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DOES CORRUPTION AFFECT THE EXECUTION OF HEALTHCARE INFRASTRUCTURES? AN EMPIRICAL INVESTIGATION FOR ITALY

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ABSTRACT. This paper investigates empirically whether the institutional features of the contracting authority as well as socio-economic variables (including the level of 'environmental' corruption) in the area where the work is localised affect the efficient execution of public contracts for healthcare infrastructures. To this purpose, a two-stage Data Envelopment Analysis (DEA) is carried out based on a sample of Italian public contracts for healthcare infrastructures during the period 2000-2005. First, a smoothed bootstrapped DEA is used to assess the relative efficiency in the implementetion of each single infrastructure contract. Second, the determinants of the efficiency scores variability are considered, paying special attention to the effect exerted by 'environmental' corruption on different types of contracting authorities. The results show that the performance of the contracts for healthcare infrastructures is significantly affected by 'environmental' corruption. Furthermore, healthcare contracting authorities are less efficient and more at risk of 'environmental' corruption than other public procurers

INTRODUCTION

Corruption, broadly defined by Transparency International as the abuse of entrusted power for private gain, is recognised to be a pervasive and perdurable worldwide problem.

A central academic debate is whether corruption "greases" or "sands" the wheels of economic growth (Bardhan 1997, Pande 2008,

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Aidt 2009). Overall, evidence on the "sand the wheels" hypothesis has informed the position of key international organizations (i.e. IMF, OECD, World Bank), which have launched over the years an increasing number of national and international anti-corruption campaigns, aiming at promoting greater transparency and accountability in public sector activities.

Few papers have explicitly explored the effects of "environmental" corruption on firms' efficiency, especially with regard to public utilities. Most of them are, however, confined within a cross-country framework and rely on aggregate country-level indices of corruption (e.g. Transparency International Index or the Corruption Perception Index), which, due to their subjective nature, may be biased (Dal Bó and Rossi, 2007; Abrate et al., 2015). Few others, using 'objective' measures of 'environmental' corruption (e.g. number of criminal charges against the public administration; Golden and Picci index, 2005; number of government officials convicted for corrupt practices), find a significant negative impact on efficiency of municipal solid waste services in Italy (Abrate et al., 2013) and major commercial airports in the United States (Yan and Oum, 2014).

The relevance of corruption for the procurement field is widely investigated at academic level (Piga, 2011) as well as by international organizations (OECD, 2005; Transparency International, 2006a). Public procurement is considered to be a 'risky' area because of the large amount of public resources involved, the asymmetric information characterizing the decision-making process and the intrinsic incompleteness of contracts. Recently, Finocchiaro et al. (2014) have highlighted how the performance of public works contracts, in terms of cost overruns and time delays, is often negatively affected by 'environmental' corruption, thus resulting in relevant social losses.

Public procurement in health sector is also highly inclined to corruption. A survey of a few years ago estimated that 10%-25% of global spending on health public procurement was lost to corruption (Transparency International, 2006b)[1].

This paper aims to contribute to the debate on the topic by investigating the interaction between corruption and a specific area of the health field, namely the provision of healthcare infrastructures. To the best of our knowledge, no previous empirical research has dealt with public procurement for healthcare infrastructures, though

expenditure for this typology of goods accounts for the largest share of capital expenditure in the health sector.

This paper aims at filling this gap. The focus is on the Italian context, which is an interesting case study for two reasons. On one hand, corruption is an extremely relevant issue in Italy. According to the Corruption Perception Index (CPI), in 2015 Italy ranked penultimate among European countries, with an overall score of 44 out of 100 (Transparency International, 2015). Italy is also the country in Europe with the most marked domestic differentiations among regions for the presence of corruption phenomena (QoG, 2010): three regions (Bolzano, Val d'Aosta and Trento) are among the best in Europe while two (Campania and Calabria) among the worst.

On the other hand, the National Health System (*Servizio Sanitario Nazionale*, SSN) in Italy exhibits some interesting institutional features. Since 1978, Italy relies on a SSN, which grants universal access to a uniform level of care throughout the country. Over the time, the country has undergone a set of reforms inspired by the principles of regionalization, managed competition and managerialism (France et al., 2005). As a result, responsibilities for the financing and delivery of healthcare are now in charge of Regional governments, which administer, organize, and finance healthcare according with their populations' needs, albeit within the national regulatory framework. These act through a network of geographic- and population-defined Local Health Authorities (*Aziende Sanitarie Locali.* Hereafter, LHA) - independent public entities with their own budgets and management, which directly run small public hospitals - major public hospitals (*Aziende Ospedaliere*), which are granted the status of trusts with full managerial autonomy and accredited private providers.

Employing an official data set on Italian public contracts during the period 2000-2005, the paper examines whether the institutional features of the contracting authority play a role in the efficient execution of the contracts for healthcare infrastructures. The performance of the contracts is assessed in terms of delays and cost overruns. Furthermore, we also investigate the effects of socio-economic variables (including the level of 'environmental' corruption) in the area where the infrastructure is localised. For this purpose, a two-stage analysis is carried out. In the first stage, the non-parametric "bootstrapping" approach (Data Envelopment Analysis - DEA)

suggested by Simar and Wilson (1998, 2000) is employed to assess the relative efficiency by each single infrastructure contract execution and distinguishing according with the type of contracting authority; in the second stage, the determinant factors of the efficiency scores' variability are investigated, paying special attention to the role played by 'environmental' corruption and to the institutional features of contracting authorities.

Our results show that "environmental" corruption plays a relevant negative role in the efficient provision of public healthcare works. Furthermore, institutional characteristics of the contracting authority matter for the efficient execution of contracts for healthcare infrastructures: healthcare contracting authorities are lower performers than other public procurers. Finally, other things being equal, the effects of corruption in reducing efficiency of public procurement is not uniform across the different types of contracting authorities but is greater for healthcare procurers.

The paper is organized as follows. The next Section briefly discusses the relevant literature. After that, the main characteristics of public works in the Italian healthcare sector are described. Methodology and dataset are then explained, followed by the presentation and discussion of the empirical results. Some remarks and policy implications conclude.

CORRUPTION, HEALTH AND PUBLIC PROCUREMENT

It is widely recognized that healthcare has a number of structural and systemic features that make it more exposed to the risk of corruption than other economic sector. As outlined by Savedoff and Hussmann (2006), the specific mix of uncertain and inelastic demand for health services, asymmetric information and large numbers of dispersed interacting actors (e.g. regulators, payers, providers, consumers) hinders transparency and accountability and provides opportunities for fraudolent and corruptive behaviours. Furthermore, the fact that private health actors are often entrusted with important public roles as well as the large amount of public money involved in the health sector further worsen the problem. Other factors, such as the level of decentralization and the type of governance and finanincing system are also important, albeit country specific (Holmberg and Rothstein, 2011).

The view of healthcare as a highly corrupted sector is reflected in recent public opinion: out of a global survey of over 114,000 people, on average, 45% believed medical and health services to be corrupt or extremely corrupt (Transparency International, 2013).

Regardless of the specific form taken by corruption in healthcare[2], its consequences are particularly serious (for a review, see Lewis, 2006; Vian, 2002 and 2008): reduction in the resources effectively available for health, lowering of quality, equity and effectiveness of healthcare services, decrease in volume and increase in cost of provided services. More generally, corruption ultimately discourages users from accessing healthcare services (Bouchard et al., 2012) and, hence, has a negative impact on population's health and welfare (Azfar and Gurgur, 2008; Factor and Kang, 2015).

Measuring the extent of the overall phenomenon and the associated costs remains elusive. Notwithstanding, a 2009 study conducted by the OECD has estimated that approximately 56 billion euro are lost annually (80 million euro per day) to fraud and corruption in healthcare within the EU (EC, 2011). Italy is no exception. Based on Button and Leys (2013)[3], Sagato et al. (2013) estimate in around 6 billion euros a year the value of the resources taken away from healthcare due to corruption. By adding to this the cost of inefficiencies and waste resulting from corrupt practices, the value reaches 23.6 billion (Forresu, 2014).

It is widely agreed that corruption is endemic in the public procurement for health goods and services, particularly pharmaceuticals and medical devices (Cohen, 2006 and Cohen et al., 2007; Rose-Ackerman and Tan, 2014)[4]. Indeed, in both the latter markets highly sophisticated and lucrative goods are traded that are often patent protected. These characteristics prevent open and effectively competitive tenders and make the stake high. The problem is particularly relevant in Italy where spending for the purchase of goods and services in the health sector represents the second expenditure voice after that on employees, ammounting to more than 35 billion euros in 2012 (MEF, 2012).

Proposed strategies to tackle corruption in health procurement are not different from those suggested for procurement in general and mainly look at the bidding phase. They include, among other things, promoting transparency in the procurement process by publishing the lists of supplies offered in tenders, establishing lists of reliable and

well-performing suppliers, offering clear documentation and public access to bidding results, using an electronic bidding systems, involving civil society at all stages of the process (Vian, 2008). However, a recent study by the European Commission (2013) emphasizes how procurement corruption in medical devices and pharmaceuticals mostly occurs in the pre-bidding phase, by tailoring the tendering specification to one preferred supplier (i.e. developing tailored terms of reference). On the contrary, corruption practices in the bidding and post-bidding phases are less likely.

Notwithstanding the importance of the issue, international empirical evidence on the role played by corruption in the health sector, in general, and in health procurement, in particular, remains very scarce. The only related paper in this regard is that by Baldi and Vannoni (2015). The authors investigate the relationship between the degree of centralization (or decentralization) in public procurement of Italian LHAs and the tender prices of selected drugs for hospital usage during the period 2009-2012. The results show that centralized and hybrid procurers are statistically associated with lower prices than decentralized ones. More importantly for this paper, corruption and istitutional quality at local level are able to shape the studied relationship: higher corruption and lower institutional quality strenghten the effects of centralization in terms of lower prices.

Strange to say, no attention in the literature has been paid to the relevance of corruption for the healthcare infrastructure provision.

An extensive literature deals with the performance of procurement as well as with the effects of corruption on procurement in general and its analysis is ouside the scope of this paper (for a review, see Finocchiaro Castro et al., 2014). Here, it is worth noting that the performance of public contracts is usually affected by the institutional features of procurement[5], as well as by corruption opportunities, which are widespread in procurement activities (Estache and Trujillo, 2009).

The risk of corruption can occur on the various phases of the public procurement cycle (Transparency International, 2006a) generating different problems. The existing literature on this topic reports a negative relationship between infrastructures provision and corruption mainly looking at the procedures for the contractor selection and at the specification of the contract (Benitez et al., 2010). Bandiera et al. (2009) detect corruption in public procurement

procedures and propose a distinction between active waste - which provides utility for the public decision-maker, such as corruption - and passive waste – which does not generate such an utility[6]. Guccio et al. (2012a) report that 'environmental' corruption, as measured by Golden and Picci (2005) index, is associated to higher adaptation costs. Finally, Finocchiaro Castro et al. (2014) investigate the relationship between the efficiency in the execution of public works contracts and the level of 'environmental' corruption at the provincial level in Italy, finding that greater 'environmental' corruption is significantly associated with lower efficiency in the execution of the public contract.

Building on the above literature, we try to assess whether 'environmental' corruption affects the performance of the contracts for healthcare infrastructures, paying special attention to the characteristics of the contracting authority.

A PICTURE OF PUBLIC WORKS IN THE ITALIAN HEALTHCARE SECTOR

Table 1 shows that in Italy during the period 2000-2005, 3,788 public contracts for healthcare infrastructures above 150,000 euros were awarded (3,73 % of the total number of public works contracts awarded in the same period), amounting to about 5,044 millions of euros (5.33 % of the total amount of public works). These figures can be considered a proxy for the overall public demand for healthcare infrastructures[7]. The geographical distribution of the contracts is rather uneven: 66.29% are located in the North while only 20.86% and 12.86% are located in the Centre and in the South, respectively.[8]

On average, the size of these works, as represented by the reserve price, is rather large (1,331.62 thousand euros), well beyond the average size of total public works (931.71 thousand euros). In particular, those located in the South exhibit a larger average amount (1,618.87 thousand euros) than the others.

It is worth noting that in the healthcare infrastructure field, as Table 1 shows, 3,148 contracts (83.10% of the total contracts) are awarded by highly specialized entities, such as LHAs and HTs. As it was outlined before, these public entities operate at regional level and are responsible to provide healthcare services; they enjoy great decision-making and financial powers. From such a perspective, they are rather unique in the Italian public sector. Whether and to what extent this high degree of managerial/financial autonomy is capable

to make a difference in the execution of contracts for healthcare infrastructures is one of our research questions. Unlike other sectors, municipalities do not play a major role, awarding only the 11.35% of the overall contracts. It is also important to outline that LHAs and HTs award contract on average of larger amount 1,353.70 than municipalities.

TABLE 1
Public works awarded in the healthcare sector in the period 2000-2005

Sectors	Number of public works	Total amount	Average amount
Total public works awarded in all sectors	101,589	94,651,035	931.71
Public works awarded in the healthcare sector	3,788	5,044,194	1,331.62
North	*2,511*	3,135,294	1,248.62
Centre	*790*	1,120,512	1,418.37
South	*487*	788,389	1,618.87
By type of contracting authorities			
Awarded by LHAs and HTs	3,148	4,261,440	1,353.70
North	*2,118*	*2,755,980*	*1,301.22*
Centre	*644*	*999,308*	*1,551.72*
South	*386*	*506,151*	*1,311.27*
Awarded by municipalities	430	269,004	625.59
North	*269*	*171,134*	*636.19*
Centre	*93*	*46,096*	*495.66*
South	*68*	*51,773*	*761.37*
Awarded by other public subjects	210	513,751	2,446.43
North	*124*	*208,179*	*1,678.86*
Centre	*53*	*75,108*	*1,417.13*
South	*33*	*230,464*	*6,983.77*

Source: our elaboration on data provided by Autorità per la Vigilanza sui Contratti Pubblici di Lavori, Servizi e Forniture (AVCP).

Note: monetary values in thousand euros at current prices.

METHODS AND DATA

Methods

Cost overruns and delays are generally considered to affect the execution of public works contracts in the majority of countries (Alexeeva et al., 2008; Bajari et al. 2009; Estache et al., 2009; Flyvberg, 2005; Iimi, 2009). This is also the case of Italy. Guccio et al. (2012a) report that in the period 2000-2005 only 29.35% of public works were completed without cost overruns and only 23.60% did not experience any delay; moreover, 24.90% of contracts experienced cost overruns above 10.00% of the original cost and 64.66% of contracts were completed with a delay longer than 20.00% of the contractual length.

In the literature special attention has been devoted to the additional costs incurred by contracting authorities above those agreed in the contract. Several drivers of extra-costs have been identified[9], which relate to the unavoidable uncertainty associated with the complexity of works, to the so-called 'optimism bias' (Flyvbjerg, 2005), or to the firms' opportunistic behaviour deriving by the incompleteness of the contract (Bajari et al., 2009; Estache et al., 2009)[10] Corruption may also influence costs overruns (Guasch, 2004), though it is not easy to disentangle the role played by inefficiency and corruption in explaining extra-costs (Bandiera et al., 2009).

Among the possible solutions to cost overruns that are likely to reduce the scope of renegotiation is the reliance on more informative negotiated procedures (Bajari et al., 2009) as well as on selection criteria based the bidders' reputation (Doni, 2006; Albano and Cesi, 2008).

Delays refer to the excess time of completion of works with respect to the length agreed on in the contract. Different factors may give rise to time overruns. Delays and cost overruns are sometimes (but not always) closely correlated[11]. This happens when the delay is determined by problems occurred during the realization of the original project, thus requiring its revision. Delays may, however, generate social welfare losses other than the costs incurred by the contracting authorities (Lewis and Bajari, 2011), which are expected to be particularly relevant in the health sector.

In most empirical investigations the efficiency of execution of public works contracts is defined in terms of either cost or time overruns. However, considering separately the two phenomena does not allow evaluating the performance of the procurer in carrying out the contract (Guccio et al., 2012b and 2014). In this respect, the best way to measure the relative efficiency of contracting authorities with regard to their capacity of achieving both the targeted results of time and costs, as determined in the contract, remains that of benchmarking their performance. In other words, for the given targets of time and costs, best performers should be considered those that minimize the actual time and costs.

A well establish and useful methodology for benchmarking performance is Data Envelopment Analysis (DEA), a nonparametric technique generally used to estimate a production function, which is capable to handle multiple inputs and outputs without requiring *a priori* assumptions of a specific functional form on production technologies and relative weighting scheme. Using linear programming techniques, DEA calculates the efficiency frontier for a set of Decision-Making Units (DMUs), as well as the distance to the frontier for each unit. It identifies as productive benchmarks those DMUs that exhibit the lowest technical coefficients, which is the lowest input amount to produce one unit of output. In doing so, DEA allows for the identification of best practices and for the comparison of each DMU with the best possible performance among the peers, rather than just with the average. Following previous literature (Guccio et al., 2012b), in this study, we have opted for an input-oriented DEA model. As an example, consider n DMUs to be evaluated; a DEA input-oriented efficiency score θ_i is calculated for each DMU solving the following program, for $i=1,\ldots, n,$ in the case of constant returns to scale (CRS):

$$\begin{aligned} &\text{Min}_{\lambda,\theta_i} \quad \theta_i \\ &\text{subject to} \quad Y\lambda - y_i \geq 0 \\ &\qquad\qquad \theta_i x_i - X\lambda \geq 0 \\ &\qquad\qquad \lambda \geq 0 \end{aligned} \qquad [1]$$

where x_i and y_i are, respectively, the input and output of *i-th* DMU; X is the matrix of inputs and Y is the matrix of outputs of the sample; λ is a $n\times 1$ vector of variables. The model [1] can be

modified to account for variable returns to scale (VRS) by adding the convexity constraint: $e\lambda=1$, where e is a row vector with all elements unity, which allows to distinguish between Technical Efficiency (TE) and Scale Efficiency (SE) (Banker et al. 1984). More recently, to account for DEA traditional limitations, which do not allow for any statistical inference and measurement error, Simar and Wilson (1998, 2000) introduced a bootstrapping methodology to determine the statistical properties of DEA estimators.[12]

In such a framework, the expected cost (i.e. the winning bid) and the expected duration (as agreed in the contract) are used as outputs, while the final cost and the actual duration of the work are considered as inputs. To evaluate the efficiency of execution, the benchmark is the actual best behaviour in terms of time completion of works of a given price size (and *vice versa*). The distance (efficiency score) between the observed public work contract and the most efficient public work contract provides a measure of the radial reduction in inputs that could be achieved for a given measure of output.

As a further step of our analysis, we investigate the impact of environmental variables (or non-discretionary inputs) on technical efficiency of contracts for healthcare infrastructures. To this purpose, we perform a second-stage analysis, running a regression with the efficiency scores as dependent variable and the environmental variables as the independent ones. We assume that the efficiency scores can be regressed – in a cross-section framework – on a vector of environmental variables along the following general specification:

$$\theta_i = f(z_i)+\varepsilon_i \qquad [2]$$

where θ_i represents the efficient score that resulted from previous stage, z_i is a set of possible non-discretionary inputs and ε_i is a vector of error terms.

To estimate [2], Simar and Wilson (2007) underline that traditional estimators yield to biased estimates due to serial correlation of efficiency scores. Therefore, they suggest applying a two-step bias-corrected semi-parametric estimator that has been successively shown by them to be the only known method for ensuring a feasible and consistent inference on the second stage regression (Simar and Wilson 2011).

Data

Our analysis is based on data provided by the Italian Authority of Public Contracts (*Autorità per la Vigilanza sui Contratti Pubblici di Lavori, Servizi e Forniture*; hereafter, AVCP) on Italian public works.

The sample employed in the empirical analysis refers to 405 contracts for the realization of healthcare infrastructures, whose reserve price is below five million euros, awarded in the period 2000-2004 and concluded by the year 2005[13]. Table 2 shows the composition of our sample.

TABLE 2
Descriptive statistics of the sample

By Contracting authorities and geographical area				
Number of public works		Total amount	Mean	St. Dev
All sample	405	176,430	435,63	422,30
LHAs and HTs	327	140,486	429,62	395,99
North	176	81,507	463,11	409,21
Centre	136	53,629	394,33	390,45
South	15	5,350	356,66	237,19
Municipalities	58	27,691	477,43	558,19
North	30	17,481	582,72	718,22
Centre	19	6,322	332,78	268,68
South	9	3,886	431,86	306,58
Other public subjects	20	8,253	412,65	70,57
North	*8*	2,570	321,21	161,09
Centre	*11*	5,371	488,29	97,95
South	*1*	312	312,16	-
By main public work categories				
OG1	250	117,522	470,09	472,84
OG11	51	20,957	410,93	342,16
OS30	24	7,345	306,06	156,36
OS28	20	5,880	294,01	124,69

Source: our elaboration on data provided by Autorità per la Vigilanza sui Contratti Pubblici di Lavori, Servizi e Forniture (AVCP).

Note: monetary values in thousand euros at current prices.

The four prevalent categories in which the largest share of the contracts for healthcare infrastructures falls are: category OG1 *Industrial and civil buildings*; category OG11 *Technological plants*; category OS28 *Heating and air conditioning plants*; category OS30 *Internal electrical, telephone, radio and television*.

For the purpose of this study, we consider each contract for healthcare infrastructure as a separate DMU with its own input and output values. Summary statistics of inputs and outputs are provided in Table 3.

TABLE 3

Descriptive statistics of the variables employed in the first stage

Variable	Number of obs.	Mean (St. Dev.)
INPUT		
Actual time of infrastructure completion (days)	405	331.39 (224.61)
Actual cost of infrastructure completion	405	452.72 (533.73)
OUTPUT		
Expected duration (days)	405	255.68 (170.85)
Value of winning bid	405	381.42(373.04)

Source: our elaboration on data provided by Autorità per la Vigilanza sui Contratti Pubblici di Lavori, Servizi e Forniture (AVCP).

Note: monetary values in thousand euros at current prices. Standard deviations in parenthesis.

RESULTS AND DISCUSSION

Given the nature and the limits of our data sample, in this Section we try to explore our research questions in several steps. First, in line with Guccio et al. (2012b) and Finocchiaro Castro et al., (2014), we assess the efficiency of different procurers in our sample using bootstrap based DEA estimator (Simar and Wilson, 2000). Then, we evaluate the role of institutional characteristics of procurer and the effects of environmental factors (i.e. level of corruption in the area in

which the infrastructure is constructed) by employing both nonparametric tests and semiparametric bootstrapped regression proposed by Simar and Wilson (2007).

Efficiency Estimates

In this Section we discuss DEA efficiency estimates in our sample. Table 4 reports the average efficiency scores under both CRS and VRS assumptions, by type of procurer. To assess the scale assumption, we performed the Banker (1996) test and the results show that we cannot reject the null hypothesis of CRS at any conventional level of significance. Thus, in what follows, we assume CRS to assess the performance of different procures in the provision of healthcare infrastructures. However, for sake of completeness, in this section the statistics of DEA efficiency estimates under VRS assumption are also reported.

In Table 4, we also show the bias correction in the efficiency estimates using the correction proposed in Simar and Wilson, (2000).

TABLE 4
Descriptive statistics of DEA efficiency estimates by type of procurers

Procurers	obs.	CRS	CRS Bias corrected	VRS	VRS Bias corrected
LHAs and HTs	327	0.8271	0.8129	0.8445	0.8296
Municipalities.	58	0.8638	0.8490	0.8740	0.8586
Others	20	0.8516	0.8367	0.8701	0.8574
All sample	**405**	**0.8336**	**0.8192**	**0.8499**	**0.8351**

Source: our elaboration on data provided by Autorità per la Vigilanza sui Contratti Pubblici di Lavori, Servizi e Forniture (AVCP).

Overall, the Table shows a relatively high average performance of procurers in the sample. Indeed, the average overall efficiency score under CRS is 83.36%, indicating a 16.64% average potential reduction in inputs. However, these relatively high efficiency scores do not imply that public contracts for healthcare infrastructures in Italy are overall executed in an efficient way.

Overall, the differences in the mean efficiency scores across the different type of procurers are not large. However, LHAs and HTs are slightly less efficient that other procurers under both assumptions on returns to scale.

To assess the waste effects of 'environmental' corruption on the execution of the contract in the area where the infrastructure is localised, we provide here some preliminary findings based on the descriptive statistics of the efficiency in the sample. Specifically, Table 5 reports mean efficiency of bias corrected DEA scores for different average levels of provincial corruption using the corruption index proposed by Golden and Picci (2005). According to the sampling distribution of the provincial corruption index, three different levels of the corruption are computed (high, middle and low level). Table 5 show that under both hypotheses of CRS and VRS, the mean efficiency of bias corrected DEA scores increases as the level of 'environmental' corruption becomes lower and *vice versa*.

TABLE 5
Conditional distribution of efficiency estimates by 'environmental' corruption level in the area

Level of environmental corruption		Bias corrected efficiency scores			
		CRS		*VRS*	
		Mean	St. Dev.	Mean	St. Dev.
Provincial corruption	*High*	0.8099	0.0117	0.8245	0.0120
	Middle	0.8139	0.0110	0.8310	0.0102
	Low	0.8326	0.0093	0.8484	0.0095
All sample		0.8192	0.0062	0.8351	0.0061

Source: our elaboration on data provided by Autorità per la Vigilanza sui Contratti Pubblici di Lavori, Servizi e Forniture (AVCP) and Golden and Picci (2005).

To further assess the role of environmental corruption in the performance, in Table 6 we reports mean efficiency of bias corrected DEA CRS scores for the above three different average levels of

provincial corruption only with regard to the subsample of 327 infrastructure managed by LHAs and HTs. Again, 'environmental' corruption appears relevant for the performance of these contracts: in fact, lower efficiency scores are related to higher level of 'environmental' corruption and *vice versa*

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TABLE 6
Subsample of infrastructure managed by LHAs and HTs

Level of environmental corruption		Bias corrected efficiency scores			
		CRS		*VRS*	
		Mean	St. Dev.	Mean	St. Dev.
Provincial corruption	*High*	0.8011	0.0142	0.8168	0.0145
	Middle	0.8097	0.0122	0.8279	0.0112
	Low	0.8269	0.0116	0.8429	0.0118
All subsample		0.8129	0.0073	0.8296	0.0072

Source: our elaboration on data provided by Autorità per la Vigilanza sui Contratti Pubblici di Lavori, Servizi e Forniture (AVCP) and Golden and Picci (2005).

Next, we test the equality of the distributions of the DEA CRS efficiency scores for the three different levels of 'environmental' corruption and the different groups of procurers. Table 7 presents the results of the Mann–Whitney and the Kolmogorov–Smirnov tests, for both the full sample and the subsample of public works managed by LHAs and HTs, and by level of 'environmental corruption and type of procurer.

As for the full sample, from Table 7 there is some evidence of significant differences in mean efficiency scores between procurers operating in different environments according to the level of corruption. In fact, in both statistical tests, the null hypothesis that the two samples are drawn from the same distributions can be rejected at 10% level of significance. Furthermore, public works managed by LHAs and HTs show statistically significant lower average levels of efficiency than those managed by other procurers (the null hypothesis is rejected at 5% level of significance, in both tests). As for

the subsample of public work managed by LHAs and HTs, results from Table 7 confirm that 'environmental' corruption is relevant for explaining the performance of contracts for healthcare infrastructures (the null hypothesis is rejected at 5% level of significance, in both tests).

TABLE 7
Equality distribution of efficiency estimates under CRS by level of environmental corruption and type of procurer

Sample	statistics.	p-value
Full sample		
High level of environmental corruption vs. middle and low levels		
Mann–Whitney	- 1.899	(0.058)
Kolmogorov–Smirnov	0.129	(0.075)
LHAs and HTs vs. municipalities and other procurers		
Mann–Whitney	- 2.393	(0.017)
Kolmogorov–Smirnov	0.182	(0.022)
Subsample of public work managed by LHAs and HTs		
High level of environmental corruption vs. middle and low levels		
Mann–Whitney	- 2.132	(0.033)
Kolmogorov–Smirnov	0.187	(0.046)

Source: our elaboration on data provided by Autorità per la Vigilanza sui Contratti Pubblici di Lavori, Servizi e Forniture (AVCP) and Golden and Picci (2005).

Assessing the Nature of Procurers and Environmental Factors in Efficient Provision of Healthcare Infrastructures

The application of DEA has shown the existence of some noteworthy differences across the different types of procurers and has outlined the relevance of 'environmental' corruption to the performance of healthcare infrastructures' execution.

To further investigate both these issues, following the approach suggested by Coelli et al. (1998), we use a second-stage analysis so

as to regress the DEA scores on a set of environmental factors affecting the efficient execution of contracts for healthcare infrastructures. Specifically, in line with previous studies (Finocchiaro Castro et al., 2014), as a measure of corruption at provincial level, we employ the index of corruption (CORR_G&P) proposed by Golden and Picci (2005). Due to the results of the previous statistical tests, we expect a negative sign for this variable.

To test for the impact of the procurer's characteristics on efficiency, we, then, use one variable LHA&HT, capturing the identity of the contracting authority (1 for the category LHAs and HTs and 0 for the other procurers). The DEA scores presented in the previous section show that LHAs and HTs are, on average, less efficient than other contracting authorities. This is rather counterintuitive, since, in principle, we would expect that the high degree of autonomy and responsibility would call for an efficient behaviour. However, the great 'power' enjoyed by managers of LHAs and HTs, if the overall institutional and social context does not provide effective monitoring, might induce managers to behave opportunistically. Moreover, these contracting authorities are specialised in specific procurement, such as medical devices, pharmaceutical supplies – which are closely related to their 'core' mission – but not necessarily in infrastructures.

Consistently with previous literature (Finocchiaro Castro et al., 2014), we also control for other factors that may affect the performance in the execution of public works. These factors are related to the procurement procedure used to select the contractor (whether it is an open auction or a restricted procedure) (OPEN), and to the degree of competition, expressed by the number of bids (BIDDERS) or by the rebate of the winning bidder (REBATE).

Finally, to control for the complexity of public works, we first distinguish between "new" works (NEW) and repair/restructuring works. We *a priori* expect that the degree of complexity and, hence, the likelihood of waste of time and costs are higher for new works than for repair/restructuring ones. As a further control for complexity, we use the classes of work values (PW_CLASS). Since complexity reduces the reliability of the project forecast of the time required to executing a work, and therefore, the higher the complexity the more likely are delays, we expect a negative impact of the variable PW_CLASS on efficiency scores.

Table 8 shows the covariates used to perform the two-stage analysis, as well as their meanings and descriptive statistics.

TABLE 8
Descriptive statistics of the variables employed in DEA two-stage analysis

Variables	Definition	Mean	St. Dev.
DEA_BC	Bias corrected DEA efficiency scores	0.8192	0.0062
CORR_G&P	Corruption index proposed by Golden and Picci (2005), at provincial level	0.9881	0.7705
LHA&HT	Dummy for *LHAs and HTs* (=1 when LHA or HT and 0 otherwise)	0.8074	0.3948
OPEN	Dummy for open procedures (=1 when open and 0 otherwise)	0.8296	0.3764
BIDDERS	Number of bidders	13.7717	16.9862
REBATE	Rebate of the winning bid	0.1214	0.0731
NEW_PW	Dummy for type of infrastructure work (new/repair) (=1 when public work is new and 0 otherwise)	0.2123	0.4095
PW_CLASS_1	Dummies for the class of reserve price (= 1 when reserve price is between 150,000 - 500,000 euro and 0 otherwise)	0.7679	0.4227
PW_CLASS_2	Dummies for the class of reserve price (= 1 when reserve price is between 500,000 - 1,500,000 euro and 0 otherwise)	0.1605	0.3675
PW_CLASS_3	Dummies for the class of reserve price (= 1 when reserve price is between 1,500,000 - 5,000,000 euro and 0 otherwise)	0.0716	0.2582

Source: our elaboration on data provided by Autorità per la Vigilanza sui Contratti Pubblici di Lavori, Servizi e Forniture (AVCP).

Table 9 provides the regression results obtained following the methodology suggested by Simar and Wilson (2007). In particular, Column 1 shows the estimates for the effects of the index of corruption at provincial level, in absence of other covariates. The

coefficient of the variable CORR_G&P is highly significant and with the expected sign. In the next two Columns, other covariates are included to control for potential omitted factors, such as the characteristics of the procurement (i.e. selection procedure, the degree of competition and the complexity of the public work in Column 2) and the type of contracting authority (Column 3). Previous results continue to be robust and the signs of the covariates are in line with the main conclusions reached in the literature, though most of them are not significant at any statistical level. More important for the purpose of this study, the variable LHA&HT is statistically significant (at 5% level) and negative, further strengthening the conclusion that, in our sample, healthcare contracting authorities are worse performers than other types of public procurers.

To better disentangle the relationship between the type of contracting authority and the level of 'environmental' corruption, in Table 9 estimates for the interaction term between the variables CORR_G&P and LHA&HT (LHA&HT*CORR_G&P) are presented. The results from Column 4 show that the coefficient of variable CORR_G&P turns out to be negative, though not statistically significant. On the contrary, the sign of the interaction term LHA&HT*CORR_G&P is negative and significant (at 5% level). Thus, other things being equal, the effects of corruption in reducing efficiency of public procurement is not uniform across the different types of contracting authorities but is greater for healthcare procurers. This seems to suggest that, in our sample, LHAs and HTs are more at risk of 'environmental' corruption than other public non-health contracting authorities.

Finally, in the last three Columns of Table 9, we check the robustness of the latter conclusion with respect to different model specifications.

TABLE 9
Bootstrap truncated semi-parametric estimates

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Constant	0.840***	0.869***	0.897***	0.843***	0.873***	0.872***	0.846***
	(0.010)	(0.029)	(0.032)	(0.010)	(0.028)	(0.029)	(0.014)
CORR_G&P	-0.021***	-0.015**	-0.016**	-0.005		-0.003	
	(0.007)	(0.007)	(0.007)	(0.011)		(0.011)	
LHA&HT			-0.033**				-0.008
			(0.015)				(0.018)
CORR_G&P* LHA&HT				-0.024**	-0.024***	-0.026**	-0.026***
				(0.011)	(0.008)	(0.011)	(0.009)
OPEN		-0.014	-0.018		-0.014	-0.017	
		(0.017)	(0.017)		(0.017)	(0.017)	
BIDDERS		-0.000	-0.000		-0.000	-0.000	
		(0.000)	(0.000)		(0.000)	(0.000)	
REBATE		-0.201**	-0.191**		-0.201**	-0.200**	
		(0.095)	(0.094)		(0.093)	(0.094)	
NEW_PW		0.020	0.017		0.018	0.018	
		(0.015)	(0.015)		(0.015)	(0.015)	
PW_CLASS_1		0.004	0.007		0.010	0.008	
		(0.024)	(0.024)		(0.024)	(0.024)	
PW_CLASS_2		-0.011	-0.006		-0.003	-0.003	
		(0.027)	(0.027)		(0.027)	(0.027)	
Observations	405	405	405	405	405	405	405

Source: our elaboration on data provided by Autorità per la Vigilanza sui Contratti Pubblici di Lavori, Servizi e Forniture (AVCP).

Note: error terms in parentheses , *** p<0.01, ** p<0.05, * p<0.1.

CONCLUDING REMARKS

In this paper, we have investigated the performance of the contracts for healthcare infrastructures, measured in terms of costs and time overruns, to assess whether it is affected by the type of procurer as well as by 'environmental corruption. So far, this topic has not been explored in the literature and, therefore, our analysis provides new results. In particular, we are able to assess that healthcare contracting authorities are less efficient than other public bodies as procurers and that the performance of the healthcare infrastructures is heavily affected by 'environmental' corruption. Our analysis, therefore, offers support to the hypothesis that the healthcare sector is particularly at risk of corruption, enlarging the analysis to the infrastructure field.

In terms of policy implications, the above results might suggest that efficiency in procurement requires 'qualified' contracting authorities since not all the public bodies might have the necessary expertise to carry on public contracts efficiently. It is worth noting that the recent evolution of the Italian procurement regulation, toward the concentration of procurement activities in few specialized procurers, seems to go to the right direction.

NOTES

[1] According to the WHO Global Health Expenditure Database, in 2012 global spending on health was about $7.2 trillion.

[2] According to a recent study by the European Commission (2013), six typologies of corruption may be identified in the health care sector: bribery in medical service delivery; procurement corruption; improper marketing relations; misuse of (high) level positions; undue reimbursement claims; fraud and embezzlement of medicines and medical devices.

[3] The authors have estimated an average corruption rate in the health system equal to 5.59%, with a range between 3.29% and 10%.

[4] According to a recent study commissioned by the European Commission's Anti-fraud Office (PWC, 2013) the probability of

corruption in the purchase of devices for mechanical, radiological, electrical and physical therapy amounts to 11-14%.

[5] Bajari and Tadelis (2001) outline the relevance of the procedures for selecting the private contractor, the specification of the contract and the enforcement of the contract.

[6] They analyse the procurement of standardized goods by Italian public bodies and find that some public bodies pay more than others for equivalent goods and that passive waste accounts for 83% of total estimated waste.

[7] The overall demand for healthcare infrastructures might be underestimated for two reasons: i) the figures refer only to the tenders for which the winner has been chosen since the (higher) number of the tenders issued is not available; ii) the figures depend on the data communicated to the Authority by each contracting authority but some of them might have not fulfilled their obligation.

[8] These differences do not represent different population sizes: in fact, 45.72% of Italian population leaves in the North; 19.90% leaves in th Centre and 34.37% lives in the South.

[9] For a detail review of this literature see Guccio et al., 2014.

[10] The extent of such an opportunistic behaviour depends on the incentives involved by the type of contract (whether fixed price or cost plus contracts) as well as by the selection procedure (whether open or negotiated procedures).

[11] Decarolis and Palumbo (2015) find that the association between cost overruns and delays is quite weak: their linear correlation is only 4.5% and no evidence exists of a nonlinear relationship.

[12] The rationale behind bootstrapping is to mimic a true sampling distribution by simulating its Data Generating Process (DGP), which in this paper are the outputs from DEA estimates (Simar and Wilson 2008). Specifically, the procedure relies on constructing a pseudo-data set and re-estimating the DEA model with this new data set. Repeating the process many times allows to achieve a good approximation of the true distribution of the sampling. However, some major issues remain unresolved regarding the use of asymptotic results and bootstrap; first, the high sensitivity of non-

parametric approaches to extreme value and outliers and, second, the way to allow stochastic noises in a non-parametric frontiers (Simar and Wilson 2008).

[13] The conclusion of each work is officially certified by the procurer. Confronting the above data with those reported in Table 1 and referring to all awarded contracts we can notice that: i) the average size is lower, probably because the larger and more complex works are likely to require more time for completion; ii) LHAs and HTs are still the largest procurers, accounting for about 81% of all completed contracts; iii) the geographical distribution is less uneven, since completed contracts in the North account for about 53%.

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