When the purchasing officer looks the other way

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[Preliminary draft]

Abstract

In this paper we argue that a corrupt local environment can affect the efficiency of public works for different reasons. Focusing on the execution stage of public contracts, we develop a theoretical model where a debauched local environment reduces the accountability of public outcomes and, thus, purchasing officers have less incentives to pursue the mandated task of monitoring the execution of public works (*passive waste effect*). Additionally, endemic corruption increases the marginal return to managerial effort devoted to lobbying activities, diverting effort from the productive activity (*active waste effect*). We empirically test the predictions of the model using official data on Italian public works. In particular, we estimate the efficiency of public works execution using parametric and non-parametric frontiers and, then, we investigate the impact of environmental variables on the efficiency scores. In line with our predictions, our estimates show a negative association between the efficiency of public works execution and different indexes of both accountability and corruption in the area in which public works take place. Therefore, our results highlight that public procurement regulation does not guarantee the efficient execution of public works and, in particular, there is a need to enhance the accountability of purchasing officers.

JEL Classification: D73, H57, C14.

Keywords: public works, endemic corruption, accountability, efficiency.

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1. Introduction

In many western countries the public works sector is still a matter of intensive discussion and debate because of its inefficient performance. Considering the huge amount of public resources involved in public works, to understand the causes and identify the prescriptions represents a strategic element for the development of nations, especially in this time of economic and financial downturn. In this regard, corruption is recognised as being one of the major problems affecting public works procurement fairly in all countries, though to different extents[1]. In the same line, many international organizations such as IMF, OECD or the World Bank, consider the battle against corruption as one of the main challenge for the future.

This paper aims at contributing to the literature providing further evidence on the relationship between the endemic corruption and the efficiency of public works contracts. In this field, several papers study the incentives for bribery, given by different public procurement regulations at the selection stage (e.g., Aidt, 2003; Dastidar and Mukherjee, 2014; Hessami, 2014). On the contrary, in our paper we focus the attention on the effects that endemic corruption has on the efficiency in the execution stage of public works. Therefore, an interesting aspect of our paper is that a high level of endemic corruption can affect the efficiency of public works even when the most efficient contractor has been selected in the procurement stage and, as will be discussed, this has important implications in terms of the prescriptions against corruption.

For this purpose, we study a theoretical model where a higher level of endemic corruption can generate two different sources of inefficiency in public works execution. Firstly, a corrupt local environment reduces the accountability of public outcomes and, consequently, purchasing officers have less incentives to pursue the mandated task of monitoring the execution of public works (*passive waste effect*). Secondly, a higher endemic corruption increases the marginal return to managerial effort devoted to lobbying activities for getting higher cost overruns, diverting effort from the productive activity (*active waste effect*). In this regard, our paper shares the same spirit of Bandiera et al. (2009) where, in the context of purchases of standardized goods by Italian public bodies, they distinguish between waste due to some malfunctioning of the regulatory system (*passive waste*) and waste due to explicit corruption in procurement (*active waste*). We find that, as a consequence of both mechanisms, in a debauched local environment the purchasing officer has the incentive to look the other way. Therefore, we conclude that both effects contribute to the

[1] Besides public works procurement, several studies investigate the negative effects of corruption on economic growth (e.g., Mauro, 1995), on financial markets (e.g., Guiso et al., 2000) and on the accountability of institutions (e.g., Hunt 2005) suggesting that corruption represents a major obstacle to economic development.

negative impact of the endemic corruption on the efficiency of public works execution and, interestingly, in our model we are able to distinguish explicitly these two waste effects.

Then, we carry out an empirical investigation on an official dataset of Italian public works contracts to test our model predictions. In particular, we estimate the efficiency of public works execution, as measured in terms of delays and cost overruns, using parametric and non-parametric frontiers; then, we investigate the impact of environmental variables on the estimated efficiency scores. As far as the role of environmental variables is concerned, our estimates confirm the negative association between the efficiency of public works execution and different indexes of accountability and corruption in the area in which public works take place. Therefore, our results underline that there is a need to enhance the accountability of the purchasing officer, monitoring *ex post* his performance.

Our paper fits into the recent strand of literature studying the effect of corruption in the efficiency of public services at the micro level. Among these, Svensson (2003) and Clarke and Xu (2004) study the characteristics of firms that pay bribes. Dal Bó and Rossi (2007) investigate the connection between corruption and the efficiency of electricity distribution firms. Looking at the strategic role of monitoring, Di Tella and Schargrodsky (2003) analyze the context of hospital procurement, whereas Yan and Oum (2014) investigate the effect of corruption on the cost efficiency of a sample of commercial airports. Although we study a different sector, our paper is slightly close to Dal Bó and Rossi (2007) and Yan and Oum (2014). Respect to those papers, however, we provide a unified framework to distinguish two different sources of inefficiency.

The analysis develops as follows: section 2 presents the theoretical model. Then, in section 3, after a brief description of the Italian institutional framework, the empirical strategy and results of efficiency estimates are presented. In section 4 we present the results on the impact of environmental variables on the estimated efficiency scores. Concluding remarks and policy prescriptions are offered in section 5.

2. Model

In this section we lay out a model where a corrupt local environment can affect the efficiency of public works for different reasons. Differently from the previous literature (e.g., Aidt, 2003; Auriol, 2006; Mizoguchi and Van Quyen, 2014; Dastidar and Mukherjee, 2014; Hessami, 2014) [2], we focus on the execution stage of contracts; therefore, in our model a high level of endemic corruption can

[2] To the best of our knowledge, almost all previous papers in the theoretical literature study the incentives for bribery and corruption, given by different public procurement regulations at the selection stage. Differently, in our model we focus on the execution stage of public works contracts and the potential effect of a debauched local environment.

affect the efficiency of public works even when the most efficient contractor has been selected in the procurement stage. In particular, we first discuss the general theoretical framework akin to the Italian public work sector. Then, we illustrate the equilibrium of the model when a debauched local environment does not give rise to explicit forms of corruption, but still reduces the accountability of public outcomes (*passive waste effect*). Finally, we introduce a more explicit form of corruption when a high level of endemic corruption increases the marginal return to managerial effort devoted to lobbying activities for getting higher cost overruns, diverting effort from the productive activity (*active waste effect*).

2.1 Theoretical framework

There are three main actors involved in public works: the contractor, the contracting authority, the bureaucrat (i.e. the purchasing officer). The relationship between the contracting authority and the bureaucrat is designed in a principal-agent framework (e.g., Laffont and Tirole, 1993; Laffont and Martimort, 2001), whereas the decision-making of the bureaucrat is modeled as a career concern model (e.g., Holmstrom, 1982; Dewatripont et al., 1999a, 1999b). In particular, the purchasing officer is the agent of the contracting authority and, thus, pursues the mandated task to monitor the efficient execution of the contract. As standard in the principal-agent framework, the principal cannot see the effort of the purchasing officer in the monitoring activity, but can only infer his talent in performing this task from the observable outcome (e.g., Dewatripont et al., 1999a, 1999b). On the other hand, the purchasing officer has not specific financial incentives to perform well this task; nonetheless, he is moved by career concerns and, thus, he has still the interest to signal to the principal (or to the market) his talent (e.g., Alesina and Tabellini, 2008). However, the purchasing officer has the incentive to do so whenever the accountability of public outcomes is high; on the contrary, when the accountability of public outcome is low, the purchasing officer has less incentives to pursue mandated tasks (e.g., Yan and Oum, 2014).

Looking at the role of the endemic corruption, many studies both in political science (e.g., Heywood, 1997; Alt and Lassen, 2003) and economics (e.g., Adserá et al., 2003; Lederman and Loayza, 2005; Hunt, 2005) have shown a strong negative correlation between the accountability of public outcomes and the level of endemic corruption in the local environment. Based on this large literature, therefore, the first assumption of our model is that a higher endemic corruption reduces the accountability of public outcomes (e.g., Yan and Oum, 2014). Additionally, a corrupt local environment might also give rise to more explicit forms of corruption and, therefore, in the second part of the model we assume that a high level of endemic corruption increases the marginal return to managerial effort devoted to lobbying activities for getting higher cost overruns (e.g., Dal Bó and

Rossi, 2007). As a consequence of both mechanisms, in a debauched local environment the purchasing officer has the incentive to look the other way.

2.2 Accountability (*passive waste effect*)

The contractor

The contractor is the winner of the public auction relative to a specific public work. Once the winning firm has been selected, the setting for the contractor of a public work is rather different respect to the competitive market, because the contract terms already define the product ($\overline{q}$) and the cost ($w_l l + w_m m$) of the public work, as well as the revenue ($\overline{\pi}$) granted to the executing firm. Nonetheless, the contractor can be more or less productive in executing the public work and, in particular, he can afford to be more slacking, according to the specific environment[3]. Beyond the specific technology $F(\overline{k}, l, m)$, in fact, the total productivity of the contractor depends also on managerial effort (e_m), which we can imagine as a form of coordination and supervision of the use of inputs, and a productivity shock (ε) following a normal distribution $\varepsilon \sim N(0, \sigma_\varepsilon^2)$. In particular, the managerial effort implies a managerial disutility $C(e_m)$ with increasing marginal disutility, that is $C'(e_m) > 0$ and $C''(e_m) > 0$. For the sake of simplicity, we eventually assume $C(e_m) = \frac{1}{2} e_m^2$.

Hence, the conditional expected utility of the contractor is the following:

$$E[W \mid a] = \overline{\pi} - w_l l - w_m m - \frac{1}{2} e_m^2 - P(a) \max\{\overline{q} - [e_m F(\overline{k}, l, m)], 0\} \quad (1)$$

where w_l and w_m are the exogenous prices of variable inputs, labor (l) and non-labor (m) including outsourcing services, whereas capital inputs ($\overline{k}$) are fixed in the short run. The last part of (1) says that when the contractor is sufficiently productive, that is $e_m F(\overline{k}, l, m) + \varepsilon \geq \overline{q}$, then he get exactly what established by the contract; on the other hand, when the contractor is somewhat slacking, that is $e_m F(\overline{k}, l, m) + \varepsilon < \overline{q}$, then he might incur some kind of penalty proportional to the contractor slack. However, the penalty is not experienced for certain, but with probability $P(a)$ depending on the monitoring activity (a) of the purchasing officer, with $P'(a) > 0$. Again, for the sake of simplicity, we eventually assume $P(a) = a$.

[3] To some extent, one could argue that being productive or slacking for an executing firm might have the effect of improving or worsening its reputation in the market and, therefore, this reputation effect should be somewhat considered by a contractor. Indeed, different studies in the literature emphasize the importance of reputation as a device to get more efficient execution of public works (e.g., Doni, 2006; Dellarocas et al., 2006). However, in the Italian public procurement this is not the case as the previous performance of a firm has not any role in increasing the probability of winning the competition for new public works (see, below, par. 3.1.) Therefore, our theoretical framework is fully in line with the subsequent empirical analysis on the efficiency of the Italian public works.

Therefore, the contractor maximizes his expected utility conditional on the monitoring activity (a) employed by the bureaucrat, that is:

$$\max_{e_m \geq 0} \overline{\pi} - w_l l - w_m m - \frac{1}{2} e_m^2 - a \; max\{\overline{q} - [e_m F(\overline{k}, l, m)], 0\}$$

yielding the following optimal managerial effort (see the technical appendix):

$$e_m^* = min \left\{ aF(\overline{k}, l, m), \frac{\overline{q}}{F(\overline{k}, l, m)} \right\} \quad (2)$$

In particular, the optimal policy (2) says that, under the sufficient expected product $\overline{q}$, the contractor chooses the managerial effort such that the marginal disutility of effort is equal to the expected marginal penalty associated with the contractor slack, that is $e_m^* = a F(\overline{k}, l, m)$. Once the contractor is sufficiently productive, however, he has no incentive to improve further his productivity and, thus, the optimal effort remains the sufficient managerial effort $e_m^* = \frac{\overline{q}}{F(\overline{k}, l, m)}$ to get the expected product $\overline{q}$ established in the contract.

Not surprisingly, the optimal managerial effort (2) strictly depends on the monitoring activity (a) employed by the purchasing officer. Specifically, a higher monitoring effort increases the expected penalty of the slack and, consequently, increases the managerial effort up to the sufficient productivity $e_m^* = \frac{\overline{q}}{F(\overline{k}, l, m)}$. In particular, in Figure 1 we show the optimal managerial effort and the effect of monitoring activity.

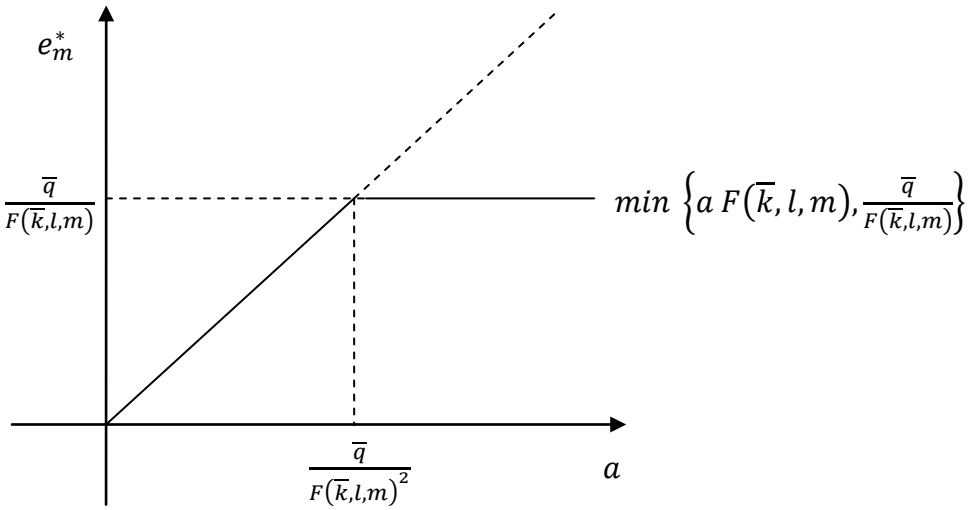

Figure 1 – Optimal managerial effort

The contracting authority

The aim of the contracting authority, as the principal, is the efficiency of the execution of public works. However, it operates through the purchasing officer, who acts as its agent pursuing the mandated task of monitoring the execution of public works. As standard in the principal-agent framework, the contracting authority cannot see the monitoring activity (a) of the purchasing officer, but can only infer his talent (θ) by the observable outcome (y) to take actions that result in benefit or reward for him (e.g., Dewatripont et al., 1999a, 1999b).

In particular, in the specific sector of public works the outcome observed by the principal is presumably the actual product at the end of the work. Following the production process described, therefore, the outcome can be thought to be equal to $y = \theta e_m^*(a)\, F(\overline{k}, l, m) + \varepsilon$, where the purchasing officer's talent is assumed to be normally distributed $\theta \sim N(1, \sigma_\theta^2)$. This implies that an agent with an average talent simply does not affect the production process, whereas agents with a higher talent affect positively the efficiency of the execution of public works. Accordingly, the outcome is also normally distributed $y \sim N(e_m^*(a)\, F(\overline{k}, l, m), \sigma_\theta^2 [e_m^*(a)\, F(\overline{k}, l, m)]^2 + \sigma_\varepsilon^2)$. Therefore, assuming that the principal expects a certain monitoring activity (a^*), the contracting authority can infer the purchasing officer's talent and, in turn, take actions towards him according to the following expected talent:

$$E[\theta |\, y, a^*] = \int \theta\, f(\theta | y, a^*)\, d\theta \;=\; \int \theta \frac{f(\theta, y | a^*)}{\hat{f}(y | a^*)}\, d\theta \tag{3}$$

where $f(\theta | y, a^*)$ is the conditional density of the bureaucrat's talent, $f(\theta, y | a^*)$ is the joint density of talent and observable outcome[4] and $\hat{f}(y | a^*)$ is the marginal density of the observable outcome.

The purchasing officer

The purchasing officer pursues the mandated task of monitoring the efficiency of public works. Although the purchasing officer has not specific financial incentives to perform well, he is moved by career concerns knowing that the principal (which, again, can also be the market) will somehow reward his talent. However, the purchasing officer has incentive to signal his talent to the principal whenever, in the field of public works, the accountability of public outcomes is high. In particular, the expected reward function considered by the purchasing officer is $R(y, \alpha) = \alpha E[\theta |\, y, a^*]$, where

[4] In particular, it can be easily shown that the joint density of talent and outcome is the following bivariate normal:

$$(\theta, y) \;\sim\; N\left(\begin{pmatrix} 1 \\ e_m^*(a)\, F(\overline{k}, l, m) \end{pmatrix}, \begin{pmatrix} \sigma_\theta^2 & e_m^*(a)\, F(\overline{k}, l, m)\sigma_\theta^2 \\ e_m^*(a)\, F(\overline{k}, l, m)\sigma_\theta^2 & \sigma_\theta^2 [e_m^*(a)\, F(\overline{k}, l, m)]^2 + \sigma_\varepsilon^2 \end{pmatrix} \right)$$

α is a measure of the accountability of public outcomes and the last term is the talent (3) inferred by the principal, implying that a higher accountability in the environment of public works increases the expected marginal benefit of signalling his talent. As we argued above, among the relevant factors reducing the accountability of public outcomes, endemic corruption in the local environment is likely to take on a predominant role (e.g., Adserá et al., 2003; Lederman and Loayza, 2005; Hunt, 2005); therefore, we assume that a high level of endemic corruption c reduces the accountability of public outcomes (e.g., Yan and Oum, 2014), that is $\alpha(c)$ with $\alpha'(c) < 0$.

Since the monitoring activity (a) is unobservable for the contracting authority, as standard in the principal-agent framework, the purchasing officer has an information advantage that he can exploit as an instrument to signal his talent to the principal. On the other hand, the monitoring effort (a) implies for the purchasing officer a disutility $C(a) = \frac{1}{2}\, a^2$ with increasing marginal disutility, that is $C'(a) > 0$ and $C''(a) > 0$. Therefore, the problem faced by the purchasing officer is to choose the monitoring effort (a) to maximize his expected utility, taking the contractor's response to monitoring (2) into account:

$$\max_{a \geq 0} \alpha(c)\, E\big[E[\theta|\, y, a^*]\big] \,-\, \frac{1}{2}\, a^2$$

where the first expectation is respect to outcome and the second is respect to talent[5], yielding the optimal monitoring effort as the following fixed-point (see the technical appendix):

$$\alpha(c)\ \mathrm{cov}\left(\theta, \frac{\hat{f}_a(y|a^*)}{\hat{f}(y|a^*)}\right) = \ a^* \qquad (4)$$

where $\hat{f}_a(y|a^*)$ denotes the first-order derivative of the marginal density of the outcome (y) with respect to the monitoring effort (a) and "cov" denotes the covariance between the talent and the likelihood ratio. The optimal policy (4) says that the purchasing officer chooses the monitoring effort such that the marginal disutility of monitoring is equal to the expected marginal benefit of signalling his talent by inducing a higher observable outcome (e.g., Dewatripont et al., 1999a).

The intuition of this result is that the purchasing officer can signal his talent only by exerting a higher monitoring effort and, in turn, inducing a higher observable outcome; however, not all of the increase in observable outcome is attributed by the principal to the purchasing officer's talent, because both talent and outcome are intrinsically stochastic. Therefore, the optimal monitoring effort tries to make bigger the covariance between the talent and the expected marginal increase in

[5] Differently from the contracting authority (3), notice that when the purchasing officer chooses the monitoring activity the outcome is still uncertain and, in particular, it is stochastic for the presence of the productivity shock ε.

the observable outcome, in order to make the outcome more informative for inferring the talent, until the marginal benefit equates the marginal disutility of monitoring effort.

The explicit form of the covariance between talent and likelihood ratio clearly depends on the explicit functional forms of the model. However, the specific form of the observable outcome ($y = \theta e_m^*(a)\, F(\overline{k}, l, m) + \varepsilon$), suggests that the covariance should exhibits an inverted u-shape respect to the monitoring effort (a), especially for the strong complementarity between talent and monitoring effort (e.g., Dewatripont et al., 1999b). Moreover, given that the marginal disutility of monitoring effort is increasing ($C''(a) > 0$), under fairly general and harmless assumption, the optimal policy (4) exists and it is unique (see the technical appendix). In particular, under the previous explicit functional forms[6], the optimal policy (4) yields:

$$\alpha(c)\ \frac{F(\overline{k},l,m)^2}{F(\overline{k},l,m)^2 a^* + \frac{\sigma_\varepsilon^2}{F(\overline{k},l,m)^2 a^* \sigma_\theta^2}} = a^* \qquad (5)$$

where the covariance exhibits an inverted u-shape respect to the monitoring effort.

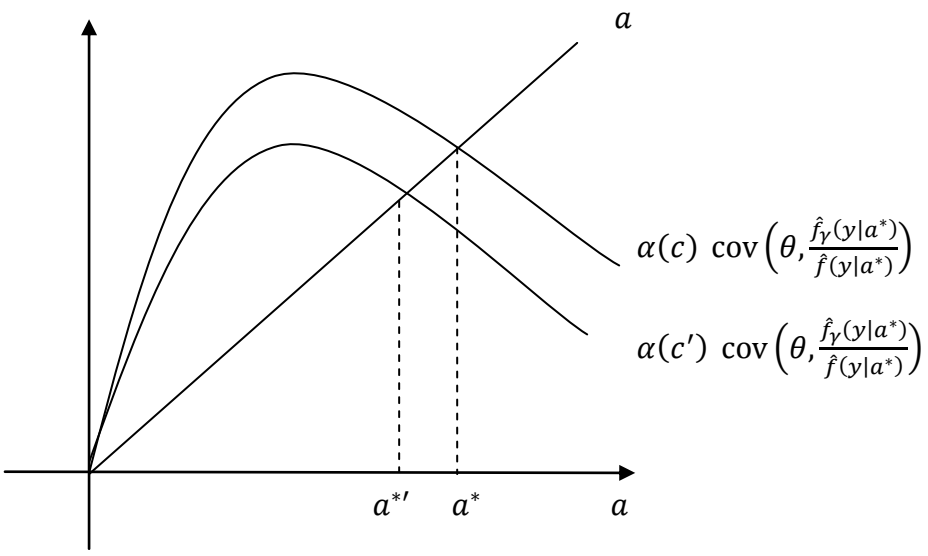

Figure 2 – Endemic corruption, accountability and optimal monitoring activity ($\mathbf{c}' > c$)

The first interesting aspect of the optimal policy (5) is that, not surprisingly, a higher accountability of public outcomes (α) increases unambiguously the purchasing officer's monitoring effort (a^*), simply because it increases the expected marginal benefit of signaling his talent. Looking at the other comparative statics of (5), they are quite reasonable and intuitive. In particular, a higher dispersion of productivity shock (σ_ε^2) decreases the expected benefit of inducing a higher observable outcome and, thus, decreases the optimal monitoring activity (a^*). On the other hand, a

[6] Indeed, other functional forms would not affect the implications of the model, as long as they follow the derivates.

higher dispersion of purchasing officer's talent (σ_θ^2) increases the covariance between talent and observable outcome and, thus, the expected benefit of signaling his talent through a higher observable outcome, leading the purchasing officer to increase the monitoring activity (a^*). In particular, in Figure 2 we show the effect of endemic corruption on the optimal monitoring activity.

Finally, coming back to the optimal managerial effort ($e_m^* = min\left\{aF(\overline{k}, l, m), \frac{\overline{q}}{F(\overline{k},l,m)}\right\}$), we can derive the main prediction of the model in terms of the effect of endemic corruption on the efficiency of public works execution:

Proposition 1. *In a corrupt local environment the lower accountability of public outcomes decreases the monitoring effort and, consequently, leads to a lower efficiency of public works.*

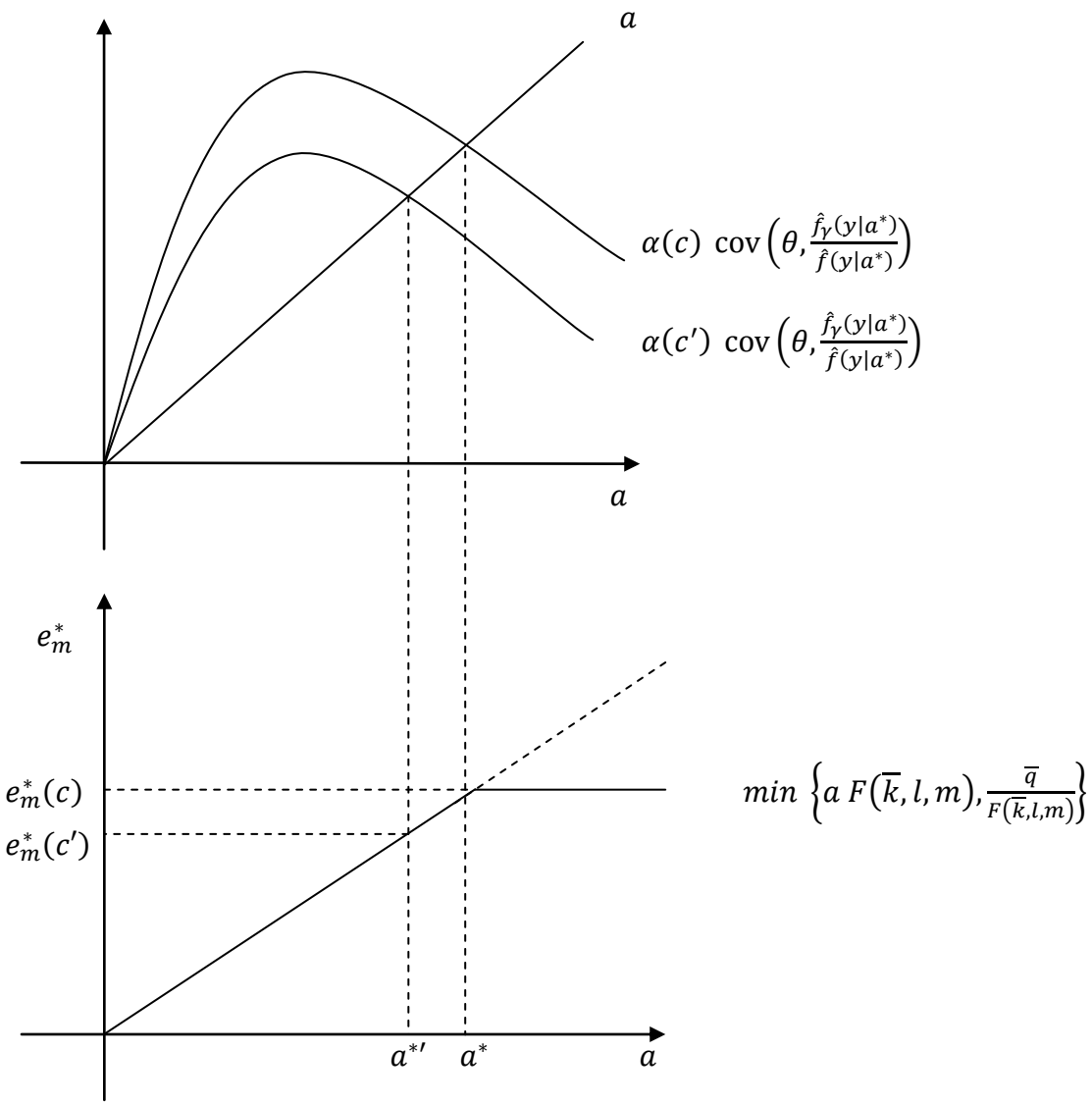

Figure 3 – Endemic corruption, accountability and the efficiency of public works ($c' > c$)

The intuition of our result is that in a debauched local environment the citizens, who are the final principal of the contracting authority in the use of public resources, do not care much about the outcome in the use of such resources in public works execution; therefore, the purchasing officer perceives that his costly monitoring activity will not be rewarded and, consequently, he has the incentive to look the other way, making the open road to the inefficient behaviour of the contracting firm (*passive waste effect*). From this perspective, our model is close to the established strand of literature that underlines the role of social capital in enhancing politicians' accountability in an agency framework (e.g., Alesina and Tabellini, 2007; Nannicini et al., 2013).

Note that so far in our model, the presence of endemic corruption increases the inefficiency in public works execution even when the procurement has not been subject to bribery, rent extraction or other explicit episodes of corruption. Even if this might clash with standard rent-seeking arguments, our theory aims at highlighting that in debauched local environment there can be severe inefficiencies in the provision of public services even when there are not corrupt public officials and, indeed, we believe that this picture is really close to the Italian public procurement. In this regards, for instance, Bandiera et al. (2009) find that passive waste accounts for 83 percent of total estimated waste in the purchase of standardized goods by Italian public bodies. Nonetheless, it is clear that a corrupt local environment could also give rise to explicit forms of corruption and, therefore, in the next section we extend our model to accommodate also the presence of *active waste effect*.

2.3 Corruption (*active waste effect*)

The contractor

Besides reducing the accountability of public outcomes, a debauched local environment can facilitate the rise of explicit corruption. In the context of public works execution, we could imagine that a contracting firm could attempt to get a higher cost overruns in exchange for a bribe to the purchasing officer. Accordingly, in this section we assume also that a high level of endemic corruption c increases the marginal return to managerial effort devoted to lobbying activities for getting higher cost overruns. In particular, we extend the model by considering two different destinations of managerial effort (e.g., Dal Bó and Rossi, 2007): the productive effort e_m^p, devoted to the coordination and supervision of inputs, and the unproductive effort e_m^u, devoted to lobbying activities for getting a higher cost overruns.

Differently from the previous section, the benefit of the contracting firm is not only that established in the contract $\overline{\pi}$, but it can be augmented by a successful lobbying activity for getting higher cost overruns. Specifically, we have that $\pi = \overline{\pi} + \delta\, b(e_m^u, c)$, with $\delta \in [0,1]$, $b'_{e_m^u}(e_m^u, c) > 0$,

$b''_{e_m^u,e_m^u}(e_m^u, c) < 0$ and, most importantly, $b''_{e_m^u,c}(e_m^u, c) > 0$. Eventually, for the sake of simplicity, we assume $\pi = \overline{\pi} + \delta\left(ce_m^u - \frac{1}{2}{e_m^u}^2\right)$. This formulation captures the fact that the additional revenue the contracting firm can get (that is, the cost overrun) depends positively, but with decreasing marginal returns, on its effort devoted to the lobbying activity e_m^u. However, the additional revenue comes in exchange for a bribe $(1-\delta)\left(ce_m^u - \frac{1}{2}{e_m^u}^2\right)$ to the purchasing officer who have power on it and, therefore, only a fraction δ of the additional revenue is enjoyed by the contracting firm. Finally, the last assumption on c captures the central element of our theory: a higher endemic corruption in the local environment increases the marginal return to managerial effort devoted to lobbying activities for getting higher cost overruns (e.g., Dal Bó and Rossi, 2007). The motivation for this assumption is that when the level of corruption in the local environment is low, devoting effort to lobbying activities for getting additional revenue could be largely unproductive for the contracting firm, if not dangerous for the risk of being convicted; on the other hand, when endemic corruption is high, lobbying activities for getting cost overruns could turn out to be very productive.

Note that, even if we have an exchange of money in the model, we remain agnostic in the evaluation of the effect of a corrupt local environment; therefore, we do not consider the bribe strictly a waste, but a simple money transfer between the contracting firm and the purchasing officer. On the other hand, we do consider the real resources wasted to get such additional revenue and, in particular, the diversion of the productive managerial effort (e.g., Hillman and Kats, 1987; Hillman and Samet, 1987; Dal Bó and Rossi, 2007).

Therefore, the contracting firm chooses how to allocate its managerial effort between the two destinations to maximise his expected utility, that is:

$$\max_{e_m^p, e_m^u \geq 0} \overline{\pi} + \delta\left(ce_m^u - \frac{1}{2}{e_m^u}^2\right) - w_l l - w_m m - \frac{1}{2}\left(e_m^p + e_m^u\right)^2 - a\,max\{\overline{q} - [e_m F(\overline{k}, l, m)], 0\}$$

yielding the following optimal managerial efforts (see the technical appendix):

$$e_m^{p\,*} = \begin{cases} min\left\{a F(\overline{k}, l, m), \frac{\overline{q}}{F(\overline{k}, l, m)}\right\} & if\ c < c^* \\ \frac{(1+\delta)}{\delta} aF(\overline{k}, l, m) - c & if\ c^* < c < c^{**} \\ 0 & if\ c > c^{**} \end{cases} \quad (6)$$

$$e_m^{u\,*} = \begin{cases} 0 \quad if\ c < c^* \\ c - \frac{aF(\overline{k},l,m)}{\delta} \quad if\ c^* < c < c^{**} \\ aF(\overline{k},l,m) \quad if\ c > c^{**} \end{cases} \tag{7}$$

with $c^* = \frac{aF(\overline{k},l,m)}{\delta}$ and $c^{**} = \frac{(1+\delta)}{\delta} aF(\overline{k},l,m)$. Figure 4 illustrates the optimal managerial efforts (6) and (7) as a function of the level of endemic corruption. When the level of corruption is zero, the contracting firm has no incentives to devote its effort to lobbying activities and, thus, the model reproduces exactly the equilibrium in the previous section. Even when the level of corruption is low, the opportunity cost of diverting managerial effort from the productive activity is still higher than the marginal return of lobbying activities. On the contrary, when the level of corruption is large, the lobbying activity becomes attractive and, therefore, the contracting firm finds optimal to distribute its managerial effort between the two destinations. In particular, we can see that a higher c increases the effort devoted to lobbying activities, while reducing the productive one, and eventually for very high level of corruption the contracting firm could even find optimal to allocate its effort entirely to the lobbying activity. The same result can be appreciated from Figure 5, where we show the optimal productive effort $e_m^{p\,*}$ as a function of the monitoring activity a, for increasing values of endemic corruption c.

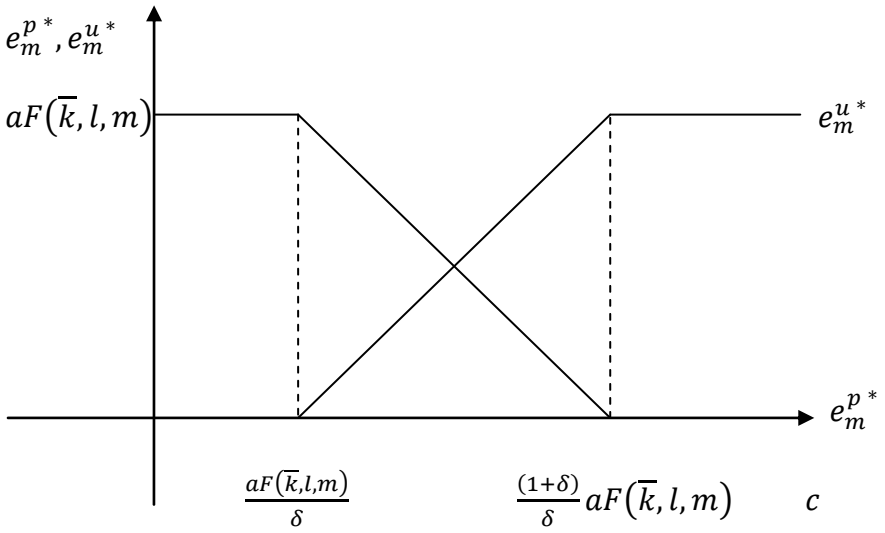

Figure 4 – Optimal productive and unproductive managerial efforts

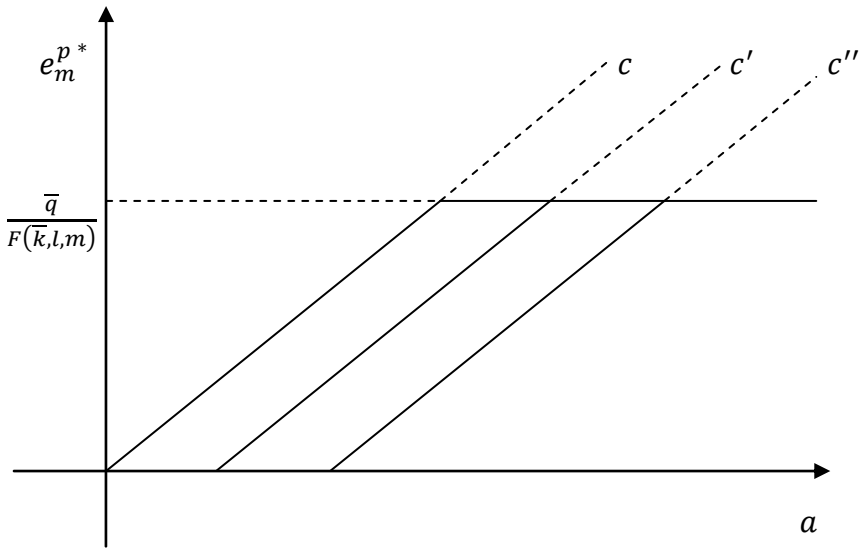

Figure 5 – Optimal productive managerial effort for increasing values of endemic corruption

The purchasing officer

Differently from the previous section, the purchasing officer does not benefit only from the expected reward of his talent, but he could also benefit from the bribe $(1-\delta)\left(ce_m^u - \frac{1}{2}{e_m^u}^2\right)$, when the contractor conducts a successful lobbying activity and gets the cost overrun. Therefore, the problem faced by the purchasing officer is to choose the monitoring effort (a) to maximize his expected utility, which now includes also the bribe, taking the contractor's response to monitoring (6) and (7) into account:

$$\max_{a\geq 0} \alpha(c)\, E\left[E[\theta|\, y, a^*]\right] + (1-\delta)\left(ce_m^u(a) - \frac{1}{2}{e_m^u}^2(a)\right) - \frac{1}{2}\,a^2$$

yielding the optimal monitoring effort as the following fixed-point (see the technical appendix):

$$\alpha(c)\ \mathrm{cov}\left(\theta, \frac{\hat{f}_a(y|a^*)}{\hat{f}(y|a^*)}\right) = a^* \left\{1 + (1-\delta)\left[\frac{F(\overline{k},l,m)}{\delta}\right]^2\right\} \qquad (8)$$

Similarly to (4), the optimal monitoring effort tries to make bigger the covariance between the talent and the expected marginal increase in the observable outcome, in order to make the outcome more informative for inferring the talent, until the marginal benefit equates the marginal disutility of monitoring effort. As can be seen from (8), however, now the marginal disutility of the monitoring effort is higher because of the negative effect on $e_m^{u\,*}$ and, thus, on the bribe the purchasing officer could get from the contracting firm. In fact, when the purchasing officer devotes a higher effort in the monitoring activity, the contracting firm will be discouraged to divert its effort from the productive to the lobbying activity and, clearly, this will reduce the amount of the bribe. Therefore,

the presence of the lobbying activity and bribery induces the purchasing officer to choose a lower level of monitoring effort respect to (4). This result is illustrated in Figure 6, along with the effect of endemic corruption on the optimal monitoring activity.

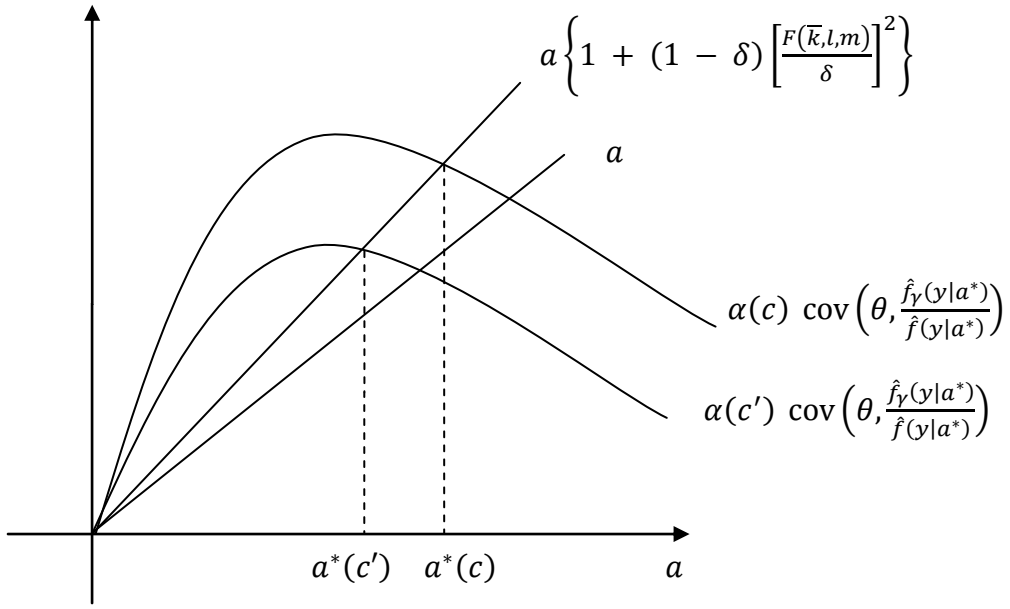

Figure 6 – Endemic corruption and optimal monitoring activity ($\mathbf{c'} > c$)

Not surprisingly, we can also see that the effect of introducing the lobbying activity and bribery on the purchasing officer's behaviour strictly depends on how the contracting firm is willing to share the cost overrun with him. In particular, when the fraction δ gets close to 1, then the effect of the lobbying activity tends to disappear. On the other hand, when the fraction δ gets smaller, then the effect on the purchasing officer's behaviour becomes very significant.

Finally, coming back to the optimal productive managerial effort (6), we can derive the main prediction of our model in terms of the effect of endemic corruption on the efficiency of public works execution:

Proposition 2. *In a more corrupted environment the lower accountability of public outcomes and the higher marginal returns to lobbying activities decrease the purchasing officer's monitoring effort and leads the contracting firm to devote more managerial effort to the unproductive activity. For both reasons, a higher endemic corruption in the local environment leads to a lower efficiency of public works execution.*

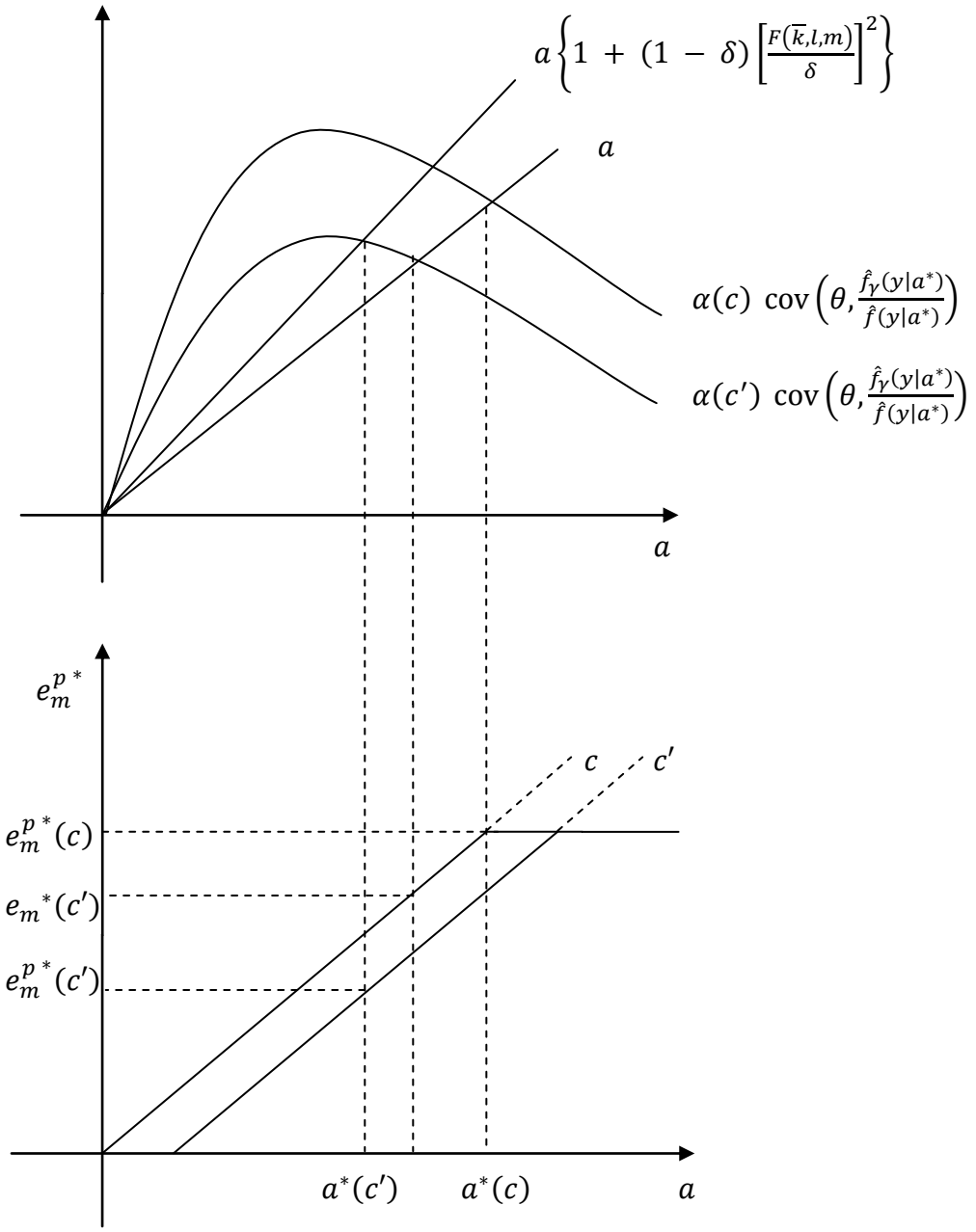

Figure 7 – Endemic corruption and the efficiency of public works ($c' > c$)

The content of Proposition 2 is illustrated in Figure 7. Note that, not surprisingly, in the complete model the negative effect of endemic corruption in the efficiency is more severe respect to the model in the previous section (see Figure 3). In fact, in the complete model not only a higher level of corruption reduces the expected marginal benefit of the purchasing officer to signal his talent, but also it increases the marginal costs of monitoring because of the negative effect on the bribe. Therefore, in a debauched local environment the purchasing officer has more than one reason to look the other way.

Overall, from our analysis of the incentives for the actors involved in the execution of public works we can conclude that a higher level of endemic corruption gives rise to two main sources of waste. The first source of waste we identify is the inefficiency induced by a low monitoring in the execution of public contracts (*passive waste effect*), probably a less direct form of waste but still important (e.g., Bandiera et al., 2009). The second source of waste is the diversion of the managerial effort of the contracting firm from the productive to the lobbying activity (*active waste effect*), probably a more direct form of waste but not necessarily the most important. Interestingly, note that in Figure 7 we are able to identify explicitly the two sources of inefficiency. In particular, we can easily see that the effect of endemic corruption $\left(e_m^{p\,*}(c) - e_m^{p\,*}(c')\right)$ can be decomposed in passive waste effect $\left(e_m^{p\,*}(c) - e_m{}^*(c')\right)$ and active waste effect $\left(e_m{}^*(c') - e_m^{p\,*}(c')\right)$.

3. Institutional background and efficiency of public work contracts in Italy

3.1 Italian institutional framework

The Italian system of public work procurement represents a good example for our investigation because of its inefficient performance, characterised by huge delays and cost overruns. According to the figures provided by the Authority for the Supervision of Public Contracts (*Autorità per la Vigilanza sui Contratti Pubblici di lavori, servizi e forniture* – AVCP, 2005), in the period 2000-2005, public works in Italy have extensively experienced cost overruns and delays: only 29.35% of works were completed without cost overruns and only 23.60% did not experience delays. The former are less marked than the latter: while 24.90% of contracts have experienced cost overruns above 10.00% of the original cost, 64.66% of contracts exhibit a delay longer than 20.00% of the completion time agreed upon in the contract[7]. These phenomena are persistent in the Italian public works as it can be seen by the most recent AVCP Annual Reports.

Cost overruns and delays can be considered 'red flags' of the malfunctioning of the procurement system in the public works field, casting some doubts on the soundness of the existing regulation[8]. The Italian public works market has been plagued by several bribery scandals through years. Since the beginning of nineties, as a response to strong public opinion reaction after a big scandal, an

[7] A possible explanation for such a difference might be found in the fact that the renegotiation of contracted costs is severely constrained by law (see note 13) while no such constraints exist for delays.

[8] An analysis of Italian legislation, in a comparative perspective, is provided by AVCP (2010).

extensive set of rules has been provided[9] to promote a fairly rigid, uniform and transparent platform for public spending. Procurement rules have been highly unstable; many changes have occurred through time and further ones are underway[10]. Public procurement objectives can be stated saying that government aims at obtaining '*value for money*', e.g. 'the right product at the right time and at a satisfactory price', and at preventing corrupt practices. To fulfil such objectives, a major role is assigned to competition[11], as a tool to select the most convenient bidder[12], while other relevant factors, such as the firm's reputation, in terms of its previous performance, cannot be taken into account by the purchasing officer. To prevent the opportunistic behaviour of private contractors, preference is given to fixed-price contracts with major limitations on the renegotiation of the contract[13].

Looking at the whole picture, the regulatory scheme raises many uncertainties. Major attention is devoted to the selection of the contractor rather than to the execution phase. Overall, a leading feature of Italian procurement legislation is to reduce as much as possible the discretion of the procurement officers.

Such an approach is confirmed, if not enhanced, in the most recent anti-corruption legislation[14]. Procurement is addressed as one of the public activities with high risk of corruption, the rotation of procurement officers is compulsory and the monitoring has been tightened[15]. Italian legislation tends to pay increasing attention to address the 'pathologies' – e.g. lack of integrity – of procurement rather than to regulate its 'physiology' – e.g. efficiency – though the two dimensions of procurement performance are closely linked (Rizzo, 2013).

[9] The reform of public works procurement was introduced by the law n. 109/94, the so-called *legge Merloni*. Among other things, the supervision of public works procurement - successively, extended to supplies and services – has been assigned to an independent Authority *(*AVCP – *Autorità per la vigilanza sui contratti pubblici)*

[10] The *Code of public contracts for works, services and supplies* (Legislative Decree n. 163/2006) is currently under revision for the transposition of the new EU Directives on procurement.

[11] Open and restricted procedures are the rule and negotiated procedures can be adopted only in well-defined circumstances.

[12] To access the public works market private contractors must be qualified on the grounds of legal, technical, economic and financial requirements.

[13] The law strictly specifies under what specific circumstances renegotiation is allowed, as well as the maximum amount, which is permitted, and the authorization procedure required.

[14] Law no. 190/2012 aims at contrasting corruption, focusing on prevention, on the basis of a model based on planning and control activities, under the supervision of the National Anticorruption Authority (ANAC).

[15] With law n. 114/2014, among the other things, procurement supervision has been entirely assigned to the National Anticorruption Authority (ANAC) (and the former Authority for the Supervision of Public Contracts – AVCP – *Autorità per la Vigilanza sui Contratti Pubblici di lavori, servizi e forniture*) has been abolished.

It is worth noting that the attempt to reduce as much as possible the purchasing officer's discretion has proved to be not successful in enhancing Italian procurement performance – as the above data on cost overruns and delays show – nor in preventing corruption. In presence of bureaucratic risk aversion, rules aimed at reducing – if not eliminating – bureaucratic discretion tend to be used as a 'shield' to stress 'compliance' to procedures rather than to pursue efficient outcomes.

Preventing any bureaucratic discretion affects the development of competences of procurement agents, which are widely considered very relevant factors of good procurement performance (OECD, 2010). Competent purchasing officers are also key elements to prevent the 'capture' of contracting authority by private contractors; therefore, they have to be granted discretion and flexibility, to be evaluated for their results – e.g. obtaining '*value for money'* – and, consequently, to be adequately rewarded.

As World Bank (2007) outlines, translating integrity and efficiency principles into operational reality may generate conflicts: "transparency requires, *inter alia*, simple rules for procurement while to minimise discretion requires more comprehensive, and generally voluminous, rule sets which obfuscates clarity and transparency. Reducing discretion may also be inconsistent with management and performance objectives".

Overall, the complexity and the instability of the Italian regulatory framework generates many uncertainties which do not facilitate the already difficult process to implement efficiency and integrity in procurement. Therefore, a proper incentive scheme for the contracting authority might imply wider discretion for officials – for instance, allowing for taking into account the firm's reputation – combined with greater accountability for purchasing officers' decisions. In the Italian legislation there are already useful monitoring tools, such as standard costs[16], which have not been adequately implemented so far. Such a tool could be used for the *ex-ante* monitoring of the bidding process and for the *ex-post* evaluation of outcomes. Discrepancies between the final cost and the standard cost above a given threshold could be considered as a 'red flag' for bad performance to be monitored, so that causes can be identified and responsibilities can be assessed. Moreover, making them transparent would foster the purchasing officers' accountability, promote benchmarking within and across administrations.

3.2. An assessment of the efficiency of infrastructure provision in Italy

[16] The calculation of standard costs is required since 1994 (L. 109/94, art. 4) and the same prescription is contained in the 2006 *Code of public contracts for works, services and supplies* (art. 7, c.4, lett. b). Methodological studies have been provided by the Authority in 2003 and, more recently, in 2012 but with no practical consequences.

To provide an empirical test of the models' predictions obtained in Section 2, we use a sample of 3,113 Italian public works contracts[17] for roads and highways[18]. The estimated engineering costs[19] of these contracts range from 150,000 euros to 5 million euros. We first analyse the efficiency of infrastructure provision in Italy at the execution stage using Data Envelopment Analysis (DEA; Charnes et al., 1978) and Stochastic frontier Analysis (SFA; Aigner et al., 1977; Meeusen and Van den Broeck, 1977) in a complementary fashion. In the next section, we control for environmental factors as the corruption level that, in principle, may affect the efficiency estimates obtained in this section.

The DEA efficiency estimates are computed according to different classes of work values and types of works, namely maintenance work or new work[20]. To check the robustness of the DEA findings with respect to the sampling variation, we implement a bootstrap procedure with 1,000 bootstrap draws (Simar and Wilson, 1998) to correct the bias in the DEA estimators and to obtain the confidence intervals. The kernel density estimates for the DEA efficiency scores by type of public work are shown in Fig. 8. The same figure shows the unbiased DEA scores obtained using the bootstrap method.

<< ***Figure 8 around here*** >>

Moreover, as an alternative to the DEA method, we examine the efficiency of public works execution using the SFA approach. Table 1 reports the statistics of the efficiency estimates using the DEA approach and the SFA distance function[21].

[17] The sample used in this study comprises public works contracts awarded in the period 2000–2004 and completed by 2005. All data were collected from the Observatory of Public Works (*Osservatorio per i lavori Pubblici*) of the Italian Public Contracts Authority (*Autorità di Vigilanza sui contratti pubblici di lavori, servizi e furniture,* AVCP) databases. In what follows, the observation unit is a single public works contract.

[18] These public works contracts are among the most commonly procured, representing about a quarter of all public works contracts procured each year (Banca d'Italia, 2011). Moreover, they are the most appropriate to use for analyzing the differences in efficiency across different levels of government, because their features are generally comparable across contracting authorities.

[19] Engineering estimated costs are used as the reserve price in tendering procedures.

[20] Here, we do not include detailed DEA first stage computations. Instead, our analysis is based on the results of Guccio et al. (2012). The authors measure the efficiency of the execution of public works contracts using an input-oriented DEA model.

[21] To apply the SFA model, we estimate relative public works efficiency by assuming the appropriateness of the log-linear Cobb–Douglas production function with half-normal distribution. In addition, I employ an input distance function to make it comparable to DEA estimates. The distance measure estimates are obtained using the methodology proposed in Jondrow et al. (1982).

<< ***Table 1 around here*** >>

Fig. 9 shows a scatterplot of the efficiency estimates using the SFA distance function and the DEA approach (both uncorrected and bias corrected). The high correlations between the DEA and SFA estimates displayed in Fig. 9 suggest that both approaches perform well in terms of external validity.

<< ***Figure 9 around here*** >>

4. 'Environmental' corruption and the efficient execution of public work contracts: the empirical findings

The application of efficiency frontiers estimates provides a measure of the relative performance in the execution of public works contracts. As a preliminary evidence on the role of 'environmental' corruption in affecting the efficient execution of public works, we follow the two-step approach suggested by Coelli et al. (1998) to regress DEA efficiency estimates against a set of covariates, along the lines of Finocchiaro et al. (2014). In particular, Table 2 shows the covariates used to perform the two-stage analysis, as well as their meanings and descriptive statistics.

<< ***Table 2 around here*** >>

The two-stage analysis is frequently implemented after conducting traditional DEA analyses. However, different estimators have been proposed (Simar and Wilson, 2011). Here, we apply semi-parametric (Simar and Wilson, 2007) and parametric (Banker and Natarajan, 2008) estimators. Moreover, we employ the SFA approach using the Battese and Coelli (1995) one-stage procedure where the inefficiency terms are estimated as a function of the set of covariates used in the second stage of the DEA approach.

As for the controls, the first two environmental variables refer to corruption indexes. Due to the nature of our data set, we adopt, as measures of corruption at provincial level, the number of crimes against public administration per 100,000 inhabitants (CORR_PA) computed by ISTAT[22] and the index of corruption (CORR_G&P) proposed by Golden and Picci (2005).

[22] As in Dal Monte and Papagni (2001) we use as a proxy of environmental corruption the number of reported crimes against the public administrations. Data at provincial level have been taken from the Annals of Criminal Statistics (Statistiche giudiziarie), National Institute of Statistics (ISTAT) from year 2000 to 2004.

The former is based on data coming from the judicial system and it has been widely adopted in the literature (e.g. Del Monte and Papagni, 2001, 2007; Fiorino et al. 2012; Abrate *et al.*, 2013)[23]. Indeed, this index appears to be affected by some problems, mainly due to the fact that the differences across provinces may depend not only on the 'objective' different degree of corruption but also on differences in the efficiency of the judicial system or on the different trust of citizens toward such a system (resulting, *ceteris paribus*, in different number of denunciations). An alternative measure of corruption in Italy is provided by Golden and Picci (2005) who compute an index of corruption applied to the public works sector at provincial level. Whereas the advantage of this index is that it has been computed using objective data, it has several problems. First, if we assume that corruption and inefficiency are somehow related, this index cannot disentangle the effects of these two phenomena. In addition, it has to be noted that the index of Golden and Picci (2005) captures the effects of long-run phenomena. Thus, the value of the index for one specific year refers to the sum of all the effects cumulated across previous years. However, in line with the literature in the field, we use this index of corruption since it offers a good representation of 'environmental' corruption and fits with the economic phenomenon under analysis. On the basis of the above-mentioned considerations, we expect that the Golden and Picci (2005) index should be able to explain a larger portion of inefficiency than the index provided by ISTAT.

We also control for other environmental factors that may affect the performances in the execution of public works. First, public works vary in terms of complexity[24]. It is, thus, reasonable to assume that contract execution becomes more uncertain as the degree of complexity of the work increases. As proxy for complexity we use the weighted composition index of a work, calculated on the different sub-categories involved in the work, weighted for their relative amount (WCI)[25]. We also differentiate between "new" works (NEW) and repair/restructuring works. We expect that the degree

[23] Moreover, such an index is used in official documents, such as the latest Report of the National Anticorruption Authority (ANAC, 2013), to represent the corruption phenomenon in Italy while stressing that the measurement of corruption is highly unsatisfactory.

[24] Previous works on this subject (e.g., Bajari *et al.*, 2009; Guccio *et al.*, 2012) use the total value of the work and duration of the work, as estimated by the contracting authority at the bidding stage, as proxies for complexity. However such variables are strictly correlated with the variables used in the first stage.

[25] The WCI is constructed taking into account the sub-categories involved in each project as well as their relevance. Complexity may be assumed to be decreasing in the concentration of works in one or few subcategories. More formally the Weighted Composition Index (WCI) is defined as a follows. If $w_{[i]j}$ is the amount of money to be spent, within the *j-th* project, with (*j;1,...,n*), for works of the *i-th* sub-category (*i; 1, ..,G*), and $w_{[i]j} \geq w_{[i+1]j} \forall i$, then $WCI_j = \sum_i i \ \frac{w_{[i]j}}{\sum w_{[j]}} \in \left[1, \frac{G+1}{2}\right]$.

of complexity and, thus, the likelihood of waste of time and cost are higher for new works than for repair/restructuring ones.

Previous studies on public works execution find that competition exerts a positive effect on infrastructures provision and seems to moderate the weight of corruption (Rose-Ackerman, 1996). To capture this influence we employ the number of bids (BIDDERS) and the rebates of the winning bidder (REBATE). Thus, when the level of competition is higher the most efficient firm should be chosen and the management of public works should be efficient. However, the Italian system of public works award seems to provide considerable chances of opportunistic behaviours to firms that may offer strong rebates to win the procurement and exploit the possibility of further renegotiation (Guccio *et al.,* 2009). To control for this effects we employ the rebate of the winning bidder (REBATE). As it has been pointed out by Guccio *et al.,* (2009), such an opportunistic behaviour is favoured by the fact that in the Italian system, competitive tendering does not leave room for taking into account firm's reputation. Thus, we expect that large rebate negatively affects public works execution.

The other features of public works that can significantly affect their performance at the execution stage are: the presence of subcontractors in the execution of the work (SUB) and the existence of legal disputes between the firm and the contracting authority (DISPUTE). We hypothesise that both variables tend to increase the completion time and the likelihood of a low performance in infrastructure provision.

Moreover, we think that "institutions matter": different models of governance affect appointment methods, soft or hard budget constraints provide different incentives to monitor the implementation of the work. This is especially important in the Italian case since public works are carried out by very different contracting authorities with different governance and levels of decentralisation.

To grasp the relation between the governance and the efficiency of the public work contracts execution, contracting authorities have been grouped into the following categories: CENTRAL (State administrations even with autonomous organisation; public institutions which enjoy budget autonomy and public ownership companies); LOCAL (local governments such regions, provinces and municipalities); and CONCESSIONAIRES (private company that holder a public concession *e.g.*, transport; highway; etc.). The omitted category is (LOCAL). Guccio *et al.* (2014) find that local governments seem to be less efficient in ensuring the completion of public works on time, as they suffer from longer delays than central government, this phenomenon being more severe for small municipalities and when the contract is mainly financed with external resources. We would expect similar effects on the performance of public works contracts, as it is measured here.

The test employed in previous section has showed that there are unobserved factors that affect the performance of the different classes of public works that must be taken into account. Thus, we control for different dimensions of public works with a set of dummies computed according to the different value of works (CLASS)[26].

Furthermore, it has to be noted that our database is time truncated because it includes the contracts awarded in the period 2000-2004 and completed by 2005. This may cause the selection of a sample with works to be completed contractually near the end of the period under consideration and, then, show systematically lower delays. To control for such an effect, we have introduced fixed time effects by the year of award (*YEAR*).

Moreover, in the last decades Italian public administration has experienced a large decentralization of regulation at regional level also in public work sector and this may influence the performance of public work execution[27]. To control for this problem, we include a full set of regional fixed effects[28].

Table 3 provides the results of our estimates obtained following the Simar and Wilson (2007) procedure. In Table 4 we report the estimates computed according to Banker and Natarajan (2008), and in Table 5 we report the SFA estimates. In each group of estimates, to provide the most robust evaluation of our empirical findings, we use a parsimonious strategy to evaluate the relative marginal effects.

<< ***Table 3 around here*** >>

[26] We computed 3 classes referred to public works with reserve price between 150,000 to 500,000; 500,000 to 1,500,000 and 1,500,000 to 5,000,000 of euros.

[27] Following a major reform giving greater autonomy to local government launched in 1990 and still under way, regions can adopt their own specific regulations in the public procurement field. Moreover, new Article 117 of the Italian Constitution gives regional governments legislative power parallel to that of the central government in specific fields such as town planning, health and public works. This legislative power must be exercised within the limits laid down by central government legislation and must not conflict with the national interest or the interests of other regions. In the public works sector, the national legislation applicable to all contract procedures, lays down that the regions and the bodies financed by them, are only required to comply with the EU Directives. They may adopt implementing legislation that is different from national legislation. Moreover, Regions with special status have adopted their own autonomous regulations for public procurement procedures.

[28] We also perform an F-test for joint significance of these variables (YEARS and REGIONS) for our baseline model employing the Banker and Natarajan (2008) estimator. The null hypothesis of no YEARS and REGIONS effects can be rejected at any conventional levels of significance. All estimates are available from authors upon request.

The results reported in Table 3 are robust and generally in line with the main conclusions reached in the literature. Both coefficients of the two corruption indexes (CORR_PA and CORR_G&P) turn out to be significant. Their effects are quite similar although, as expected, the index of Golden and Picci (2005), CORR_G&P, has a stronger marginal effect. This implies that if we measure the effects of corruption in terms of efficiency losses, they would be stronger than if we adopt the other index (CORR_PA). In addition, both indexes show negative signs in specification (2) and (3); therefore, a corrupted environment affects negatively the efficiency in the execution of public works, thus offering a confirmation to the predictions of the model presented in section 2. In more general terms, our preliminary results provide some support to the well-established tenet that corruption has detrimental effects on the efficiency of institutions. However, it has to be noted that the marginal effects of both indexes are quite low.

Finally, among the other variables included in the empirical analysis, WCI, COMPETITION, REBATE and CENTRAL show to be significant and with the expected signs. It is worth mentioning that our results provide support to the idea that in competitive environment firms tend to adopt opportunistic behaviour; therefore, the common wisdom that competition is always beneficial on efficiency is not confirmed. Moreover, the negative sign of CENTRAL seems to show that the execution of public works is more efficient at central level than at local level[29].

Among all the statistically not significant covariates, DISPUTE deserves a further explanation. This result, that may appear as counterintuitive, it is likely to depend on the fact that our dataset consider only completed works; the observation period is not very long (4 years); as shown in Table 5, only 2% of the public works in our sample experienced a legal dispute between the firm and the contracting authority.

The Simar and Wilson (2007) procedure, although overcomes the problems of the traditional two-stage approaches, is not immune from weaknesses (Badin, 2014). Thus, to further validate the robustness of our two-stage results, we apply the Banker and Natarajan procedure (2008) by regressing the (CRS) DEA efficiency scores on the environmental variables discussed above. In fact, Banker and Natarajan (2008) show that a typical DEA two-stage approach with OLS in the second stage yields consistent estimates if the inputs are not (too much) correlated with the environmental variables.

<< ***Table 4 around here*** >>

[29] Similar results are obtained by Guccio *et al*., (2014) showing that local governments do not seem to be under sufficient and effective pressure to behave efficiently in the execution of public works.

Finally, we use the SFA approach, as an alternative one to DEA, to examine the efficiency of public works execution. Following well-established conventions in the literature, we estimate a Cobb-Douglas production function with half-normal distribution and we employ an input distance function to make it more comparable to DEA estimates. Table 5 reports the parameter estimates of the environmental variables in SFA distance function that confirm the DEA findings[30]. In particular, the estimates of the indexes of environmental corruption are significant and negative as expected. The only difference with the DEA estimates is given by the higher marginal effects found in the SFA approach. However, this result may be ascribed to the specific characteristics of the adopted estimator (Kumbhakar and Lovell, 2000).

<< ***Table 5 around here*** >>

5. Concluding remarks

This paper contributes to the literature on the effects of corruption on the efficiency of public works both from a theoretical and empirical perspective. The prescriptions of our theoretical model suggest that endemic corruption reduces the incentives for the purchasing officer to pursue mandated tasks and, therefore, his effort in promoting the efficiency of the execution of public works. In other words, in corrupted environment the purchasing officer tends "to look the other way" rather than monitoring the outcome of the contract. Our empirical analysis, carried out using both the DEA and SFA approaches to determine performance levels in a large sample of Italian public works contracts for roads and highways, offers support to the model's predictions, showing a negative association between the efficiency of public works execution and different indexes of both accountability and corruption in the area in which public works take place.

Therefore, our results highlight that in a principal-agent framework, such as the one characterizing procurement, the rules aimed at promoting competition and at reducing the purchasing officer's discretion do not guarantee efficient procurement outcomes. The main policy implication is that there is a need to enhance the accountability of the purchasing officers. In such a perspective, the use of standardized costs might be an effective tool for the *ex ante* and *ex post* monitoring of his performance, providing incentives for the purchasing officer to "look the right way" and to control the private contractor activity.

[30] The whole model is available from the authors upon request. Beside the Cobb-Douglas production function with half-normal distribution, we have also estimated a Cobb-Douglas production function with exponential distribution and a truncated-normal distribution with results similar to those reported. Also these estimations are available upon request.

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TECHNICAL APPENDIX

In this appendix we show more rigorously the technical details of the theoretical model. We first characterize the optimal managerial effort of the contractor (2), then the optimal monitoring effort of the purchasing officer (5) and, finally, our main result concerning the effect of the endemic corruption on the efficiency of public works execution (Proposition 1).

Optimal managerial effort

The optimal managerial effort of the contractor e_m^* satisfies the following:

1. $e_m^* \in \left[0, \frac{\overline{q}}{F(\overline{k},l,m)}\right]$;

2. When $e_m^* \in \left(0, \frac{\overline{q}}{F(\overline{k},l,m)}\right)$, then $e_m^* = aF(\overline{k}, l, m)$;

3. e_m^* is strictly increasing with respect to the monitoring effort a of the bureaucrat in the open interval $\left(0, \frac{\overline{q}}{F(\overline{k},l,m)}\right)$.

Proof. 1., let suppose $e_m^* > \frac{\overline{q}}{F(\overline{k},l,m)}$, that is the optimal managerial effort is higher than the effort sufficient to produce the expected product $\overline{q}$. Then, according to the conditional expected utility (1), the contractor can always marginally reduce the managerial effort without incurring any penalty associated to the contractor slack, but reducing the disutility of effort. For 2., when $e_m^* \in \left(0, \frac{\overline{q}}{F(\overline{k},l,m)}\right)$, it is the $\text{argmax}_{e_m} \overline{\pi} - w_l l - w_m m - \frac{1}{2} e_m^2 - a\left[\overline{q} - e_m F(\overline{k}, l, m)\right]$. The first-order condition is $\left[- e_m + aF(\overline{k}, l, m)\right]\Big|_{e_m = e_m^*} = 0$, implying that the optimal managerial effort of the contractor is $e_m^* = aF(\overline{k}, l, m)$. From 1. and 2., therefore, we can conclude that $e_m^* = min\left\{aF(\overline{k}, l, m), \frac{\overline{q}}{F(\overline{k},l,m)}\right\}$. Finally for 3., when $e_m^* \in \left(0, \frac{\overline{q}}{F(\overline{k},l,m)}\right)$, since the disutility of effort is a convex function $C''(e_m) > 0$, the optimal managerial effort of contractor is strictly increasing with respect to the monitoring effort a of the purchasing officer, that is $\frac{\partial e_m^*}{\partial a} = C''^{-1}\left[P(a)F(\overline{k}, l, m)\right]P'(a) = F(\overline{k}, l, m) > 0$. ■

Optimal monitoring effort

The optimal monitoring effort of the purchasing officer a^* satisfies the following:

1. a^* is the fixed-point of the self-map on the effort space $\alpha(c)$ $\frac{F(\overline{k},l,m)^2}{F(\overline{k},l,m)^2 a^* + \frac{\sigma_\varepsilon^2}{F(\overline{k},l,m)^2 a^* \sigma_\theta^2}} = a^*$;

2. The equilibrium effort a^* exists and it is unique under fairly general and harmless assumptions;

3. a^* is strictly decreasing with respect to the endemic corruption c.

Proof. 1., the purchasing officer chooses the effort to spend in the monitoring activity, given a principal's expectation a^*, to maximize his expected utility, taking the contractor's response to (2) into account. Thus, the equilibrium effort is the $\text{argmax}_a \left\{\alpha(c)\, E\left[E[\theta|\, y, a^*]\right] - \frac{1}{2}a^2\right\}$, satisfying the following first-order condition:

$$\frac{\partial}{\partial a}\, \alpha(c) \left(\int \left(\int \theta \frac{f(\theta, y|a^*)}{\hat{f}(y|a^*)}\, d\theta \right) \hat{f}(y|a)\, dy \right)\Bigg|_{a=a^*} = a^*$$

from which we get

$$\alpha(c) \int \left(\int \theta \frac{f(\theta, y|a^*)}{\hat{f}(y|a^*)}\, d\theta \right) \hat{f}_a(y|a^*)\, dy = a^*$$

or

$$\alpha(c) \iint \theta\, \frac{\hat{f}_a(y|a^*)}{\hat{f}(y|a^*)}\, f(\theta, y|a^*)\, d\theta\, dy = a^*$$

As standard in career concern models (e.g., Dewatripont et al., 1999a, 1999b), knowing that the expected value of the likelihood ratio is zero, then, we can write our equilibrium condition for the monitoring effort in the following general form:

$$\alpha(c)\ \text{cov}\left(\theta, \frac{\hat{f}_a(y|a^*)}{\hat{f}(y|a^*)}\right) = a^*$$

Finally, given the independent and normality assumptions on the distributions of talent θ and productivity shock ε, along with the implied distribution of the outcome y, we get the equilibrium monitoring effort in our more explicit form:

$$\alpha(c)\, \frac{F(\overline{k},l,m)^2}{F(\overline{k},l,m)^2 a^* + \frac{\sigma_\varepsilon^2}{F(\overline{k},l,m)^2 a^* \sigma_\theta^2}} = a^*. \ \blacksquare$$

2. The equilibrium effort a^* exists if there is at least a fixed-point in the self map on the effort space $\alpha(c)\, \frac{F(\overline{k},l,m)^2}{F(\overline{k},l,m)^2 a^* + \frac{\sigma_\varepsilon^2}{F(\overline{k},l,m)^2 a^* \sigma_\theta^2}} = a^*$. We first show that the LHS of our equilibrium condition exhibits an inverted u-shape respect to the monitoring effort:

$$\frac{\partial\, LHS}{\partial a^*} = -\frac{\alpha(c)\,\mu}{\left[\mu a^* + \frac{\sigma_\varepsilon^2}{\mu a^* \sigma_\theta^2}\right]^2}\left[\mu - \frac{\sigma_\varepsilon^2}{\mu\,\sigma_\theta^2\, a^{*2}}\right] = \begin{cases} > 0 & when \;\; a^* < \frac{\sqrt{\sigma_\varepsilon^2/\sigma_\theta^2}}{\mu} \\ = 0 & when \;\; a^* = \frac{\sqrt{\sigma_\varepsilon^2/\sigma_\theta^2}}{\mu} \\ < 0 & when \;\; a^* > \frac{\sqrt{\sigma_\varepsilon^2/\sigma_\theta^2}}{\mu} \end{cases}$$

where $\mu = F\left(\overline{k}, l, m\right)^2$, which says that the LHS exhibits an inverted u-shape. Moreover, even if the LHS evaluated at $a^* = 0$ does not exist, we can easily see that:

$$\lim_{a^* \to 0} \alpha(c)\, \frac{F\left(\overline{k}, l, m\right)^2}{F\left(\overline{k}, l, m\right)^2 a^* + \frac{\sigma_\varepsilon^2}{F\left(\overline{k}, l, m\right)^2 a^*\, \sigma_\theta^2}} = 0$$

from which we can say that the LHS of our equilibrium condition has an inverted u-shape starting from the axis origin. Finally, knowing that the marginal disutility of monitoring effort is strictly increasing ($C''(a) > 0$), as long as the marginal disutility of effort is not "too much high", there exists at least one fixed-point in the self map on the effort space given by our equilibrium condition.

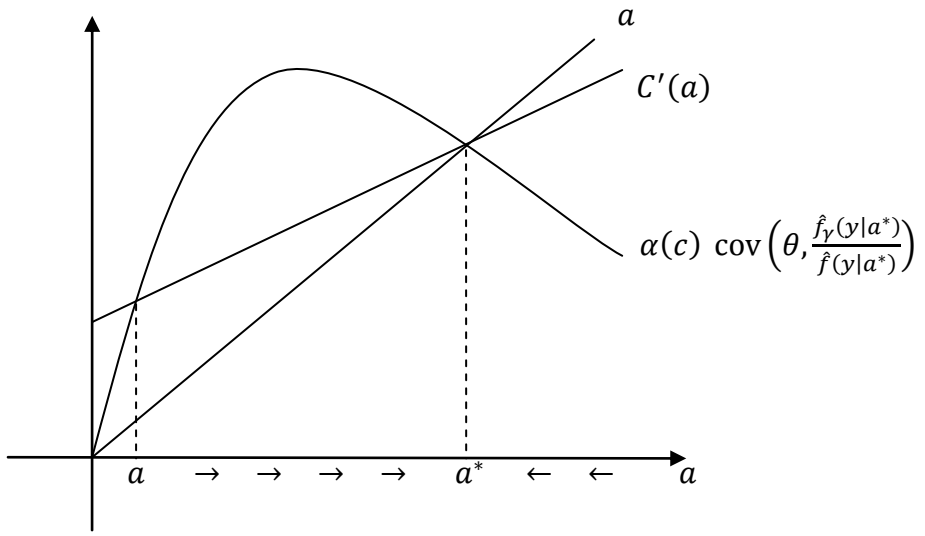


Figure A1 – Existence and uniqueness of the equilibrium monitoring effort a^*

Furthermore, if $C'(a^*)|_{a^*=0} = 0$, as when $C(a) = \frac{1}{2}a^2$, then we have that the equilibrium monitoring effort is unique and stable; differently, if $C'(a^*)|_{a^*=0} > 0$, then we have two fixed-points given by our equilibrium condition, but the first clearly unstable and only the second stable (as shown in Figure A1). ■

3. To show that the equilibrium monitoring effort a^* is strictly decreasing with respect to the endemic corruption c, we can write our equilibrium condition in the following implicit form:

$$D(a) \equiv \alpha(c) \frac{F(\overline{k},l,m)^2}{F(\overline{k},l,m)^2 a + \frac{\sigma_\varepsilon^2}{F(\overline{k},l,m)^2 a \sigma_\theta^2}} - a = 0$$

from which we have

$$\frac{\partial a^*}{\partial c} = -\frac{\partial D(a)/\partial c}{\partial D(a)/\partial a}\Big|_{a=a^*} = -\frac{\alpha'(c)\, LHS}{\alpha(c)\frac{\partial LHS}{\partial a} - 1}\Big|_{a=a^*} < 0. \blacksquare$$

The effect of the endemic corruption on the efficiency of public works

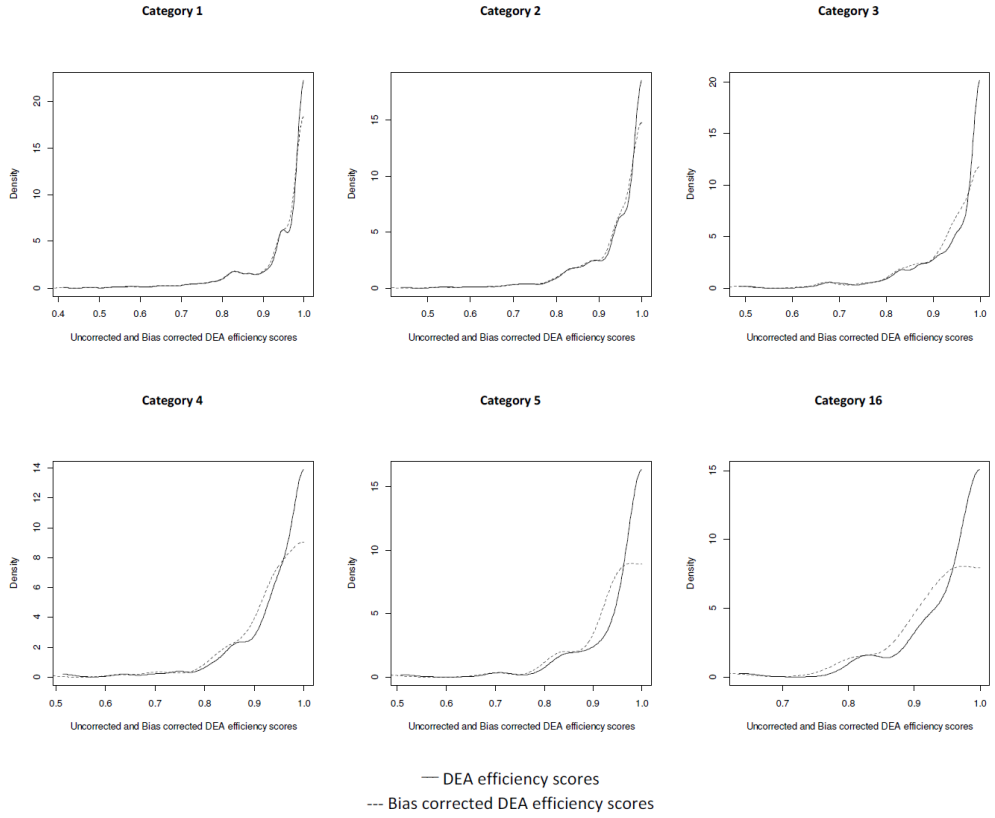
Proposition 1 summarizes our main result concerning the effect of the endemic corruption on the efficiency of public works:

1. In a corrupt local environment the lower accountability of public outcomes decreases the monitoring effort and, consequently, leads to a lower efficiency of public works.

Proof. The optimal managerial effort, when $e_m^* \in \left(0, \frac{\overline{q}}{F(\overline{k},l,m)}\right)$, is $e_m^* = a^*(c)\, F(\overline{k},l,m)$ from which we have $\frac{\partial e_m^*}{\partial c} = \frac{\partial a^*}{\partial c} F(\overline{k},l,m) < 0$. Not surprisingly, when e_m^* is already at the level sufficient to produce the expected product $\overline{q}$, that is $e_m^* = \frac{\overline{q}}{F(\overline{k},l,m)}$, the level of endemic corruption does not seem to affect managerial effort, but it is clear from $e_m^* = min\left\{a(c)\, F(\overline{k},l,m), \frac{\overline{q}}{F(\overline{k},l,m)}\right\}$ that e_m^* is less likely to be at the efficient level $\frac{\overline{q}}{F(\overline{k},l,m)}$ when the endemic corruption c is higher. ■

TABLES AND FIGURES

Fig. 8 - The kernel density distribution of DEA efficiency scores by type of public work



Note: Kernel density functions of public works contract efficiencies derived from both uncorrected and bias corrected DEA efficiency scores using univariate kernel smoothing distribution and the appropriate bandwidth. The reported kernel density estimates employ the reflection method described by Silverman (1986) and Scott (1992).

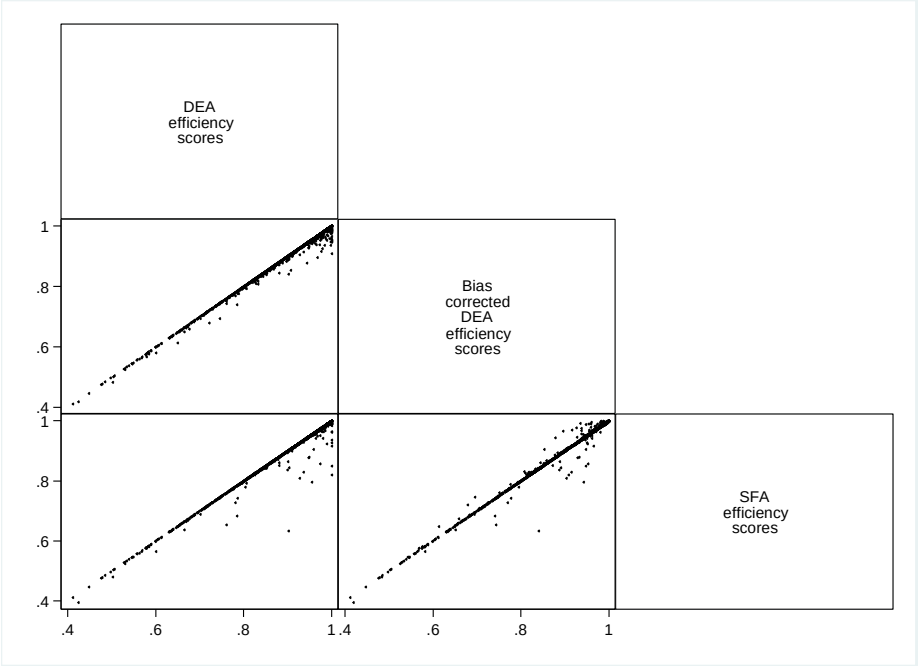
Source: Authors' elaboration on data provided by AVCP and by Guccio *et al.* (2012).

Table 1 - Statistics of DEA/SFA Efficiency Estimates by category of public work

Category			Number of public works	DEA estimates		SFA estimates	
				Mean	St. Dev.	Mean	St. Dev.
(1)	maintenance	150,000 - 500,000	1,811	0.9301	0.0871	0.9273	0.0799
(2)	new		810	0.9305	0.0795	0.9184	0.0880
(3)	maintenance	500,000 - 1,500,000	247	0.9223	0.0887	0.9155	0.1008
(4)	new		104	0.9249	0.0938	0.9102	0.0960
(5)	maintenance	1,500,000 - 5,000,000	85	0.9296	0.0880	0.9104	0.0827
(6)	new		56	0.9279	0.0842	0.8944	0.1024
All sample			**3,113**	**0.9294**	**0.0855**	**0.9259**	**0.0876**

Source: Authors' elaboration on data provided by AVCP and by Guccio *et al.* (2012).

Fig. 9 - Scatterplot between efficiency estimates



Source: Authors' elaboration on data provided by AVCP and by Guccio *et al.* (2012).

Table 2 – Variables employed in the second stage

Variables	Definition	Mean	St. Dev.	Minimum	Maximum
CORR_PA*	Crimes against public administration per 100,000 inhabitants at provincial level	4.86	3.10	0.27	17.35
CORR_G&P $	Corruption index proposed by Golden and Picci (2005), at provincial level	1.12	0.93	0.41	6.44
CORR_PA_SQ*	CORR_PA square	33.18	44.26	0.07	301.02
CORR_G&P_SQ $	CORR_G&P square	2.11	5.91	0.17	41.47
WCI♦	Weighted public work composition index	1.14	0.36	0.00	3.92
NEW♦, a	Dummy for type of infrastructure work (new/repair) (=1 when public work is new and 0 otherwise)	0.31	0.46	0.00	1.00
BIDDERS♦	Number of bidders	32.92	33.42	1.00	250.00
REBATE♦	Rebate of the winning bidder (percent)	13.78	9.88	0.00	57.00
SUB♦, a	Dummy for subcontracting (=1 when subcontracting and 0 otherwise)	0.76	0.43	0.00	1.00
DISPUTE♦, a	Dummy for legal dispute (=1 when legal dispute and 0 otherwise)	0.02	0.13	0.00	1.00
CENTRAL♦, a	Dummy for central body (= 1 when state administrations and 0 otherwise)	0.14	0.34	0.00	1.00
LOCAL♦, a	Dummy for local body (= 1 when local administration and 0 otherwise)	0.81	0.39	0.00	1.00
CONCESSIONAIRES♦, a	Dummy for private concessionaires (= 1 when private firm concessionaires and 0 otherwise)	0.06	0.23	0.00	1.00
CLASS_1♦, a	Dummies for the class of reserve price (= 1 when reserve price is between 150,000 - 500,000 euro and 0 otherwise)	0.84	0.36	0.00	1.00
CLASS_2♦, a	Dummies for the class of reserve price (= 1 when reserve price is between 500,000 - 1,500,000 euro and 0 otherwise)	0.11	0.32	0.00	1.00
CLASS_3♦, a	Dummies for the class of reserve price (= 1 when reserve price is between 1,500,000 - 5,000,000 euro and 0 otherwise)	0.05	0.21	0.00	1.00
$YEAR_i$♦	Dummies for year of public work award: 2000, 2001, 2002, 2003.				
$REGION_j$♦	Dummies for region in which the infrastructure takes place				

Source: * ISTAT, *Statistiche giudiziarie*, 2000-2004; $ Golden and Picci (2005); ♦ Our computation on data from *Osservatorio per i lavori Pubblici*, AVPC;

[a] Since the variable is a dummy, the reported average values represent the percentage of observations being equal to 1.

Table 3 – Truncated regressions second stage estimation results – public works with a value over 150,000 EUR, awarded in the period 2000-2004 and completed by 2005

Variables	(1)	(2)	(3)
Intercept	0.883***	0.883***	0.898***
	(0.011)	(0.010)	(0.011)
CORR_PA		-2.38^{-4} ***	
		(5.36^{-5})	
CORR_G&P			-0.003***
			(0.001)
WCI	-0.015***	-0.014***	-0.014***
	(0.004)	(0.004)	(0.004)
BIDDERS	2.32^{-4} ***	2.30^{-4} ***	2.34^{-4} ***
	(5.11^{-5})	(5.10^{-5})	(5.11^{-5})
NEW	0.001	0.001	0.001
	(0.003)	(0.003)	(0.003)
REBATE	-0.003***	-0.003***	-0.003***
	(0.000)	(0.000)	(0.000)
SUB	-0.002	-0.001	-0.002
	(0.004)	(0.004)	(0.004)
DISPUTE	-0.003	-0.003	-0.004
	(0.011)	(0.011)	(0.011)
CENTRAL	0.031***	0.029***	0.029***
	(0.009)	(0.009)	(0.009)
CONCESSIONAIRES	-0.009	-0.010	-0.010
	(0.007)	(0.007)	(0.007)
Control for YEAR	*yes*	*yes*	*yes*
Control for CLASS	*yes*	*yes*	*yes*
Control for REGION	*yes*	*yes*	*yes*
Observation	3,113	3,113	3,113

Source: Our computation on data provided by *Osservatorio per i lavori Pubblici,* AVPC.

***, ** and *: coefficients are significantly different from zero at the 99%, 95% and 90% confidence levels respectively.

[(a)] Double bootstrap truncated estimates algorithm 2 (n=500), (Simar and Wilson, 2007)

Table 4 – OLS second stage estimation results – public works with a value over 150,000 EUR, awarded in the period 2000-2004 and completed by 2005

Variables	(1)	(2)	(3)
Intercept	0.942***	0.946***	0.953***
	(0.037)	(0.037)	(0.037)
CORR_PA		-1.62^{-4} ***	
		(5.24^{-5})	
CORR_G&P			-0.009***
			(0.002)
WCI	-0.012***	-0.012***	-0.012***
	(0.004)	(0.004)	(0.004)
BIDDERS	2.56^{-4} ***	2.72^{-4} ***	2.70^{-4} ***
	(4.27^{-5})	(4.25^{-5})	(4.26^{-5})
NEW	0.002	0.002	0.002
	(0.003)	(0.003)	(0.003)
REBATE	-0.003***	-0.003***	-0.003***
	(0.000)	(0.000)	(0.000)
SUB	0.000	0.001	0.000
	(0.004)	(0.004)	(0.004)
DISPUTE	-0.003	-0.003	-0.003
	(0.011)	(0.011)	(0.011)
CENTRAL	0.027***	0.028***	0.027***
	(0.005)	(0.005)	(0.005)
CONCESSIONAIRES	0.005	0.007	0.007
	(0.007)	(0.007)	(0.007)
Control for YEAR	*yes*	*yes*	*yes*
Control for CLASS	*yes*	*yes*	*yes*
Control for REGION	*yes*	*yes*	*yes*
Observation	3,113	3,113	3,113
F test (Prob > F)	0.000	0.000	0.000
R-squared	0.218	0.221	0.221

Source: Our computation on data provided by *Osservatorio per i lavori Pubblici*, AVPC.

***, ** and *: coefficients are significantly different from zero at the 99%, 95% and 90% confidence levels respectively.

Table 5 – SFA model second stage results– public works with a value over 150,000 EUR, awarded in the period 2000-2004 and completed by 2005

Variables	(1)	(2)	(3)
Intercept	-5.912***	-5.920***	-6.150***
	(0.184)	(0.184)	(0.192)
CORR_PA		-0.003***	
		(0.001)	
CORR_G&P			-0.212***
			(0.048)
WCI	-0.433***	-0.431***	-0.420***
	(0.076)	(0.076)	(0.076)
BIDDERS	0.003***	0.003***	0.003***
	(0.001)	(0.001)	(0.001)
NEW	-0.027	-0.011	-0.027
	(0.059)	(0.059)	(0.059)
REBATE	-0.072***	-0.071***	-0.070***
	(0.004)	(0.004)	(0.004)
SUB	0.006	-0.029	-0.036
	(0.069)	(0.070)	(0.070)
DISPUTE	-0.174	-0.152	-0.145
	(0.204)	(0.204)	(0.204)
CENTRAL	0.573***	0.573***	0.579***
	(0.092)	(0.092)	(0.092)
CONCESSIONAIRES	0.785***	0.758***	0.790***
	(0.131)	(0.131)	(0.131)
Sigma	0.000***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)
Control for YEAR	*yes*	*yes*	*yes*
Control for CLASS	*yes*	*yes*	*yes*
Control for REGION	*yes*	*yes*	*yes*
Observation	3,113	3,113	3,113
Log likelihood	4364.215	4370.346	4373.931
Wald (Prob > chi2)	0.0000	0.0000	0.0000

Source: Our computation on data provided by *Osservatorio per i lavori Pubblici*, AVPC.

***, ** and *: coefficients are significantly different from zero at the 99%, 95% and 90% confidence levels respectively.