)	0.050	0.059	0.056	0.101	0.049	0.079
	Cost change (million €)	21.5	15.1	8.0	10.4	3.3	3.6
	Cost change (€ per inhabit.)	7.93	11.64	8.74	15.71	9.14	11.15
Δ Accountability (to minimum value)	Cost change (% variation)	0.102	0.082	0.080	0.059	0.089	0.050
	Cost change (million €)	44.6	21.2	11.8	6.1	6.0	2.2
	Cost change (€ per inhabit.)	16.45	16.34	12.96	9.09	16.38	7.07
Δ Accountability (to maximum value)	Cost change (% variation)	-0.026	-0.024	-0.033	-0.101	-0.021	-0.108
	Cost change (million €)	-11.6	-6.1	-4.9	-10.4	-1.4	-4.9
	Cost change (€ per inhabit.)	-4.28	-4.68	-5.40	-15.71	-3.83	-15.31

Table 5. Robustness check of cost inefficiency determinants

	Parameter	Extended Model A (Model 3 + time + reg. dummies)	Extended Model B (A with CORR$_{GP}$ instead of CORRUPT)	Extended Model C (A + CORR$_{GP}$)	Extended Model D (C + interaction CORR$_{GP}$ × LWPOL)
ln ACCOUNT	δ_{ACC}	0.106	0.040	0.080	0.080
		(0.092)	(0.064)	(0.069)	(0.069)
CORP	δ_{CORP}	-0.051	-0.042*	-0.048*	-0.047*
		(0.037)	(0.025)	(0.026)	(0.026)
ln ACCOUNT×CORP	δ_{ACC_CORP}	-0.341***	-0.180***	-0.226***	-0.224***
		(0.102)	(0.062)	(0.068)	(0.068)
ln CORRUPT	δ_{CORR}	0.388***		0.148***	0.138***
		(0.077)		(0.048)	(0.049)
LWPOL	δ_{LW}	0.124***	0.079***	0.085***	0.086***
		(0.032)	(0.018)	(0.020)	(0.021)
ln CORRUPT×LWPOL	δ_{CORRLW}	-0.224***		-0.113**	-0.091
		(0.083)		(0.059)	(0.062)
ln CORR$_{GP}$	δ_{GP}		0.181***	0.141***	0.151***
			(0.022)	(0.020)	(0.023)
ln CORR$_{GP}$ ×LWPOL	δ_{GPLW}		-0.051*		-0.032
			(0.030)		(0.034)
DSOUTH	δ_{SOUTH}	0.179***	-0.029	0.007	0.006
		(0.057)	(0.029)	(0.033)	(0.033)
DNORTH	δ_{NORTH}	-0.011	0.028	0.016	0.018
		(0.047)	(0.037)	(0.031)	(0.031)
TIME	δ_{T}	-0.071***	-0.064***	-0.060***	-0.060***
		(0.019)	(0.012)	(0.013)	(0.013)
Constant	δ_{0}	0.241***	0.518*	0.438***	0.433***

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