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

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Abstract: This paper explores the link between voters' information, corruption, and efficiency in the context of a career concern model, where politically connected local monopolies are in charge of the provision of a local public service. We find that both a corrupt environment and a low level of voters' information on managerial actions induce managers to reduce effort levels, thereby contributing to drive down efficiency. We test our predictions using data on solid waste management services provided by a large sample of Italian municipalities. We estimate a stochastic cost frontier model that provides robust evidence that services produced in more corrupted regions with low voters' information are substantially less cost-efficient.

Keywords: fight against corruption; economic vote; inefficiency of the public sector; new models of public management; Governance 4.0

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 [1]. Markets with an extensive degree of interaction between politicians and firms tend to be associated to higher levels of corruption and patronage [2]. This is empirically documented by Menozzi et al. [3], in their analysis of the effects of political connections on utilities' performances.

In this non-competitive environment of local public service provision, where do incentives for managers to generate value for the company come from? In this paper, we attempt to answer this question. We argue that managerial incentives to efficiency originate from two sources. One is political accountability. Informed voters, when they perceive the company is mismanaged, hold the politician associated with that manager accountable, and base their re-election decision on that consideration. A second one is the level of corruption of the environment in which the manager operates. Along the lines of the World Bank's definition of corruption, we regard corruption as the

abuse of public office for private gain—to be more precise, in this case, the abuse of a managerial position for private gain, within a company with tight political connections. However, we provide a specific characterization of a corrupt environment, which we believe is an accurate, yet often overlooked by the literature, representation of the incentives involved. In a corrupt environment, the manager, while in charge, reaps substantial private benefits from devoting his time to activities that have no effect (neither positive nor negative) on the productivity of the company. Examples of these unproductive activities (in the company's perspective) include helping out the politician in her re-election bid, or spending time meeting politicians or businessmen to build personal networks. Private returns from such activities arise in part immediately and in part in the long run, after the manager's tenure at the company ends. Their extent is determined by the level of corruption of the environment. Our interpretation of the notion of corruption stresses its geographic dimension, as it is the organization of the market at the local level—that is local institutions (e.g., relevance of informal networks, prevalence of non-market transactions)—that determines the rewards for unproductive activities, and, as a result, the incentives to managerial efficiency. Corruption in our model does not directly damage the firm. That notwithstanding, our characterization implies that the higher the level of corruption, the more the scarce managerial time (or, equivalently, the scarce managerial attention) will be diverted away from productivity-enhancing managerial tasks. The qualitative result of our analysis would persist, even if we assumed a direct negative impact of the manager's unproductive activity.

We first model the relation between productivity, voters' information, and the presence of a corrupt environment, using a standard career concern approach to political agency. The fact that more voters' information is associated with a higher productivity of the public service is well-known [4–7]. It results from the interplay of two factors: each manager puts in more effort, and, on average, more talented managers are selected. We enrich this standard setting, by explicitly introducing corruption into it. We show that by holding voters' information constant, a corrupt environment distorts managerial effort incentives, leading to an increase in the extent of inefficiency. While voters' information and corruption operate through two different channels—the former reduces overall managerial effort, and the latter diverts it away from efficiency maximization—for both variables, our model predicts an association with efficiency. Hence, our testable implication is that inefficiency is greater for utilities located in more corrupted regions, as well as in regions with low voters' information.

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 voters' information and of a corrupt environment on the costs of providing municipal solid waste (MSW) services. We proxy voters' information by newspapers' readership, while we measure the extent of corruption of the environment by the number of criminal charges against the State, public governments, and social institutions. The empirical evidence supports our predictions. We find that both voters' information and corruption have a separate impact, in the expected direction, on the costs of MSW services. Moreover, by enriching our cost frontier specification, we obtain some interesting additional insights. In particular, we find that the impact of voters' information on reducing inefficiency is smaller, or even disappears, when municipalities organize the service in-house, or join an inter-municipal consortium, while operating in a corrupt area is less detrimental to efficiency when municipalities are ruled by left-wing parties.

The relationship between voters' information and the performance of local public governments has rarely been investigated empirically. An exception is Giordano and Tommasino [8], 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, health-care, and waste disposal, while measures of social capital do not have any discernible effect. They do not consider the impact of a corrupt environment.

The negative incidence of corruption on efficiency is well documented. Most of the empirical literature relies on cross-country comparisons, and makes use of country-level measures of corruption such as the Transparency International Index or the Corruption Perception index, while very few papers use disaggregated data at the firm or at the local government level. For instance, Dal Bò and Rossi [9] estimate a labor requirement function on a set of 80 electricity distribution firms active in 13 Latin America countries, and show that firms operating in more corrupt environments tend to be less efficient in terms of labor use. Yan and Oum [10] provide a single-country firm level study. They investigate the effect of a corrupt environment on the cost efficiency of a sample of 55 US commercial airports observed from 2001 to 2009, and find a detrimental effect of corruption on efficiency. Moreover, airports tended to contract out a larger set of activities to replace in-house labor under more corrupt environments.

Some scholars investigate the role of information on corruption. For example, DiRienzo et al. [11] found that for a sample of 85 countries, the use of information and communication technologies by citizens is negatively related to a country's Corruption Perception Index. More recently, Jha and Sarangi [12] updated such an analysis by including a proxy for the use of social media, finding that for a sample of 150 countries, Facebook penetration has a negative impact on corruption, especially for countries with low press freedom.

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

Waste collection is a particularly suitable sector for our analysis. In Italy, waste collection and disposal are mainly carried out by publicly-owned firms under the control of local governments, and ultimately, of citizens. Although the latter should be, in principle, interested in the efficient management of mandated tasks, due to the impact this would have on the tax burden, the assumptions that they have complete information about the technology and that they are able to make an informed assessment of the economic performance seem quite unreasonable. This is especially true in contexts plagued by situations of widespread corruption and the entrenched presence of criminal organizations. The 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 uncontested matter of fact [13]. 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. Finally, some recent cases of bad MSW management have emerged as being topical. The media have widely reported on the recent waste crisis in Naples and its surrounds, while a number of books and movies have clearly informed about the connection between waste management and illegal practices. Among the latter, the best-seller book *Gomorra* [14] reached a large international audience and contributed to sensitize the public opinion against the plague of environmental crimes. This paper also contributes to the literature that suggests new governance models of public entities, and new laws to reinforce the need to change the management model of public services [15,16]. As suggested by Popescu et al. [16] in their analysis of the shadow economy in Romania: *"Policy makers need to focus on building reliable and transparent institutions with a lower level of corruption, regulations, and bureaucracy, regaining people's confidence in public institutions, and elaborating effective strategies for tackling the undeclared activities that will contribute to the achievement of sustainable development desideratum"*.

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

2. The Model

We model a MSW service operated by a company that is 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, the 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 that they have appointed, because firing a manager is administratively complicated and costly. 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. For example, Letizia Moratti (a center-right mayor of Milan in the 2006–2011 time period) fired several municipal managers and replaced them with high-wage external consultants. When Giuliano Pisapia (center-left party) replaced Moratti as mayor of Milan, he in turn fired the ATM (the local bus and metro company) top management. In the same vein, after recent Italian local elections, the mayors of Rome and Naples fired several top managers and chairmen in charge of local public services, such as water distribution and bus transport.

Each manager operates in an environment that is characterized by a certain degree of corruption. In corrupt environments, managers are privately rewarded for engaging in a range of activities that provide no value to the firm [9].

2.1. Setting

We analyze a political/managerial agency model with elections, in which agents are infinitely lived and discount the future at a rate $\delta \in [0; 1]$. There is a representative risk-neutral voter. Her 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.

Managers are career-concerned, and have a fixed per period reward R , which does not depend on effort. The task of the manager consists of minimizing the cost borne by the firm. We denote as θ_t the value that the manager provides to the company in time t . In particular, θ measures how much the manager is able to reduce the cost, with respect to a benchmark. In what follows, with a slight abuse of definition, we will designate θ as managerial productivity. θ_t depends both on managerial talent η_t , and on how much effort he puts into managing the company (which we designate as productive effort), denoted a_t^p , according to the following relation:

$$\theta_t = \eta_t + a_t^p \quad (1)$$

Besides exerting effort into productivity-enhancing activity a^p , the manager also can exert effort in an activity that, while potentially generating a private benefit for the manager, has no direct impact, either positive or negative, on the firm's performance. This effort, which we designate as unproductive (having in mind the perspective of the company), is denoted a^u . Effort in unproductive activity generates a marginal return τ_a to the manager (while generating a null return for the company). τ_a thus measures how rewarding distorting effort away from the productive activity is; when $\tau_a = 0$, the effort distortion is not rewarding at all. Hence, we regard τ_a as a measure of the level of corruption in the institutional environment in which the firm operates, in a way that is similar to [9]. To keep things simple, we assume that all the managers, irrespective of their talent, have the same return from the unproductive activity. Managers keep devoting their effort to 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 for the development of long-term links and networks that can be exploited, even after the manager loses his job [17]. However, we assume

that the returns from a^u when the manager is ousted from his job, denoted τ_β , are potentially lower than when the manager is in charge, so that $\tau_\beta \leq \tau_a$. A manager that has lost his job, and thus has $a^p = 0$, $R = 0$, but $a^u \geq 0$.

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 that are involved in 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 model thus revolves around the manager. The managerial talent η_t evolves over time according to the following relation:

$$\eta_t = \rho_{t-1} + \rho_t \quad (2)$$

where ρ_{t-1} and ρ_t (which we will refer to as period-specific skills) are i.i.d. random shocks, and $\rho \sim N(\bar{\rho}, \sigma_\rho^2)$.

In this formulation (see also [18,19]), managerial ability changes gradually over time, capturing the notion that firms operate in a dynamic environment, which requires continuously evolving skills for the manager. It follows that we can rewrite:

$$\theta_t = \rho_{t-1} + \rho_t + a_t^p \quad (3)$$

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

$$\hat{\theta}_t = \eta_t + a_t^p + \varepsilon_t \quad (4)$$

where ε_t is an i.i.d. shock $N(0; \sigma_\varepsilon^2)$, uncorrelated with talent. The voter observes the same signal $\hat{\theta}_t$. The variance of the noise σ_ε^2 reflects the extent of imprecision in the observability of managerial behavior. A high σ_ε^2 thus indicates less voter's information on managerial behavior. The voter uses $\hat{\theta}_t$ to make her own inference on the level of the time-specific skill $\hat{\rho}_t$. In period $t + 1$, the managerial competence is $\rho_t + \rho_{t+1}$. Thus, the voter's expectation on the level of managerial competence at time $t + 1$, in case the incumbent manager is reappointed, is $\hat{\rho}_t + \bar{\rho}$, where the unconditional expectation $\bar{\rho}$ is the best predictor of ρ_{t+1} . If, instead, a new manager is appointed at $t + 1$, both ρ_t and ρ_{t+1} are randomly drawn; in this case, the best predictor at time t of a new manager's competence at $t + 1$ is $2\bar{\rho}$. At stage three, elections are held, pitting the incumbent politician to a randomly drawn challenger. The voter recognizes that the fate of the manager is tied to that of the politician. She thus re-elects 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 $\hat{\rho}_t > \bar{\rho}$.

2.2. Equilibrium Effort and Selection

We solve for the rational-expectation stationary equilibrium of this dynamic game. First, we find the conditions under which the representative voter confirms the politician (and, as consequence, the manager), by taking into consideration that only the noisy managerial productivity signal $\hat{\theta}_t$ is observed, and therefore by solving a standard signal extraction problem. Second, we find the optimal effort choices a_t^p and a_t^u of the manager, by assuming that the manager's cost is a convex function of the sum of the efforts put in the two (productive and unproductive) tasks: $C(a_t) = 0.5(a_t^p + a_t^u)^2$. Finally, we solve for the expected managerial productivity $E(\theta_t) = E(\eta_t) + a_t^p$. The full details of the model are available in the working paper version of this paper [20]. The results are summarized in the following:

Proposition. *The expected managerial productivity (weakly) decreases when the environment is more corrupt (i.e., when the parameters τ_a and τ_β increase). Also, it declines when the voter has less precise information (i.e., high σ_ε^2).*

The result that voter's information reduces managerial productivity is consonant with results on the positive relation between observability and political efficiency [4–7]. Observe that both low voter's information and the presence of a corrupt environment are associated with a decline in managerial productivity. However, they operate through two distinct mechanisms: low voter's information (higher variance σ_ε^2 of the noise) entails a reduction in the total effort that is put in by the manager, while a corrupt environment induces a diversion of the effort away from the productive activity. This stems from our assumed convexity of the cost function in the sum of the effort in the productive and in the unproductive activity. In turn, convexity follows from our characterization of corruption as a geographic phenomenon, related to local institutions, which provide the politician with incentives on the use of his scarce managerial time (or, equivalently, scarce managerial attention). We therefore regard a corrupt environment as one in which a lot of rent dissipation occurs, in particular in terms of managerial time and effort that are dissipated into an activity that has no effect on the company. Finally, voters' information has an impact on managerial-expected talent. More informed voters are better at replacing untalented managers. On the other hand, the level of corruption of the environment has no effect on this. Managers differ only with the dimension of talent for the productive activity. A corrupt environment in our model does not affect the pool of talent, nor the precision of the signal obtained by voters. In addition, the voter perfectly predicts the effort-diversion effect due to corruption. Hence, her screening capacity is unaffected by the level of corruption.

3. Empirical Analysis

3.1. The Econometric Model

As highlighted by Narbón-Perpiña and De Witte in their recent review [21,22], the literature is rich in empirical studies that have a main focus on the evaluation of efficiency in local governments. The majority of works analyze cross-sectional data and use nonparametric tools such as Data Envelopment Analysis (DEA). Moreover, some studies focus on a specific local service, such as refuse collection and disposal [23,24], while other studies refer to a wide range of services and facilities that are offered by municipalities [25].

We recognize that there have been big developments in the use of nonparametric techniques. Indeed, recent advanced robust nonparametric efficiency measures, order- m frontiers [26] and order- α quantile type frontiers [27], as well as DEA panel data estimation techniques, have overcome the main drawbacks of traditional nonparametric efficiency estimators [24,28]. This notwithstanding, we test our theoretical predictions that costs are greater for utilities located in more corrupt regions, and in regions where voters are less well-informed, by adopting a stochastic cost frontier approach.

The econometric model can be expressed in general terms as:

$$\begin{aligned} \ln TC_{it} &= c(y_{it}, p_{it}; \beta) + u_{it} + v_{it} \\ u_{it} &\sim N^+(\mu(z_{it}; \delta), \sigma_u^2) \\ v_{it} &\sim N(0, \sigma_v^2) \end{aligned} \quad (5)$$

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

δ) are estimated simultaneously. This is what is referred to as a 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. Some authors [29,30] suggest the adoption of a linear specification of the mean value of the inefficiency term:

$$\mu_{it} = \delta_0 + z'_{it}\delta \quad (6)$$

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. 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 efforts of the municipalities, or on their negotiation capabilities.

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. [31], therefore, suggest to estimate u_{it} as its conditional expectation \hat{u}_{it} , given the fitted value of $\varepsilon_{it} = u_{it} + v_{it}$, i.e., $\hat{u}_{it} = E(u_{it}|\varepsilon_{it})$. The latter can then be transformed into a measure of distance from the optimal frontier, following Battese and Coelli [32], who define the cost inefficiency measure, CI_{it} , as:

$$CI_{it} = E(e^{u_{it}}|\varepsilon_{it}) \quad (7)$$

Inefficiency values are greater than (or equal to) one, and they are 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:

$$\frac{\partial CE}{\partial z} = (1 - \hat{\gamma}) \left(\frac{\frac{\varphi\left(\frac{\mu^*}{\sigma^*} - \sigma^*\right)e^{-\mu^* + \frac{1}{2}\sigma^{*2}}}{\sigma^*\Phi\left(\frac{\mu^*}{\sigma^*}\right)} - \frac{\Phi\left(\frac{\mu^*}{\sigma^*} - \sigma^*\right)\varphi\left(\frac{\mu^*}{\sigma^*}\right)e^{-\mu^* + \frac{1}{2}\sigma^{*2}}}{\sigma^*\left(\Phi\left(\frac{\mu^*}{\sigma^*}\right)\right)^2} + \frac{\frac{\varphi\left(\frac{\mu^*}{\sigma^*} - \sigma^*\right)e^{-\mu^* + \frac{1}{2}\sigma^{*2}}}{\Phi\left(\frac{\mu^*}{\sigma^*}\right)}}{\sigma^*\left(\Phi\left(\frac{\mu^*}{\sigma^*}\right)\right)^2} \right) \frac{\partial \mu}{\partial z'} \quad (8)$$

where $\Phi(\cdot)$ and φ denote the cumulative distribution function and the density function of the standard normal distribution, $\mu^* = (1 - \hat{\gamma})\hat{\mu} + \hat{\gamma}\hat{\varepsilon}$, $\sigma^* = \sqrt{\hat{\gamma}(1 - \hat{\gamma})}\hat{\sigma}$, $\hat{\sigma} = \hat{\sigma}_u + \hat{\sigma}_v$, $\hat{\gamma} = \frac{\hat{\sigma}_v}{\hat{\sigma}}$, $\hat{\sigma}_u$ is the estimated value of the standard deviation of the inefficiency term, $\hat{\sigma}_v$ is the estimated value of the standard deviation of random noise, $\hat{\varepsilon}$ is the estimated value of the composed error term ($\hat{\varepsilon} = \hat{u} + \hat{v}$), and $\hat{\mu}$ is the estimated expected value of the truncated distribution of the inefficiency term, based on the δ parameters [33]. The marginal effects that are 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 being 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 center of Italy) observed over the period 2004–2006. Table 1 presents the summary statistics of the variables included in the cost frontier specification. For each municipality, we observe:

- the total cost (TC), which is the sum of labor, capital, and fuel costs that are 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 the 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 the depreciation costs by the capital stock.

Table 1. Summary statistics.

Variable	Description	Mean	Std. dev.	Min	Max
TC	Total cost (000 €)	5436	23,965	46	48,065
y_D	Waste disposed (t)	17,125	71,195	118.44	1,462,128
y_R	Waste recycled (t)	3770	13,044	8.86	210,211
p_L	Price of labor (€/employee)	36,394	5744	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
DEN	Population density (inhabitants per square km)	903	1241	22	9441
$TOUR$	Beds in tourist accommodation per 100,000 inhab.	1939	7127	1	127,983
$CORP$	Limited responsibility company (dummy)	0.819	0.386	0	1
$HOUSE$	In-house provision (dummy)	0.100	0.300	0	1
$INTMUN$	Inter-municipal partnership (dummy)	0.081	0.273	0	1
$LWPOL$	Left-wing political orientation (dummy)	0.287	0.453	0	1
$RWPOL$	Right-wing political orientation (dummy)	0.178	0.383	0	1
$CIVIC$	Civic or municipal lists (dummy)	0.534	0.499	0	1
$VOTINFO$	Newspaper readers (per 1000 inhabitants)	351	105	148	599
$CORRUPT$	Crimes against public faith (per 100,000 inhab.)	5.492	1.819	1.703	15.113
$LATIT$	Latitude coordinate	42.524	2.661	35.503	46.610
$LONGIT$	Longitude coordinate	12.413	2.789	7.333	18.377
GDP	Per-capita value added	21,782	7,014	11,639	36,542

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 these were provided by Ecocerved, a limited consortium company that is owned by the Italian Chambers of Commerce, which collects and elaborates data on waste management. The fact that we are able to observe the total cost of the integrated waste cycle at the municipality level is a clear strength of our paper. While we have balance sheet-data (in the case in which the service is managed by a limited liability company) and information about the costs of the waste collection service (in the cases of in-house provision or inter-municipal consortia), we used them only for double checking, in the few cases in which Ecocerved data were missing or incomplete. Input prices have been computed by integrating the information available in the MUDs, with additional information drawn from questionnaires sent to 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: 17,125 tons are disposed (to landfills or incinerators), and only 3770 are sent to recycling (around 18 per cent of the total waste). The average cost per ton is in the neighborhood of 260 euros.

Our database also includes information about the population density and the impact of tourism in the various municipalities. Population density is obtained by dividing the local population for the municipality's area. The information about the impact of tourism has been drawn from the National Institute of Statistics (ISTAT), and is represented by the number of beds in tourism accommodation structures per 100,000 inhabitants. Both these variables are expected to be increase costs. Tourism is usually associated with seasonal variations, and it tends to increase the complexity of the service.

As for the density, it may be considered as a proxy of the frequency of the service. It may be expected, in fact, that the more densely populated areas are characterized by a more accentuated saturation rate of the collection points, and they therefore need more structurally frequent passages to collect waste. We also gathered information concerning the organizational structure of the MSW service as well as the political orientation of the municipality. The limited liability company is by far the most popular legal form (82 percent of the entire sample), followed by in-house provision (10 percent) and inter-municipal partnership (8 percent). The political environment is captured by data on the political majorities ruling the municipalities. Data indicate that left-wing parties are governing around 29 percent of municipalities, right-wing parties around 18 percent, and “civic or municipal lists”, that is, independent local political groups which are not affiliated to major nation-wide left wing or right-wing parties, the remaining 53 percent. Additional control variables are the localization of municipalities in terms of geographical coordinates (latitude and longitude), and the *GDP*, measured at the province-level.

Finally, the cornerstone of the analysis is related to the measurement of voters’ information (*VOTINFO*) and the level of corruption of the environment. We proxy voters’ information by newspapers diffusion (as in [34]). The data were drawn from Audipress, an organization monitoring newspapers data in Italy, and refer to the number of readers of the most popular newspapers in the province for every 1000 inhabitants (i.e., newspapers whose circulation exceeds 50,000 copies). In the statistics, therefore, both local and national newspapers are included. This indicator is available only at the province-level of disaggregation; thus, we associated each municipality to its provincial value. This seems to be a reasonable degree of approximation, given that the average dimension of an Italian province is quite small (around 2700 km² and 500,000 inhabitants). Moreover, in our dataset, there is a total of 101 provinces (out of 110); thus, a suitable degree of cross-section variability is ensured.

A crucial point of the analysis clearly concerns the complex assessment of the level of corruption of the environment. As argued by Golden and Picci [35], 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, since the most commonly used measures are based on corruption perceptions, 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” [36] (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 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 in [37], 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. As a robustness check, we use also the corruption index proposed by [35], which is based on the difference between the cumulative amount of resources devoted to public works in each province and the physical quantities of infrastructures actually realized. This “missing expenditure” index, which has been widely used in the literature [7,38], is similar to the one computed by [36], who compared the amount of money spent for road-building projects in Indonesian villages with an independent estimate of the actual cost of project realization provided by a team of engineers. The results are very similar.

Jha and Panda [39] stressed the role of cultural norms in determining corruption. In particular, they investigated on a large cross-section of countries the relationship between the individualism/collectivism of citizens, and the perceived corruption level. Others cultural aspects are power distance (unequal distribution of power), masculinity, and uncertainty avoidance (unwillingness to challenge authority and rules in cases of high uncertainty) [11]. The main

findings of such studies are that countries with high levels of feminine cultural values and individualism (i.e., a belief system in which individual achievement is ideal) are less prone to corruption, while masculine societies and collectivist countries are more conducive to nepotism and favoritism. We recognize that culture is an important determinant of corruption, and we are indebted to an anonymous referee for having raised this issue. Unfortunately, we are not able to include cultural measures as controls, given the unavailability of reliable proxies at the municipal or provincial level.

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:

$$\begin{aligned} \ln\left(\frac{TC_{it}}{p_{F_{it}}}\right) = & \beta_0 + \sum_{r \in (D,R)} \beta_r \ln y_r + \sum_{s \in (L,K)} \beta_s \ln\left(\frac{p_s}{p_{F_{it}}}\right) \\ & + \sum_{r \in (D,R)} \sum_{s \in (L,K)} \beta_{rs} \ln y_s \ln\left(\frac{p_{s_{it}}}{p_{F_{it}}}\right) + \frac{1}{2} \sum_{r \in (D,R)} \sum_{l \in (D,R)} \beta_{rl} \ln y_r \ln y_l \\ & + \frac{1}{2} \sum_{s \in (L,K)} \sum_{m \in (L,K)} \beta_{sm} \ln\left(\frac{p_{s_{it}}}{p_{F_{it}}}\right) \ln\left(\frac{p_{m_{it}}}{p_{F_{it}}}\right) + \beta_{DEN} DEN_{it} + \beta_{TOUR} TOUR_{it} + u_{it} + v_{it} \end{aligned} \quad (9)$$

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 ($s = F$).

The cost and input prices are divided by the price of fuel (p_F) to ensure a 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:

$$\mu_{it} = \delta_0 + \delta_{VOT} \ln VOTINFO_{it} + \delta_{CORR} \ln CORRUP_{it} \quad (10)$$

Model 2:

$$\begin{aligned} \mu_{it} = & \delta_0 + \ln VOTINFO_{it} (\delta_{VOT} + \delta_{VOT_CORP} CORR_{it}) \\ & + \ln CORRUP_{it} (\delta_{CORR} + \delta_{CORR_LW} LWPOL_{it}) + \delta_{CORP} CORR_{it} + \delta_{LW} LWPOL_{it} \end{aligned} \quad (11)$$

Model 3:

$$\begin{aligned} \mu_{it} = & \delta_0 + \ln VOTINFO_{it} (\delta_{VOT} + \delta_{VOT_CORP} CORR_{it}) \\ & + \ln CORRUP_{it} (\delta_{CORR} + \delta_{CORR_LW} LWPOL_{it}) + \delta_{CORP} CORR_{it} + \delta_{LW} LWPOL_{it} \\ & + \delta_S SOUTH_i + \delta_N NORTH_i + \delta_{LONG} LONGIT_i + \delta_{LAT} LATIT_i + \delta_{GDP} GDP_{it} + \delta_T TIME_t \end{aligned} \quad (12)$$

Following the indications from the theoretical model developed in Section 2, Model 1 sets the municipality inefficiency as a function of voters' information and corruption. Model 2 enriches the analysis using additional variables that can impact on the way in which voters' information or

corruption are affecting the efficient provision of MSW services. More specifically, it emphasizes the potential interactions between voters' information and the organizational form of service supply, on the one hand, and corruption and political orientation on the other. First, we control for the type of service organization, by adding a dummy identifying municipalities that manage the service through limited responsibility companies (*CORP*). This type of ownership may directly impact on efficiency, even though empirical evidence in this sense is rather mixed [40]. Furthermore, if the potential impact of voters' information varies across different types of service organizations, we may observe an additional indirect effect through the parameter δ_{VOT_CORP} . The underlying assumption is that the efficiency benefits from higher voters' information may be diluted, or even disappear when services are not provided through a limited liability company (the only one subject to the private law administrative and accounting rules). For instance, under an 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 the case of poor performance in the management of the service.

The second control concerns the type of political leadership in the local councils, measured by the dummy variable *LWPOL*. In this case, as well, the political variable is included by itself and in terms of interaction with the level of corruption. The underlying idea is that local administrations 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 [41] 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 [42] find that, in a large sample of Spanish municipalities, 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 they are caught being involved in corruption activities. Finally, Model 3 adds several control variables in the mean inefficiency ancillary equation, as a further robustness check on the key interest parameters. In particular, the presence of a geographical effect is captured both by means of two macro-area dummies (*NORTH* and *SOUTH*) and by the exact latitude (*LATIT*) and longitude (*LONGIT*) coordinates of each municipality. In addition, we account for the time trend (*TIME*) and the *GDP* per capita of the province, a control that is meant to proxy for shocks that could affect simultaneously corruption and efficiency.

Our selection of the explanatory variables to be included in this study is partially due to data limitation, and partially to the previous experience that we have accumulated on estimating the costs of local public services [3,43,44]. We are confident that our specification, while being parsimonious, includes the most relevant factors that can have an impact on the costs of collecting solid waste. Da Cruz and Marquez [45] argued that the inclusion of environmental factors in empirical efficiency analyses of local governments often lacks structure, and they tried to identify the variables that are associated to better/worse performance. In doing so, they provided a taxonomy of the various types of variables to facilitate and structure the interpretation of the empirical results. Our list of explanatory variables includes most of the categories highlighted by the authors, namely natural determinants (*TOUR*, *LONGIT*, *LATIT*), citizen-related determinants (*GDP*, *VOTINFO*, *DEN*), institutional determinants (*LWPOL*, *RWPOL*, *CIVIC*, *CORP*, *HOUSE*, *INTMUN*).

3.4. Results

The one-step total cost frontier (9), combined with the inefficiency model (10) or (11) or (12), is estimated by using the maximum likelihood technique. As a normalization strategy, we have divided all continuous variables (cost, output, input price, voters' information, and corruption measures) by their sample geometric mean. This allows for the direct interpretation of first-order parameters as cost elasticities at the local approximation point. Table 2 displays the estimated parameters. All first-order parameters of the cost frontier are strongly significant, and they 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 0.721 to 0.750% or 0.198 to 0.221% 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 at around unity in all of the models, thus suggesting that the average municipality exhibits constant returns to scale. The estimates of labor and capital price elasticities are given by the 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) that is used as numeraire can then be obtained residually. All of the three models estimate a labor cost share (between 39% and 43%) that is higher than the capital cost share (between 16% and 23%), and about the same as the fuel cost share (between 35% 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 for a pointwise estimate of the output and input price elasticities. In particular, the parameter β_{DR} is negative and significant, suggesting cost complementarities in the joint provision of disposal and recycling services. The specification of the cost function is simple, but it contains all the relevant information to fit the precisely observed costs. For more details concerning the technological features of MSW services see [43], which focuses on the impact of different recycling shares on refusal collection costs, and provides a complete analysis of scale and scope economies.

Table 2. Cost frontier estimates.

Variables	Parameters	Model 1	Model 2	Model 3
$\ln y_D$	β_D	0.750 *** (0.010)	0.740 *** (0.010)	0.721 *** (0.012)
$\ln y_R$	β_R	0.198 *** (0.008)	0.200 *** (0.008)	0.221 *** (0.010)
$\ln p_L$	β_L	0.434 *** (0.048)	0.415 *** (0.048)	0.388 *** (0.054)
$\ln p_K$	β_K	0.200 *** (0.044)	0.231 *** (0.045)	0.164 *** (0.048)
$(\ln y_D)^2$	β_{DD}	0.164 *** (0.012)	0.164 *** (0.012)	0.157 *** (0.012)
$(\ln y_R)^2$	β_{RR}	0.088 *** (0.007)	0.087 *** (0.007)	0.093 *** (0.007)
$(\ln p_L)^2$	β_{LL}	−0.047 (0.371)	−0.141 (0.368)	0.070 (0.374)
$(\ln p_K)^2$	β_{KK}	−1.113 *** (0.400)	−1.017 ** (0.399)	−0.620 (0.441)
$(\ln y_D)(\ln y_R)$	β_{DR}	−0.111 *** (0.008)	−0.110 *** (0.008)	−0.109 *** (0.008)
$(\ln p_L)(\ln y_D)$	β_{LD}	0.047 (0.047)	0.050 (0.047)	0.028 (0.047)
$(\ln p_L)(\ln y_R)$	β_{LR}	0.028 (0.034)	0.043 (0.035)	0.042 (0.035)

Table 2. Cont.

Variables	Parameters	Model 1	Model 2	Model 3
$(\ln p_L)(\ln p_K)$	β_{LK}	−0.140 (0.308)	−0.134 (0.307)	−0.256 (0.336)
$(\ln p_K)(\ln y_D)$	β_{KD}	0.031 (0.050)	0.027 (0.050)	−0.007 (0.051)
$(\ln p_K)(\ln y_R)$	β_{KR}	−0.056 * (0.033)	−0.069 ** (0.033)	−0.033 (0.034)
$\ln DEN$	β_{DEN}	0.077 *** (0.008)	0.079 *** (0.008)	0.071 *** (0.010)
$\ln TOUR$	β_{TUR}	0.014 *** (0.004)	0.016 *** (0.004)	0.016 *** (0.004)
Constant	β_0	−0.277 *** (0.030)	−0.299 *** (0.037)	−0.351 *** (0.040)
Inefficiency model				
$\ln VOTINFO$	δ_{VOT}	−0.515 ** (0.206)	−0.060 (0.101)	0.028 (0.087)
$CORP$	δ_{CORP}		−0.135 ** (0.064)	−0.040 (0.033)
$\ln VOTINFO \times CORP$	δ_{VOT_CORP}		−0.396 ** (0.182)	−0.259 *** (0.098)
$\ln CORRUPT$	δ_{CORR}	0.352 ** (0.139)	0.389 *** (0.131)	0.275 *** (0.066)
$LWPOL$	δ_{LW}		0.171 *** (0.060)	0.115 *** (0.030)
$\ln CORRUPT \times LWPOL$	δ_{CORRLW}		−0.318 ** (0.136)	−0.221 *** (0.077)
$SOUTH$	δ_S			0.249 *** (0.064)
$NORTH$	δ_N			−0.218 *** (0.062)
$LONGIT$	δ_{LONG}			−0.366 *** (0.089)
$LATIT$	δ_{LAT}			1.223 *** (0.393)
GDP	δ_{GDP}			0.001 (0.108)
$TIME$	δ_T			−0.051 *** (0.017)
Constant	δ_0	−0.174 (0.264)	0.103 (0.131)	0.271 *** (0.079)
Std. Dev. one-sided error term	σ_U	0.288 *** (0.064)	0.226 *** (0.046)	0.173 *** (0.039)
Std. Dev. two-sided error term	σ_V	0.234 *** (0.009)	0.232 *** (0.010)	0.231 *** (0.014)
Lambda	λ	1.229 *** (0.065)	0.973 *** (0.050)	0.749 *** (0.051)
Log-Likelihood Function		−213.537	−195.575	−161.686
Likelihood Ratio test		103.70 ***	67.78 ***	
Number of observations		1587	1587	1587

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

Turning to cost inefficiency, Table 2 shows that the coefficient δ_{VOT} in Model 1 is negative and highly statistically significant. A greater propensity to participation by citizens—and therefore less opacity in the relationship between citizens and decision-makers—can substantially reduce the cost inefficiency. This is in line with [4], as well as with a large amount of anecdotal evidence pointing at the notion that a greater pressure by public opinion is able to route managers and policy-makers towards more efficient decisions. As expected, δ_{CORR} is instead positive, suggesting that more widespread corruption negatively affects the efficiency performance of MSW services. On the whole, this lends support to our theoretical section.

Model 2 explores in greater details the effects of voters' information and corruption. In this case, the parameter δ_{VOT} measures the impact of the degree of voters' information in the base case in which waste is collected directly by individual municipalities or through inter-municipal consortia, while the parameter of the interacted term δ_{VOT_CORP} should be interpreted as the incremental effect due to the presence of limited liability companies. By itself, the corporatization of waste collection generally reduces cost inefficiency ($\delta_{CORP} = -0.135$, $p < 0.05$). This result is in line with empirical evidence about the positive effects of corporatization on the performance of local public services provision [44]. The marginal impact of voters' information in the case of service supply through distinct business organizations is significant ($\delta_{VOT_CORP} = -0.396$), while δ_{VOT} is not statistically significant. This means that voters' information reduces the 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.

Similarly, we analyze the differential prevalence of corruption across different political majorities. The parameter δ_{CORR_LW} represents the incremental cost inefficiency due to corruption under left-wing political guidance. In Model 2, δ_{CORR} still remains positive and highly statistically significant, while the interaction term δ_{CORR_LW} is inefficiency-reducing. The resulting effect of corruption in municipalities led by left-wing local councils is equal to 0.071, and it is significant. 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 behavior of left-wing municipal councils is, however, more spending-oriented ($\delta_{LW} = 0.171$, $p < 0.01$). In Model 3, all of the additional variables that are included in the inefficiency model are significant, with the exception of GDP. The geographical dummies confirm the well-known north–south division, suggesting higher (lower) refuse collection costs for southern (northern) municipalities, while the time trend is negative and significant at the 1% level across all the models, indicating cost-reducing technological progress. Interesting enough, the coefficient for *LONGIT* is negative, suggesting that, after having checked for the three macro regions (north, center and south), eastern municipalities are associated with lower costs. This implies, for example, that municipalities localized in the northeastern Veneto region (or Lazio and Apulia, for center and south, respectively) are more efficient than municipalities that are localized in Piedmont (Sardinia and Sicily, respectively). More importantly, the effects of corruption and voters' information are confirmed, even if the magnitude of coefficients reduces with respect to Model 2. The last rows in Table 2 show the statistics for the λ coefficient, which is defined as the ratio between the standard deviation of the inefficiency term σ_{η} and the standard deviation of random noise. The values are statistically significant at the 1% level, indicating that the inefficiency term has a significant contribution on the 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.

Using Equation (8), we compute the marginal effects on the estimated cost efficiency for our preferred specification (Model 3). The results are displayed in Table 3, which provides a measure of the marginal improvement in the efficiency level that can be achieved by reducing corruption or increasing voters' information.

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

	Mean	Std. Dev.	Min	Max
Voters' information if CORP = 1	0.051	0.011	0.022	0.069
Corruption if LWPOL = 1	−0.042	0.022	−0.074	−0.006
if LWPOL = 0	−0.011	0.002	−0.014	−0.006
	−0.054	0.012	−0.074	−0.023

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 voters' information by 10% would move the efficiency level towards the frontier by approximately 0.5%. Furthermore, decreasing corruption by 10% would increase the efficiency level, on average, by 0.42%, with a more remarkable impact for non-left-governed municipalities (0.54%). While these figures describe the average impact, both effects tend to be more pronounced when the estimated efficiency decreases.

3.5. Impact of Voters' Information and Corruption on Costs

In this section, we provide evidence on the impact of voters' information and corruption changes on cost variation. Table 4 simulates the average cost change, due to the reduction or expansion of voters' information and corruption levels, respectively, up to the maximum/minimum level.

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

		If CORP = 1	If LWPOL = 1	If LWPOL = 0
Average population		45,662	54,152	35,828
Δ corruption (to minimum value)	Cost change (% variation)		−0.016	−0.074
	Cost change (million €)		−0.1	−0.4
	Cost change (€ per inhabit.)		−1.91	−7.75
Δ corruption (to maximum value)	Cost change (% variation)		0.016	0.075
	Cost change (million €)		0.1	0.3
	Cost change (€ per inhabit.)		1.93	7.66
Δ voters' information (to minimum value)	Cost change (% variation)	0.056		
	Cost change (million €)	0.4		
	Cost change (€ per inhabit.)	6.380		
Δ voters' information (to maximum value)	Cost change (% variation)	−0.036		
	Cost change (million €)	−0.2		
	Cost change (€ per inhabit.)	−3.878		

Accordingly, a reduction in voters' information to the minimum level results in a cost increase of approximately 5.6% of the observed cost while expanding the level of voters' information to the maximum value (within the sample) would allow cost savings in the order of 3.6%, corresponding to approximately 3.9 euros per inhabitant. If extended to the whole Italian population, this figure would translate to total cost savings of almost 250 million euros. A more widespread level of corruption

(to the maximum level) would increase costs by 1.6% in the presence of local governments leaning to the left and by up to 7.5% in the group of non-left-wing observations. By contrast, programs aimed at curbing corruption would allow, in the non-left-wing group, cost savings of up to 7.4%, corresponding to approximately 7.8 euros per inhabitant. These figures are as almost four times those for the group of municipalities ruled by left-wing political parties, and they corroborate previous evidence concerning a lower permeability of the latter to the corruption plague.

Finally, Table 5 details cost simulations for a set of large municipalities (with more than 300,000 inhabitants).

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

		Rome	Milan	Turin	Palermo	Florence	Bari
Average population		2,711,491	1,297,244	910,437	662,046	366,074	321,747
Geographical region		Center	North	North	South	Center	South
Δ corruption (to minimum value)	Cost change (% variation)	−0.073	−0.074	−0.036	−0.110	−0.059	−0.011
	Cost change (million €)	−31.3	−19.2	−5.0	−11.3	−4.0	−0.5
	Cost change (€ per inhabit.)	−11.56	−14.83	−5.50	−17.12	−10.96	−1.64
Δ corruption (to maximum value)	Cost change (% variation)	0.037	0.050	0.041	0.095	0.041	0.032
	Cost change (million €)	15.7	12.8	5.7	9.8	2.8	1.4
	Cost change (€ per inhabit.)	5.77	9.85	6.29	14.81	7.66	4.45
Δ voters' inform. (to minimum value)	Cost change (% variation)	0.074	0.062	0.062	0.028	0.080	0.041
	Cost change (million €)	32.5	15.9	9.1	2.9	5.3	1.9
	Cost change (€ per inhabit.)	11.99	12.24	10.00	4.34	14.57	5.84
Δ voters' inform. (to maximum value)	Cost change (% variation)	−0.019	−0.020	−0.035	−0.091	−0.022	−0.084
	Cost change (million €)	−8.5	−5.1	−5.2	−9.4	−1.5	−3.8
	Cost change (€ per inhabit.)	−3.13	−3.91	−5.66	−14.18	−4.10	−11.92

With reference to the two most populated Italian cities, Rome and Milan, a large reduction in the degree of corruption is expected to result in a relative cost saving of 7.3–7.4%, equivalent to around 12–15 euros per inhabitant. Also, the second largest southern city, Palermo, looks like it would be heavily affected by a hypothetical improvement in the degree of corruption. In the same vein, an improvement in the level of voters' information in the two most populous cities is shown to induce a relative cost saving, ranging between 1.9% and 2%, which is equivalent to a saving of 3–4 euros per inhabitant. The major benefit would concern, in this case, the Southern municipalities (Palermo and Bari), which are generally plagued by less transparency in the decision-making process.

3.6. Robustness Checks

In this section, we focus on the causality relation between inefficiency and corruption, addressing the potential endogeneity problem arising from the model specification. First, we could argue that using corruption data at the provincial level and municipal-level data from one particular industry should reduce potential endogeneity problems [9]. In fact, while it is likely that existing corruption in a province has an impact on the cost efficiency of a subset of firms, such as our waste management providers, it is less likely that the inefficiency of the latter will affect the province's overall corruption level.

However, our corruption proxy might still capture the effect of some other omitted factors (such as, for instance, the corruption crimes that are not reported to the police). For this reason, as a robustness analysis, we adopt an instrumental variable strategy. Our instruments exploit the correlation between history and institutional quality variables, such as corruption and voters' information. The idea is that some critical historical events (such as a foreign domination or the formation of civic traditions) still matter for current institutional settings of a region (such as corruption), but they do not plausibly influence current economic performance. The first set of instruments follows [46], who proposed a 9-scale measure of civic-ness of Italian provinces in the period between 1860 and 1920. In particular, the index has been computed using data on membership in mutual aid societies and in cooperatives, the strength of the mass parties, the turnout in the few open elections before the advent of Fascism, and longevity of local cultural and recreational organizations. The second, alternative, instrument that we use follows [47]. The authors analyze the link between institutional quality and the economic performance of Italian provinces by using the histories of the different foreign dominations that ruled Italian regions (in a time span of 700 years before the unification of Italy, which occurred in the late 19th century) as instruments. We use two instruments, $FORDOM_{year}$ and $FORDOM_s$. $FORDOM_{year}$ accounts for the number of years during which each province has been ruled (the maximum value is for the provinces controlled by the Papal State, who ruled for 700 years). $FORDOM_s$ accounts for the number of different dominators that governed a specific province at different periods of time in the seven centuries taken into consideration. In particular, it is constructed as a Krugman's specialization index: $FORDOM_s = \sum_i |b_i - \bar{b}|$, where i identifies the nine possible dominations (the Normans, the Swabians, the Anjou, the Aragonese, the Bourbons, the Papal State, the Savoy, the Austrians, and the Republic of Venice), b_i is the percentage of years that a specific dominator ruled a province (i.e., $b_i = \text{total number of years}/700$), and \bar{b} is the average of b for all provinces. A high value of $FORDOM_s$ means that the province has been ruled by the same regime for a long period of time, while a low value occurs if there have been different dominations over the centuries.

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

The estimates, shown in Table 6, confirm most of previously reported results. In particular, the impact of corruption on inefficiency remains significant in all models, and the magnitude of the coefficients is even higher than in Model 3 (at least for Model 4 when using Putnam's civic-ness indicators). This means that, if a problem of endogeneity due to omitted variable exists, it might go in the direction of underestimating the effect of corruption. This result seems consistent with the idea that the proposed measure of corruption (*CORRUPT*), based on reported corruption crimes only, might partially underestimate the true phenomenon, and thus the cost benefits emerging from our simulations might be regarded as conservative.

Table 6. Instrumental variable estimates of the inefficiency model.

Variables	Parameters	Model 4	Model 5
		Instruments: Putnam civic-ness Number of instruments: 8	Instruments: Dominations (1100–1800) Number of instruments: 2
<i>lnVOTINFO</i>	δ_{ACC}	0.025 (0.063)	−0.014 (0.068)
<i>CORP</i>	δ_{CORP}	−0.015 (0.022)	−0.024 (0.023)
<i>lnVOTINFO</i> × <i>CORP</i>	δ_{ACC_CORP}	−0.173 *** (0.064)	−0.141 ** (0.067)
<i>lnCORRUPT</i>	δ_{CORR}	0.411 *** (0.053)	0.200 ** (0.081)
<i>LWPOL</i>	δ_{LW}	0.084 *** (0.016)	0.083 *** (0.017)
<i>lnCORRUPT</i> × <i>LWPOL</i>	δ_{CORRLW}	−0.431 *** (0.080)	−0.105 (0.106)
<i>SOUTH</i>	δ_S	0.199 *** (0.034)	0.174 *** (0.036)
<i>NORTH</i>	δ_N	−0.115 *** (0.032)	−0.103 *** (0.035)
<i>LONGIT</i>	δ_{LONG}	−0.252 *** (0.056)	−0.207 *** (0.063)
<i>LATIT</i>	δ_{LAT}	1.210 *** (0.272)	1.305 *** (0.276)
<i>GDP</i>	δ_{GDP}	−0.004 (0.055)	−0.008 (0.059)
<i>TIME</i>	δ_T	−0.038 *** (0.011)	−0.045 *** (0.011)
Constant	δ_0	0.193 *** (0.040)	0.835 *** (0.038)
First stage F-statistic (instruments only) ^(a)		F (8, 1568) 71.32	F (2, 1574) 77.82
(<i>p</i> -value)		(0.000)	(0.000)
Number of observations		1587	1587

Statistically significant at 1% ***, 5% **, standard errors in round brackets; ^(a) The F-statistic tests the validity of instruments: the null hypothesis is that, respectively, Putnam civic-ness dummies and domination indexes are jointly not significantly different from 0 in the first-stage regression. The F-statistic must be at least larger than 10 to avoid the problem of weak instruments.

From a methodological point of view, the high value of the first stage F-statistic suggests that both civic-ness and historical dominance are good instruments for corruption. In particular, as a rule of thumb, one could say that an instrument is not weak when the F-statistic is larger than 10. Actually, [48] develops more rigorous tables defining the critical minimum value of F, to avoid the problem of weak instruments, depending on the number of instruments. In both Models 4 and 5, the value of F is much larger than such critical values.

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, due to their relations with the politicians.

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

On the theory side, we provide a novel characterization of a corrupt environment, stressing its geographical dimension. We fit this into a standard career concern model. We show how the extent of voters' information and the level of corruption of the environment in which the manager operates affect managerial effort. We do not model corruption as an activity that directly damages the firm; our choice reflects the notion that managers respond to incentives to corruption, which are determined by a geographical dimension. We find that inefficiency is larger for operators that are located in areas where information on their performances is less precise. We also show that inefficiency is larger in more corrupt environments, in which managers' incentives are distorted towards activities that do not benefit the company, while they are privately rewarding. We believe this reflects a common occurrence in public companies with low-powered incentives.

Our theoretical predictions are tested using a rich dataset on solid waste management services provided by Italian municipalities for the years 2004–2006, and using stochastic frontier analysis to measure performance levels, in line with [49]. The results of our cost frontier estimates show that both voters' information, measured by newspapers' readership, and corruption, measured using official data about the criminal activity at provincial level, matter, and they exhibit a significant impact (negative for corruption, positive for voters' information) on efficiency levels. In addition, we show that the effect of voters' information declines or even disappears when municipalities provide the service in-house, or by adhering to inter-municipal consortia, which appear to be less efficient ways of organizing the activity, as compared to entrusting it to a limited liability company. Some authors contrast the benefits of public services in-house provision versus their outsourcing through procurement contracts, showing that procurement is preferable when the public sector employs too many workers and suffers from patronage [50]. This is likely the case for the Italian public sector, and that is probably why the service provided by limited liability companies in our sample exhibits superior efficiency with respect to that provided in house. Finally, we find that, while municipalities that are ruled by left-wing parties exhibit higher inefficiency levels, they are also those in which the impact of corruption on inefficiency is lower. Our results are robust to the introduction of further explanatory variables of the mean value of the inefficiency term, to the measurement of corruption through the missing-expenditure index introduced by [35], and to the use of instrumental variables estimation.

Overall, our findings suggest that effective anti-corruption measures, and/or carefully designed incentives for citizens to acquire information, can have substantial 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 1–11%, if corruption declined to the minimum value that was observed in the sample, while they can decrease in the range of 2–9%, if voters' information increased up to its maximum value. Therefore, improving transparency and information would make the citizens more responsible in their voting behavior [51], and this could contribute to the reduction of corruption practices, and to the improvement of local public good provision [52].

The recent survey on public sector efficiency across various countries [21,22] reviews studies that deal with a single service such as waste management, water supply, health, education, and public transport, as well as studies that evaluate the global supply of services that are provided by local governments. While the results of our study, which focuses on solid waste collection and disposal activities of Italian municipalities, cannot be easily generalized to other services, it would be interesting to apply our methodology to evaluate the impact of corruption and voters' information on the efficiency of providing the wide variety of services and facilities that are supplied by local governments.

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