

# Is competition able to mitigate the waste effects of corruption on public work contracts?

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## Abstract

The aim of this paper is to provide an empirical test of the impact of competition in procurement to reduce the effects of 'environmental' corruption. For this purpose, the paper examines whether competition is able to constrain the waste effects of corruption in the area where the public work is localised. We evaluate the effects of corruption on infrastructure provision assessing whether more competition matters in constraining 'environmental' corruption by using different bootstrap robust non-parametric frontier estimators. Our results, in line with previous literature show that greater corruption, in the area where the infrastructure is localised, is associated with lower efficiency in public contracts execution; moreover, we also show that increasing competition does not mitigate the negative effects of 'environmental' corruption on public works executions. Our empirical findings are robust to alternative estimators and for different measure of corruption and competition.

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## 1. Introduction

The efficient provision of public infrastructure is crucial for economic growth (Estache and Fay, 2010; Straub, 2011) and, in this perspective, a relevant role is played by the efficiency of procurement procedures. Indeed, though it is widely agreed that public procurement should aim at obtaining ‘value for money’, this is not always the case. On the contrary, the extensive literature in the field (Arvan and Leite, 1990; Flyvbjerg and Skamris 1997, Flyvbjerg et al., 2002; Odeck, 2004; Guccio et al., 2012b) outlines that costs overruns and delays usually characterize the performance of public works provision, both in developed and developing countries. At the same time, the efficiency of public contracts is also negatively affected by corruption opportunities, which are widespread in procurement activities (Estache and Trujillo, 2009) as it is also stressed by many international agencies (Transparency International, 2006, p. 15), and competition is usually advocated as a tool to prevent corruption. The aim of this paper is to provide an empirical test of the impact of competition in procurement to constrain ‘environmental’ corruption. For this purpose, the paper examines whether competition is able to reduce the waste effects of corruption in the area where the infrastructure is localised.

For this purpose, a two-stage analysis is carried out. In the first stage, with a non-parametric approach (Data Envelopment Analysis – DEA and Free Disposal Hull - FDH) we investigate the relative efficiency scored by each public work contract. In the second stage, the determinant factors of the variability of efficiency scores are investigated, focusing on the effects exerted by ‘environmental’ corruption as well as by competition and other controls. Special attention will be paid to the interaction between competition and corruption to assess whether the former, as it is usually claimed, is, indeed, an effective tool to overcome the negative effects of corruption.

This analysis relies on two large microeconomic databases on Italian public works contracts in the period 2000-2005 and on the firms, which are qualified to enter such a market. Unlike previous empirical studies on the efficient management of public works, which rely on aggregate data (Golden and Picci, 2006), we use microeconomic data to examine whether the ‘environmental’ characteristics (*i.e.*, in particular the corruption level) affect the performance of public works contracts. Moreover, instead of using subjective corruption indexes we use two objective

measures of corruption at provincial level: the number of crimes against public administration and the measure of corruption in Italy's provinces proposed by Golden and Picci (2005), obtained by comparing the value of existing infrastructure stocks to past spending for infrastructure.

Our study relates to a growing literature on the role of competition and corruption on infrastructure provision reviewed in the next Section. For its aim, it is close to Finocchiaro Castro et al. (2014). With respect to Finocchiaro Castro et al., (2014) we expand the analysis by providing an in deep analysis of competition. We, moreover, provide additional robustness checks by using and comparing different non-parametric estimators.

Our results confirm Finocchiaro Castro et al., (2014) findings that greater 'environmental' corruption, in the area where the infrastructure is localised, is associated with lower efficiency in public contracts execution; moreover, we also find that increasing competition does not mitigate these negative effects of corruption.

The analysis develops as follows: we discuss the relevant literature and briefly sketch the Italian system of public works procurement, respectively, in Sections 2, and 3. Then in Section 4, we describe the methodological issues underlying the empirical analysis. Section 5 presents the data and the results of the empirical analysis, and Section 6 offers some concluding remarks.

## **2. Literature review**

### ***2.1 The effects of corruption: "sand vs. grease the wheels" hypotheses***

When reviewing the literature on the effects of corruption on the economic and institutional systems, two different views stem out that can be summarised by the expression "sand vs. grease the wheels" hypotheses.

Both international organisations (IMF, OECD, and World Bank) and the empirical literature support the opinion that corruption exerts negative effects on economic growth. Thus, several works have tested for the "sand the wheels" hypothesis, showing negative correlation between corruption and economic development. This is particularly relevant in countries with weak institutional contexts. For instance,

Myrdal (1968) and Kurer (1993) show that bureaucrats may slow down the provision of public goods to make subjects offering bribes to speed up the procedures. In the case of new licence assignment, Rose-Ackerman (1997) reports that corrupt behaviour may lower the probability that the winner is the most efficient competitor. Also corruption is found to affect negatively the efficiency of public investment, being diverted towards unproductive sectors (Mauro, 1995; Mo, 2001) and the accountability of institutions (Hunt, 2005; Hunt and Laszlo, 2005). Notwithstanding the impact of corruption on investments, it imposes a negative weight on economic growth (Méon and Sekkat, 2005). Finally, when the political and institutional contexts appear uncertain, corruption may be seen as an insurance against risks, although it is an illegal agreement very difficult to secure. Thus, the uncertainty due to corrupt acts may just add to that caused by political instability enhancing its negative effect on the efficiency of the economic system (Bardhan, 1997; Lambsdorff, 2003).

By contrary, some scholars supported the positive role of corruption on speeding up development. In details, corruption represents an efficient way to decrease the time wasted dealing with bureaucrats (Leff, 1964; Leys, 1965; Lui, 1985). Also corruption seems to be able to offset the inefficiency of regulations or bad public policies (Bailey, 1996). Recently, the above-mentioned competing hypotheses on the role of corruption have been tested finding evidence in favour of its positive effects, especially when the institutional context is weak (Méon and Sekkat, 2010)<sup>1</sup>.

Summing up, it is important to put forward that both hypotheses state that corruption negatively affect economic performance when the institutional framework is efficient. They differ only in the case of inefficient institutional framework suggesting negative (sand) versus positive (grease) effects of corruption on efficiency.

## ***2.2 Efficiency, environmental corruption and competition in public procurement***

The previous section has reported two possible effects exerted by corruption on economic systems. Here we discuss, first, the results coming from empirical studies

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<sup>1</sup> Méndez and Sepúlveda (2006) examine country-level evidence by using different proxies for corruption, as well as the Freedom House index of political freedom as a proxy for overall institutional quality. They find that the relationship between corruption and growth is non-monotonic with corruption having negative effects only at high levels of incidence.

focusing on the relationship between performance and ‘environmental’ corruption, and on the effects of such a corruption on the efficiency of procurement. Then, we look at the role of competition in reducing the portion of inefficiency of public procurement that can be ascribed to the level of ‘environmental’ corruption.

The vast majority of empirical studies investigating the relationship between inefficiency and ‘environmental’ corruption use aggregated data at country level, whereas there are relatively few studies adopting micro-level data to analyse the relationship between ‘environmental’ corruption and the level of performance in the provision of public goods and services. For instance, Dal Bo and Rossi (2007) study the market of electricity distribution in Latin America countries finding that when the level of ‘environmental’ corruption is high, firms tend to be more inefficient in terms of labour use. On the same vein, Abrate et al. (2014) show that ‘environmental’ corruption significantly increases inefficiency when looking at solid waste collection activities in Italian municipalities. Both studies rely on country-level measures of corruption that being subjective indices may suffer of potential distortions.<sup>2</sup> Differently, other works use objective measure of ‘environmental’ corruption together with micro-level data. Yan and Oum (2014) show that airport productivity in the U.S. is negatively affected by the corruption rate at state level. Also, Abrate et al. (2013) find that both ‘environmental’ corruption, measured by the number of criminal charges against the public institutions as well as by the Golden and Picci index (2005), and a low degree accountability of public operators negatively affect the cost efficiency of the solid waste collection and disposal activity in Italy.

More in details, an extensive literature deals with the performance of procurement as well as with the effects of corruption on procurement. The performance of public contracts is usually affected by the features of procurement procedures such as the selection of the private contractor - whether it is competitive or not - the specification of the contract - whether it is fixed price or cost plus - and the enforcement of the contract (Bajari and Tadelis, 2001). At the same time, the efficiency of public contracts is also negatively affected by corruption opportunities, which are widespread in procurement activities (Estache and Trujillo, 2009), as it is also

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<sup>2</sup> The characteristics of subjective and objectives indicators of corruption are analysed below (par. 4.2).

stressed by many international agencies (Transparency International, 2006, p. 15). The risk of corruption can occur on the various phases of the public procurement cycle, generating different problems: when the demand is assessed, when the process design and the bid documents are prepared; when the contractor is selected and the contract awarded; when the contract is implemented, and when final accounts are certified. 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 looking at the prices paid for goods and services provided by the public sector. They distinguish between the corruption (called “active waste”) and inefficiency in managing purchases (called “passive waste”) showing that the weight of passive waste is four times stronger than the one of active waste. Guccio et al. (2012a) report that high levels of corruption, as measured by Golden and Picci (2005) indicator, are associated to higher adaptation costs. Also, corruption may be a relevant variable for the decision to adopt first price sealed bid auction instead of average bid auctions in the awarding of public work contracts. On this matter, De Carolis (2014) shows no statistically significant effect of measures of Italian public administrations corruption. Whereas, Hessami (2014) provides evidence that corruption in public procurement is also a problem in OECD countries, in the waste disposal and health sector and causes a distortion in the allocation of public resources<sup>3</sup>.

Finally, Finocchiaro Castro et al., (2014) make a contribution in this area by investigating the relationship between the efficiency in the execution of public works contracts and the level of corruption at the provincial level in Italy. By using both nonparametric and parametric techniques they find that greater corruption in the area where the infrastructure is localised is significantly associated with lower efficiency in the execution of the public contract.

At the same time, it is usually agreed (Estache and Wren-Lewis, 2011) that corruption is likely to be worse without competition and this view is also underlying the existing regulation in most countries (OECD, 2005). Boehm and Oloya (2006)

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<sup>3</sup> Hessami and Uebelmesser (2016) discuss how social funds may be appropriated by politicians and bureaucrats - which can also be viewed as a type of corruption, *i.e.* corruption in public procurement is only one channel through which public resources may be inefficiently used.

discuss the role of transparency, as a tool to increase competition, on mitigating corruption in public contracting auctions in Argentina and Colombia. Using the Integrity Pact (Transparency International, 2004), they find that implementing transparent procedures helps in preventing corruption and enhances competition in school services and telecommunications sectors. Also, Amaral et al. (2009) compare the French and London auctions procedures to provide urban public transport service to understand whether increasing the level of competition for the field may or may not be an efficient way to prevent anti-competitive behaviours and corruption. They show that the London auction procedure has successfully adopted high level of transparency to make the procedure more competitive and mitigating collusion and corruption as much as possible. However, it is also recognized that competitive open procedures are not immune to corruption and/or collusion (Compte et al., 2005; Lengwiler and Wolfstetter, 2006). Celentani and Ganuza (2002) demonstrate that more competition will not automatically reduce the problem of corruption in public procurement. In addition, OECD (2005) suggests caution in assessing the overall effects of open procedures aimed at preventing corruption since transparency might increase the scope for the collusion among the bidders themselves.<sup>4</sup>

### **3. The Italian system of public works procurement**

The Italian rules on public works procurement are highly unstable and continuously changing. An exhaustive review of the Italian legislation is out of the scope of this paper and only few main points will be recalled<sup>5</sup>. Since the beginning of nineties, as a response to big scandals, a reform of public works procurement was introduced by the law n. 109/94, the so-called *legge Merloni*, “to improve the efficiency, the effectiveness, the transparency and the quality of public works” (art.1)<sup>6</sup> and

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<sup>4</sup> In a different perspective, Di Gioacchino and Franzini (2008), distinguishing two different forms of corruption, i.e. bribery and extortion, show that competition in public administration is effective in reducing extortion while enhancing bribery.

<sup>5</sup> For an analysis of Italian legislation in a comparative perspective, see AVCP (2010).

<sup>6</sup> From an economic perspective, the principles underlying such a reform are examined by La Pecorella and Rizzo (2002).

afterwards many changes have been introduced<sup>7</sup> and others are underway,<sup>8</sup> aimed at the simplification of rules, the reduction of the number of contracting authorities as well as the reform of the qualification system.

The supervision of public works procurement - successively, extended to supplies and services – has been initially assigned to an independent Authority (AVCP – *Autorità per la vigilanza sui contratti pubblici*)<sup>9</sup>. In response to the principles of EU Directives, Italian legislation promotes a fairly rigid, uniform and transparent platform for public spending where the discretion of procurement officers is reduced as much as possible (Rizzo, 2013). A major role is assigned to competition, as a tool to select the most convenient bidder, on the assumption that this will also minimize the costs for the contracting authority and ensure integrity. Open and restricted procedures are the rule and negotiated procedures can be adopted only in well-defined circumstances. Auctions are mainly based on price<sup>10</sup> but it is possible to adopt multiple criteria through a scoring rule. To avoid the opportunistic behaviour of private contractors the preferred tools are fixed-price contracts with major limitations on the renegotiation of the contract<sup>11</sup>.

To access the public works market private contractors must be qualified on the grounds of legal, technical, economic and financial requirements.<sup>12</sup>

Great attention is devoted to procurement integrity. The new legislation aimed at preventing corruption and improving transparency<sup>13</sup> in public administration,

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<sup>7</sup> *Merloni-bis* in 1995, *Merloni-ter* in 1998, and *Merloni-quater* in 2002). Other changes have been introduced by the *Code of public contracts for works, services and supplies* (Legislative Decree n. 163/2006),

<sup>8</sup> The *Code of public contracts for works, services and supplies* is under revision to transpose the new EU Directives on ordinary public procurement (*PE-COS 74/13 and 5862/14 ADD 1*) and on procurement by entities operating in the utilities sectors (*PE-COS 75/13*).

<sup>9</sup> The former denomination was Authority for the Supervision of Public Works - *Autorità per la vigilanza sui lavori pubblici* – AVLP.

<sup>10</sup> After the 2006 reform, the use of first price format, for contracts below the EU threshold with respect to the average bid format, was expanded but afterwards, in 2011, such a tendency has been reversed. Bidder selection procedures are investigated by De Carolis (2009).

<sup>11</sup> Renegotiation is allowed only under circumstances, which are strictly specified by the law and monitoring procedures have been tightened through time (law n. 114/2014).

<sup>12</sup> Qualification is carried out by private companies with public functions, *Società organismi di attestazione* – SOA, operating under the Authority's supervision. This system is under revision (see above, note 6)

<sup>13</sup> Law no. 190/2012 aims at preventing corruption, under the supervision of the National Anticorruption Authority (ANAC). Major tools are: transparency, staff training, codes of conduct and



identifies procurement as one of the public activities with high risk of corruption. Afterwards, as a response to new relevant scandals which have shaken public opinion, the monitoring of procurement has been tightened: among the changes introduced by law 114/2014, it is worth noting that the Authority for the Supervision of Public Contracts (AVCP) has been abolished and its functions have been transferred to the National Anticorruption Authority (ANAC).

Looking at the whole picture, the regulatory scheme raises many doubts. Overall, the complexity and the instability of the legislative framework is likely to create obstacles to the already difficult implementation of efficiency (Rizzo, 2013). Thus, there is increasing attention paid to the assessment of integrity of procurement rather than to address its efficiency, notwithstanding the close link between these two dimensions of performance.<sup>14</sup>

## **4. Methods**

### ***4.1 The measurement of efficiency in public works contracts execution***

#### *4.1.1 Cost overruns and delays in public work procurement*

By and large, the efficient management of public works contracts can be measured alongside different aspects related to both the output/outcome of the work (*e.g.*, the quality of the work, its capability of satisfying the objectives and the needs for which it has been carried out, *etc.*) and the process of the execution of the contract, which is instrumental to the realisation of the output/outcome. We will focus on the latter issue. We do not investigate how resources are allocated and whether such a decision is efficient or not, *e.g.* whether the infrastructure which maximizes social welfare is chosen and the best project is selected, though we are aware that the efficiency in the allocation of resources cannot be taken for granted (Benitez et al. 2010). As said before, we concentrate on the execution phase but it is important to outline, however, that the quality of allocation decisions may affect the performance of execution process itself.

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risk analysis. Transparency obligations are further detailed in the *Code of transparency* (legislative decree n. 33/2013).

<sup>14</sup> The National Anticorruption Plan requires that the planning instruments related to performance, transparency and anti-corruption are to be integrated within each public administration (ANAC, 2013a).

The performance of execution of public works contracts can be measured using two indicators: costs overruns and delays, (Guccio et al., 2012b).

Cost overruns are the additional costs incurred by contracting authorities above those agreed on in the contract; delays refer to the excess time of completion of works with respect to the length agreed on in the contract.

Several factors have been outlined in the literature as drivers of cost overruns (Guccio et al., 2012a).

It is widely agreed that there is an unavoidable degree of uncertainty related to the execution of the contract when complex goods are procured and this may cause a difference between what is planned and what is actually realised, or needs to be realised (Ganuza, 2007).

Apart from such 'technical' element, there are other possible determinants which are 'endogenous' to the decision-making process, namely what is referred to as 'optimism bias', e.g. a subjective will to underestimate costs, when designing the project, depending on planning fallacy (Lovallo and Kahneman, 2003) or on the politicians' desire to obtain short term political benefits (Flyvbjerg, 2005).

Another 'endogenous' motivation underlying cost overruns refers to the potential opportunistic behaviour of firms, deriving by the incompleteness of the contract, which leaves room for renegotiation (Bajari et al., 2009; Estache et al., 2009; Chong et al., 2009).

Procurement features connected with the nature of the contract (fixed price vs. cost plus contracts) and with the contract awarding procedure (auctions vs. negotiations) may affect the strength of the firms' incentives to behave opportunistically (Bajari and Tadelis, 2001). On the other hand, opportunistic behaviour of firms might depend on the relationship they establish with politicians - clear cut corruption as well as too "friendly" behaviour - affecting both the selection process and the possibility of renegotiation (Benitez et al., 2010).

As De Carolis and Palumbo (2011) point out, cost overruns and delays can be correlated: the presence of delays in the completion of a work may imply cost overruns, when the delay is representative of problems connected with the realisation of the original project, and additional works are required. However, there can be delays without cost overruns. Moreover, delays are representative of other costs that

are not included in cost overruns for the contracting authorities, due to the potential negative impact on the social welfare generated by the delayed realisation of public works.

Cost overruns and delays are a widespread phenomenon in most countries. Both are very relevant in the execution of public works contracts in Italy, though cost overruns are less marked than delays.<sup>15</sup> In the period 2000-2005, 24.90 % of all public works contracts have experienced cost overruns above 10.00% of the original cost while 64.66% of all public works contracts have exhibited a delay longer than 20.00% of the completion time agreed upon in the contract.<sup>16</sup> These phenomena are remaining through time in the Italian public works as reported by the most recent AVCP Annual Reports.

Therefore, the issue of investigating the performance of public works contract execution is worth exploring.

#### *4.1.2. The use of non-parametric frontier for measuring the efficient management of public work execution*

The above-mentioned indicators represent an easy and straightforward way to measure the capacity to complete works within the cost (cost overruns) and the time (delay) agreed on in the contract. Non-parametric frontiers can be used to compare the performance of different decision-makers, on the basis of the two indicators, so as to ascertain the relative capacity of different decision-makers to achieve both contractual targets (Guccio et al., 2012b).

The non-parametric frontier is a technique, generally used to estimate a production or a cost function with minimal assumptions, and it can easily handle multiple inputs/outputs situations. One of the most well-established and useful techniques for measuring efficiency in public sector activities is DEA (Data Envelopment Analysis)<sup>17</sup>. The reasons for the widespread use of DEA are summarised as follows: it can handle multiple inputs and outputs without a priori assumptions for a specific

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<sup>15</sup> A possible explanation is that the renegotiation of contracted costs is severely constrained by the law (see above, note 9) while no such constraints do exist for delays.

<sup>16</sup> See Autorità di Vigilanza sui contratti pubblici di lavori, servizi e forniture (2007)

<sup>17</sup> DEA has been employed in the literature on procurement, also to assess the efficiency of suppliers (see de Boer et al., 2001).

functional form of production technologies; it does not require a priori a relative weighting scheme for the input and output variables; it returns a simple summary efficiency measurement for each Decision Making Unit (DMU), and it identifies the sources and levels of relative inefficiency for each DMU.

By constructing envelopment unitary isoquants corresponding to comparable DMUs across different situations, DEA identifies as productive benchmarks those DMUs that exhibit the lowest technical coefficients, i.e. lowest input amount to produce one unit of output. In so doing, unlike statistical methods, which enable to estimate average performance<sup>18</sup>, 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.

Once the reference frontiers have been defined, it is possible to assess what would be the potential efficiency improvements available to the inefficient DMUs if they were to produce according to the best practice technologies of their benchmark peers. From an equivalent perspective, these simulations identify the necessary changes that each DMU needs to undertake to reach the efficiency levels of the most successful DMU. In other words, DEA calculates the efficiency frontier for a set of units (DMUs), as well as the distance from the frontier for each unit. This distance (efficiency score) provides a measure of the radial reduction in input that could be achieved for a given measure of output<sup>19</sup>.

#### ***4.2 Corruption measurement issues and its effects on public works execution***

Since the first empirical papers studying the effects of corruption, its measurement has represented a serious problem, leading to different approaches. Different measures of corruption have been suggested in the literature: subjective as well objective indexes have been used. Broadly speaking, subjective indexes of corruption are based on the collection of the results of several cross-country surveys of citizens and experts being asked to state their corruption perceptions, such as the Transparency International Corruption Perception index (Lambsdorff, 2003) and the

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<sup>18</sup> Statistical analysis allows for measuring a central tendency that identifies average performance and the performance of each unit is estimated by deviation from the central tendency.

<sup>19</sup> See Cooper et al. (2007).

World Bank Governance Indicators (Kaufmann et al., 2005). A massive number of academic studies adopted this type of index to show that corruption lowers investment and economic growth (Dal Bo and Rossi, 2007; Estache and Rossi, 2008)<sup>20</sup>.

These indexes have been criticised and Olken (2009) provides an interesting comparison between objective and perception based indexes of corruption. He finds a weak correlation between the two indexes, showing that both capture the same phenomenon although perception based measures tend to underestimate its magnitude.

From a different perspective, as ANAC (2013b) outlines, several objective measures of corruption can be used. On one hand, economic measures can be adopted, using market or statistical indicators, such as the prices of inputs procured by the public sector, which are somehow linked to the corruption phenomenon.<sup>21</sup> Another economic indicator is the one suggested by Golden and Picci (2005). They study the effects of corruption on public infrastructure realisation in Italy and measure corruption as the gap between the number of physically existing public infrastructures and the financial resources cumulatively allocated by government to build them.<sup>22</sup>

Among the objective measures, criminal justice statistics are widespread in all countries and widely used, though to develop reliable comparative analysis such measures require a uniform classification scheme across countries (OECD, 2013).

Looking at the Italian context, judiciary measures are computed by the Italian National Institute of Statistics (ISTAT) considering the number of crimes against the public administrations (per 100,000 inhabitants).<sup>23</sup>

Having shortly described the major strands in the measurement of corruption, we turn to the analysis of the effects of ‘environmental’ corruption on public works

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<sup>20</sup> For a detailed discussion of perception based measure of corruption see, for example, Kaufmann et al. (2007).

<sup>21</sup> As it is reported by ANAC (2013b), a critical evaluation of these methods has been provided by Sequeira (2012).

<sup>22</sup> Golden and Picci (2005) find that corruption increases the costs of public infrastructures realisation, especially in the South of Italy.

<sup>23</sup> It is an objective, aggregated and direct measure that, however, takes into account several crimes, such as embezzlement, extortion and conspiracy (Abrate et al., 2012).

execution. The few works investigating this issue focus on the impact of corruption on the occurrence of renegotiation of public works contracts and on the increase of cost overruns. Regarding the former, being public works contracts usually incomplete, the winning firm may behave opportunistically or illegally through contract renegotiation to maximise its profits (Bajari et al., 2006; Guccio et al., 2009). Guccio et al. (2009) show that corruption, as measured by the number of crimes in accordance with articles 416 and 416-bis of Italian Criminal Code per 100,000 inhabitants, does not seem to affect the occurrence of renegotiation of public works contracts in Italy. In the second case, some empirical works have shown that cost overruns are affected by corruption. For instance, Auriol (2006) estimates the cost of corruption to be between 4 and 10% of procurement spending. Guccio et al. (2012a) show that higher levels of corruption, as measured by the index proposed by Golden and Picci (2005), are associated to higher cost overruns.

## **5. Empirical findings**

### **5.1. Data**

On the basis of the above-mentioned issues, we investigate whether competition is able to constrain the waste effects of ‘environmental’ corruption in the area where public works are localised. The analysis is based on the database of the Italian Authority for Public Contracts (*Autorità di Vigilanza sui Contratti Pubblici di lavori, servizi e forniture* - AVCP). The AVCP collects data on all contracts for public works with a reserve price above €150,000, procured by all contracting authorities. However, we restrict the analysis to the simplest types of public works (consisting of roadwork construction and repair jobs) having an engineering estimated costs<sup>24</sup> between €150,000 and €5 million<sup>25</sup>. The public work contracts<sup>26</sup> in the sample are awarded between 2000 and 2004 and completed by 2005. Data were examined for errors, outliers, and missing values. The final sample contain 3,113 observations.

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<sup>24</sup> Engineering estimated costs are used as reserve price in tendering procedures.

<sup>25</sup> These public works contracts are among the most commonly procured, representing about a quarter of all public works contracts procured each year. To limit heterogeneity, the public works with a value over 5 million Euros were not included in the sample because of the longer time required to complete mega projects.

<sup>26</sup> In what follows, the observation unit is a single public works contract.

Table 1 reports the descriptive statistics of public works in our sample, according to engineering estimated costs and the type of work (whether it is a new or maintenance work). Table 1 shows that the largest number of contracts is between 150,000 and 500,000 euros (84%) of engineering estimated costs and that maintenance works are more numerous than new works.

**(Insert TABLE 1 about here)**

Table 2 shows the summary statistics of the main variables used in our empirical assessment, separately according to the stages of our analysis. In the first part of Table 2 we list the variables connected with performance assessment of public works execution and in the second part those representing competition and ‘environmental’ corruption. Finally, in the lower part of the Table 2 we report other control variables.

**(Insert TABLE 2 about here)**

## ***5.2. Empirical Strategy***

In this section, we explain the empirical strategy used to assess the effect of corruption and competition on public work outcomes. To investigate the effects of corruption on the performance of public works execution we empirically test the following questions:

Q<sub>1</sub>: is the performance of public works execution affected by ‘environmental’ corruption?

Q<sub>2</sub>: do the two adopted measures of corruption provide similar results?

Q<sub>3</sub>: what is the relationship between competition and corruption?

In what follow we employ two different approaches to examine the impact of corruption and competition on the performance in the Italian public works execution. As we previously illustrated, no single approach can fully capture the idea of public work performance. Here we use an approach that focus on the contract execution (i.e. the capacity to complete works within the costs and the time agreed on in the contract). Namely, we assume that the best way to assess the relative efficiency of procurers in the capacity of achieving both the time and costs determined in the

contract is through the benchmarking of their relative performance using the best practice frontier (Guccio et al. 2012b). In this approach, for given targets of time and cost, the best performers are the ones that minimize the actual time and costs. Thus, to assess the performance in the execution of each public work contract, as described above, we could estimate the best practice frontier based on observed behaviour of procurers and obtain inefficiency levels measured as the distance of each observation unit from the best practice frontier.

Once public work performance estimates are obtained, different empirical strategies are considered to investigate our research questions. We first apply several non-parametric tests to assess whether corruption matters for public work performance. Then, we statistically test the hypothesis that different levels of competition are able to mitigate the waste effects of corruption as far as performance estimates are concerned.

As a further investigation, following Finocchiaro Castro et al. (2014), we first apply a DEA two-step methodology proposed by Simar and Wilson (2007) to the DEA efficiency scores. Specifically, we assume that DEA efficiency scores can be regressed – in a cross-section framework – on a vector of environmental variables along the following general specification:

$$\theta_i = f(z_i) + \varepsilon_i \quad [1]$$

where  $\theta_i$  represent the efficient scores resulting from the previous stage,  $z_i$  is a set of possible non-discretionary inputs and  $\varepsilon_i$  is a vector of error terms. In the next sections, we will discuss in depth our explanatory variables  $z_i$ , as well as some other control variables, which are used to assess the impact of competition and corruption on efficiency levels.

Simar and Wilson (2007) have underlined that traditional estimators yield to biased estimates due to serial correlation of efficiency scores and have suggested to apply semi-parametric two-stage techniques.<sup>27</sup> Since this suggestion, there has been a wide debate on the best method to apply the second-stage DEA analysis; criticism and alternative proposals are based on different assumptions for the DEA-score DGP and sample variation (e.g. Hoff 2007; Banker and Natarajan 2008; Ramalho et al. 2010).

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<sup>27</sup> More specifically, estimating [1] with Tobit or OLS regressions leads to the violation of the assumption of the independence between  $\varepsilon_i$  and  $z_i$ .



Recently, Simar and Wilson (2011) showed that the two-step bias-corrected semi-parametric estimator proposed by Simar and Wilson (2007) is the only known method that ensures a feasible and consistent inference on the second stage regression.<sup>28</sup> Therefore, in what follows we use the Simar and Wilson (2007) bootstrap truncated estimator as baseline approach.

### ***5.3. Preliminary findings***

To assess whether competition is able to constrain the waste effects of ‘environmental’ corruption in the area where the infrastructure is localised and to affect the efficient execution of the public work contract, in the next section we will perform a DEA two-stage analysis following Finocchiaro Castro et al., (2014). Here, we provide some preliminary findings based on the descriptive statistics of the sample.

First, as it has been pointed out before, the efficiency of execution of public works contracts is usually defined in terms of the capacity to complete works within the costs and the time agreed on in the contract and it has been traditionally measured considering either cost overruns (i.e. the difference between the final payment and the winning bid as a percentage of the reserve price) and time delays (i.e. the difference between the actual and the contractual time as a percentage of the contractual time).

Table 3 shows that cost overruns and delays are quite relevant in the sample: on average, cost overruns are 8.18% of the agreed cost while delays are 76.53% of the completion time agreed upon in the contract. Moreover, Table 3 reports cost overruns and delays for different average levels of ‘environmental’ corruption using the variables CORR\_PA and CORR\_G&P. Thus, we consider three possible levels of both variables CORR\_PA and CORR\_G&P according to their sampling distributions. Table 3 shows that cost overruns trend is increasing in both the adopted

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<sup>28</sup> However also this approach shows two weaknesses: first, the potential impact of the environmental factors on the distribution of the efficiency scores occurs only if the separability condition is verified (i.e. environmental factors do not influence the shape of the production set). Second, the two-stage approach imposes parametric assumptions on the functional form of the regression and error distribution (Bădin et al. 2013). In our case it seems reasonable to assume that the employed environmental factors affect the production process but not the attainable set and its frontier.

corruption measures: instead, no clear relationship between delay and ‘environmental’ corruption indexes can be inferred from data.

**(Insert TABLE 3 about here)**

A second issue worth discussing is the relationship between ‘environmental’ corruption and competition level. Here we investigate only the correlation between corruption indexes and competition level, represented by the number of bidders and the rebate levels.<sup>29</sup> Figure 1 reports the scatterplot between the number of bidders and CORR\_G&P and CORR\_PA, showing only a slight positive relationship, suggesting no clear evidence of causality in the relationship between competition, measured by the number of bidders, and ‘environmental’ corruption.

A different result is reported in Figure 2, where the scatterplot between rebate levels and corruption indexes is offered. In fact, in such a case, a clear positive relation appears; however, in evaluating such a result caution is needed since the variable – rebate level – might be affected by the above mentioned opportunistic behaviour of firms.<sup>30</sup>

**(Insert FIGURE 1 about here)**

**(Insert FIGURE 2 about here)**

#### ***5.4. Performances in public work execution using non-parametric frontier estimators***

Above-mentioned preliminary findings show that, in the execution of the public contracts for road and highways, there are relevant differences between cost overruns and delays in relation with corruption indices. Considering separately cost overruns and delays, however, does not allow for evaluating the performance of the procurer in carrying out the contract. More significant insights can be provided when cost

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<sup>29</sup> To measure the level of competition we have not used a variable representing the procedure (whether open or negotiated) because the open procedure is by large the most used (almost 86% of contracts are assigned by open procedure). Moreover, the variable we use -number of bidders- is clearly related to the procedure.

<sup>30</sup> See above, section 4..

overruns and delays are simultaneously taken into account, so as to develop a measure of overall efficiency of public works contracts execution. As stated before, the best way to measure the relative efficiency of contracting authorities in the capacity of achieving both the targeted results of time and costs, as determined in the contract, is through the benchmarking of their performance using DEA.

In this section we report the estimates of DEA efficiency scores following Finocchiaro et al (2014).

The bootstrap bias correction procedure<sup>31</sup> slightly affects the estimates (92.58%), as it is shown by Figure 3, that jointly reports the cumulate distributions of DEA efficiency scores and bias corrected ones.

Moreover, as Finocchiaro et al (2014) stress, the mean efficiency value of 92.75% does not imply that public contracts for roads in Italy are overall executed in an efficient way, being the variability of efficiency scores very high (both in uncorrected and bias corrected distribution).<sup>32</sup>

In order to test more thoroughly the efficiency scores before and after the bias correction, we used kernel density estimates of the efficiency scores that rely on the reflection method (Simar and Wilson, 2008). In such a way, we are able to avoid the problems of bias and inconsistency at the boundary of support.

**(Insert FIGURE 3 about here)**

The 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 are shown in Figure 4 for each class of reserve price. The kernel density functions, reported in Figure 4, show that, from the perspective of sensitivity analysis, the efficiency estimates are quite robust with respect to sampling variation since there are only small differences between

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<sup>31</sup> To control for sampling variation, we use a bootstrap procedure with 1,000 bootstrap developed by Simar and Wilson (1998) to correct the DEA estimate bias, generate confidence intervals and control for sampling variation.

<sup>32</sup> More than 25% of the contracts have a level of inefficiency between 10% and 60% and about the 75% of contracts has a level of inefficiency below 10%, confirming that cost overruns and delays are relevant phenomena.

biased and biased corrected efficiency estimates. Furthermore, the different classes of reserve price do not seem to affect the average level of DEA efficiency.

**(Insert FIGURE 4 about here)**

To provide a further assessment of our research questions in Table 4 we consider once again three possible levels of both variables CORR\_PA and CORR\_G&P according to their sampling distributions and report unconditional and conditional distribution of the DEA efficiency scores according to different competition levels measured by the number of bids (BIDDERS). Namely, we assume that poorly competitive procedures are characterized by a number of bidders equal or below the median value in the sample whereas high competitive procedures are characterized by a number of bidders above the median value.

**(Insert TABLE 4 about here)**

Although the conditional distribution in Table 4 show only slightly differences between efficiency scores some regularities seem to emerge. Firstly, we observe a detrimental effect of corruption on the performance of public work execution for both corruption indexes. Second the competition seems to play a positive role only in presence of low ‘environmental’ corruption. In the next paragraph we will try to explain the observed variability of efficiency scores, paying special attention to the effects exerted by corruption and by the role of competition.

### ***5.5. The waste effect of corruption and the role of competition: a two-stage approach***

In section 3 it has been outlined that corruption may affect in a relevant way the provision of infrastructures and some measures of corruption have been examined. Here, building on the analysis provided by Finocchiaro Castro et al., (2014), we examine the hypothesis that the performance in public works execution is affected by the level of ‘environmental’ corruption, focusing attention on assessing whether

more competition matters in constraining these effects. We also control for other public work characteristics, following the two-step approach, as suggested by Coelli et al., (1998) so as to regress DEA efficiency scores on a set of explanatory variables. The first ‘environmental’ controls refer to corruption indexes. Due to the nature of our data set, we adopt, as measures of corruption at provincial level, the crimes against public administration per 100,000 inhabitants (CORR\_PA) computed by ISTAT and the index of corruption (CORR\_G&P) proposed by Golden and Picci (2005).

Following Finocchiaro et al (2014), we also control for other variables that may affect the performances in the execution of public works. Assuming that contract execution becomes more uncertain as the degree of complexity of the work increases, as a 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).<sup>33</sup>

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 the presence of subcontractors and legal disputes tend to increase the completion time and the likelihood of a low performance in infrastructure provision. Finally, we control for the year of award (YEAR)<sup>34</sup>.

Special attention is dedicated to the effects of competition. 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

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<sup>33</sup> In the literature, (e.g., Bajari et al., 2009; Guccio et al., 2012a) the total value of the work and the 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 variables used in the first stage.

<sup>34</sup> We introduced fixed time effects by the year of award (YEAR) because our data base is time truncated, including the contracts awarded in the period 2000–2004 and completed by 2005. This might cause a sample selection consisting in the fact that the works which are to be completed contractually near the end of the period under consideration could show systematically lower delays.

efficient firm is likely to be chosen with positive effects on the performance of public works execution. However, as Celentani and Ganuza (2002) show, the relationship between competition and corruption is not straightforward; to investigate closely such a relationship, in the econometric analysis, we also include an interaction term between each of the two adopted corruption indexes and the competition levels (BIDDERS\*CORR\_PA; BIDDERS\*CORR\_G&P; REBATE\*CORR\_PA; REBATE\* CORR\_G&P).

As in Finocchiaro et al (2014), to provide the most robust evaluation of our empirical findings, we use a parsimonious strategy to evaluate the relative marginal effects. In Table 5 column (1) shows the results for baseline specification; whereas columns from (2) to (7) show the results of the estimations for different effects of corruption index on the performance in public works execution, according to each of the above questions. It is worth noting that competition when measured by the number of bidders is significant and has a positive effects on efficiency. Instead, the variable representing the rebate of the winning bidder has a negative sign. Such a difference can be explained recalling that, as it was pointed out before,<sup>35</sup> such a variable might also be affected by the opportunistic behaviour of firms and, therefore, caution is needed in interpreting its meaning.

The first two questions can be addressed by looking at the coefficients of the two corruption indexes (CORR\_PA and CORR\_G&P). Given that both indexes turn out to be significant, they clearly affect efficiency levels in public works execution. Their effects are quite similar although the index of Golden and Picci (2005), CORR\_G&P, has a stronger marginal effect, as shown by its coefficients in model 2, 4 and 6. 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) supporting the “sand the wheels” hypothesis against the “grease the wheels” one. In other words, we provide some support to the well-established result stating that corruption has detrimental effects on efficiency of institutions.

**(Insert TABLE 5 about here)**

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<sup>35</sup> See above par. 5.3

The last question to be answered refers to whether, in procurement, the effects of ‘environmental’ corruption may be mitigated or enhanced by competition. For this purpose, we use two interaction terms obtained multiplying each corruption index by our measures of competition (BIDDERS\*CORR\_PA and BIDDERS\* CORR\_G&P; REBATE\*CORR\_PA and REBATE\* CORR\_G&P). Both interaction terms based on the number of bidders turn out to be significant and negative. This means that increasing in competition does not mitigate the negative effects of ‘environmental’ corruption on the efficiency of public works executions, as suggested by Celentani and Ganuza (2002). The interaction terms based on rebate are not significant and show a positive sign. Finally, almost all the other variables included in the empirical analysis show to be significant and with the expected signs.

Summing up, we confirm the awareness that in Italy the beneficial effects of open procedures on the performance of public works contracts should not be taken for granted. Moreover, we also find that competition is not effective in contrasting the negative effects of “environmental” corruption on such a performance.

## **6. Conclusions**

In this paper, we tried to investigate whether competition is able to constrain the effects of ‘environmental’ corruption on the efficiency in the execution of public contracts for roads, in terms of delays and cost overruns. A two-stage analysis was carried out: in the first stage, using a non-parametric approach (Data Envelopment Analysis - DEA), the relative efficiency scores were estimated and in the second stage, the determinant factors of the scores variability were investigated, paying special attention on the effects exerted by corruption and competition.

Our results confirm that ‘environmental’ corruption negatively affects the efficiency of the execution of public contracts, supporting “the sand the wheels” hypothesis. Our results also shows that competition does not mitigate the detrimental effects of ‘environmental’ corruption.

In terms of policy implications our results would suggest to introduce in the regulation framework incentives to improve , on one hand, the bidding process and,

on the other hand, the execution phase. Taking into account the firm's reputation in the selection of the contractor might be useful to prevent the firm's opportunistic behaviour; Introducing ex-post evaluation of the outcome of procurement, with some form of standard cost,<sup>36</sup> would enhance the overall accountability of public action. In fact, discrepancies between the final cost and the standard cost could be considered a 'red flag' for bad performance to be monitored, so that causes are identified and responsibilities are assessed. Moreover, to enhance the social control on public action transparency should be fostered, requiring contracting authorities to publish cost overruns and delays.

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<sup>36</sup> The use of standard costs is required since 1994 (L. 109/94, art. 4) but it has not been implemented so far.



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## Tables and figures

**Table 1** – Descriptive statistics of the sample (public works for roads and highways, by type of public work and class of reserve price)

Type and class of reserve prices			Public works		
			Numbers works	Total amount (€)	Average amount (€)
(1)	maintenance	150,000 - 500,000	1,811	400,857,966	221,346.20
(2)	new		810	185,736,394	229,304.19
(3)	maintenance	500,000 - 1,500,000	247	146,356,710	592,537.29
(4)	new		104	58,650,129	563,943.54
(5)	maintenance	1,500,000 - 5,000,000	85	122,696,033	1,443,482.75
(6)	new		56	76,118,863	1,359,265.40
<b>All sample</b>			<b>3,113</b>	<b>990,416,094</b>	<b>318,154.86</b>

Source: Our elaboration on data provided by *Autorità per la vigilanza sui contratti pubblici di lavori, servizi e forniture* (AVPC)

Note: Monetary values in euros at current prices.

**Table 2** – Descriptive statistics of the variables

Variables	Definition	Obs.	Mean	St. Dev.
<i>Variables used in the assessment of public work performance</i>				
A_TIME	Actual time of public work completion	3,113	277.07	184.60
A_COST	Actual cost of public work completion, in thousand	3,113	345.01	356.10
P_TIME	Planned time of public work completion	3,113	176.65	123.45
W_BID	Agreed cost of public work completion, in thousand	3,113	318.15	318.39
<i>Variables connected with competition and corruption level</i>				
BIDDERS	Number of bidders	3,113	32.92	33.42
REBATE	Rebate of the winning bidder (percent)	3,113	13.78	9.88
CORR_PA	Crimes against public administration per 100,000 inhabitants at provincial level	3,113	4.86	3.10
CORR_G&P	Corruption index proposed by Golden and Picci (2005), at provincial level	3,113	1.12	0.93
BIDDERS*CORR_PA	Interaction term between variables BIDDERS and CORR_PA	3,113	167.85	247.54
BIDDERS*CORR_G&P	Interaction term between variables BIDDERS and CORR_G&P	3,113	42.83	82.92
REBATE*CORR_PA	Interaction term between variables BIDDERS and CORR_PA	3,113	0.74	0.87
REBATE*CORR_G&P	Interaction term between variables BIDDERS and CORR_G&P	3,113	0.19	0.34
<i>Other variables</i>				
WCI	Weighted public work composition index	3,113	1.14	0.36
SUB	Dummy for subcontracting	3,113	0.76	0.43
DISPUTE	Dummy for legal dispute	3,113	0.02	0.13

Source: our elaboration on data provided by *Autorità per la vigilanza sui contratti pubblici di lavori, servizi e forniture* (AVPC), ISTAT, *Statistiche giudiziarie*, several years, and Golden and Picci (2005).

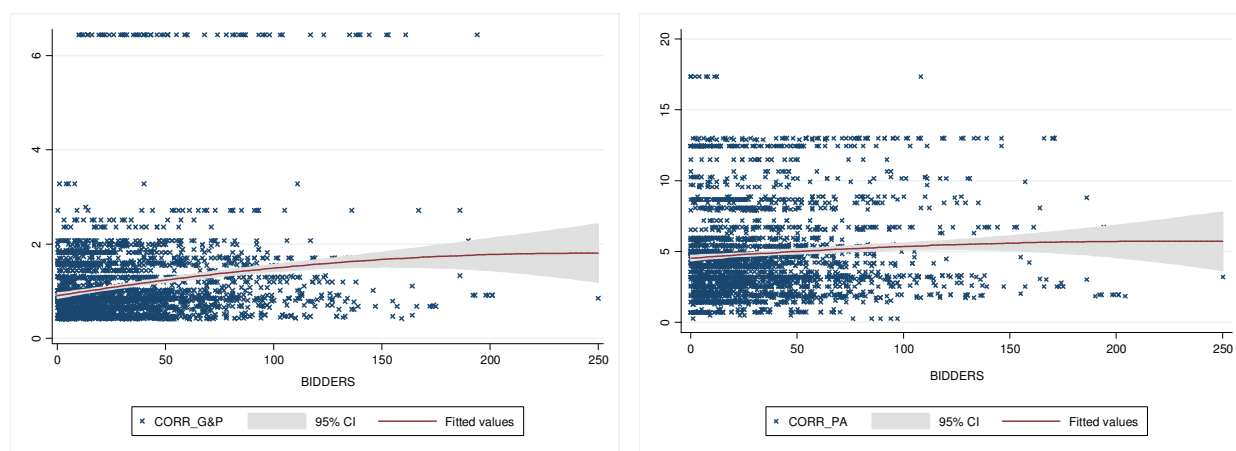
Note: Monetary values in thousand euros at current prices.

**Table 3** – Descriptive statistics of cost overruns and time delays of public works for roads and highways by ‘environmental’ corruption level in the area

Level of environmental corruption		Public works			
		Cost overruns		Time delay	
		Mean	St. Dev.	Mean	St. Dev.
CORR_G&P	High	0.1027	0.1900	0.6327	1.0688
	Middle	0.0904	0.1348	0.8698	1.3192
	Low	0.0659	0.1098	0.7076	1.0714
CORR_PA	High	0.1045	0.1858	0.7108	1.0887
	Middle	0.0785	0.1290	0.7826	1.2327
	Low	0.0721	0.1064	0.7788	1.1975
<b>Total</b>		<b>0.0818</b>	<b>0.1367</b>	<b>0.7653</b>	<b>1.1881</b>

Source: Our elaboration on data provided by *Autorità per la vigilanza sui contratti pubblici di lavori, servizi e forniture* (AVCP), ISTAT, *Statistiche giudiziarie*, several years, and Golden and Picci (2005).

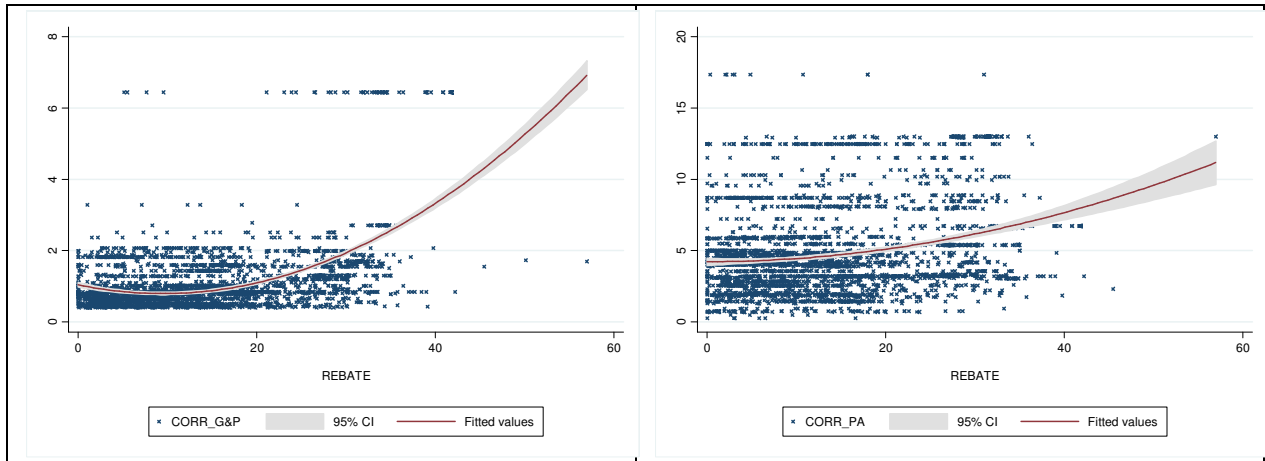
**Figure 1** – Scatter plot between number of bidders and corruption indices - CORR\_G&P (Left) and CORR\_PA (Right)



Source: Our elaboration on data provided by *Autorità per la vigilanza sui contratti pubblici di lavori, servizi e forniture* (AVCP), ISTAT, *Statistiche giudiziarie*, several years, and Golden and Picci (2005).

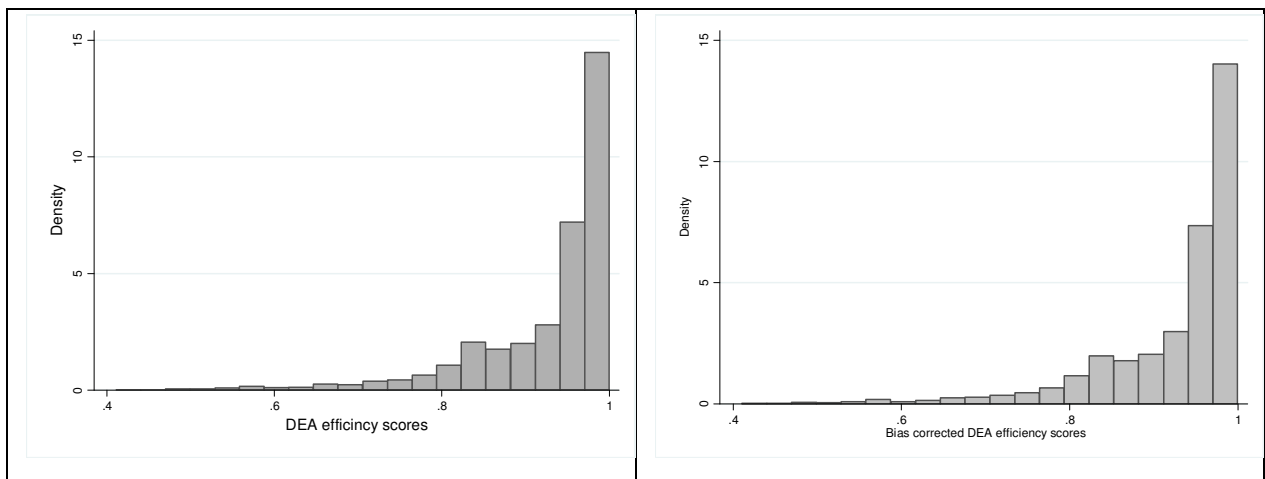


**Figure 2** – Scatter plot between rebate and corruption indices - CORR\_G&P and CORR\_PA



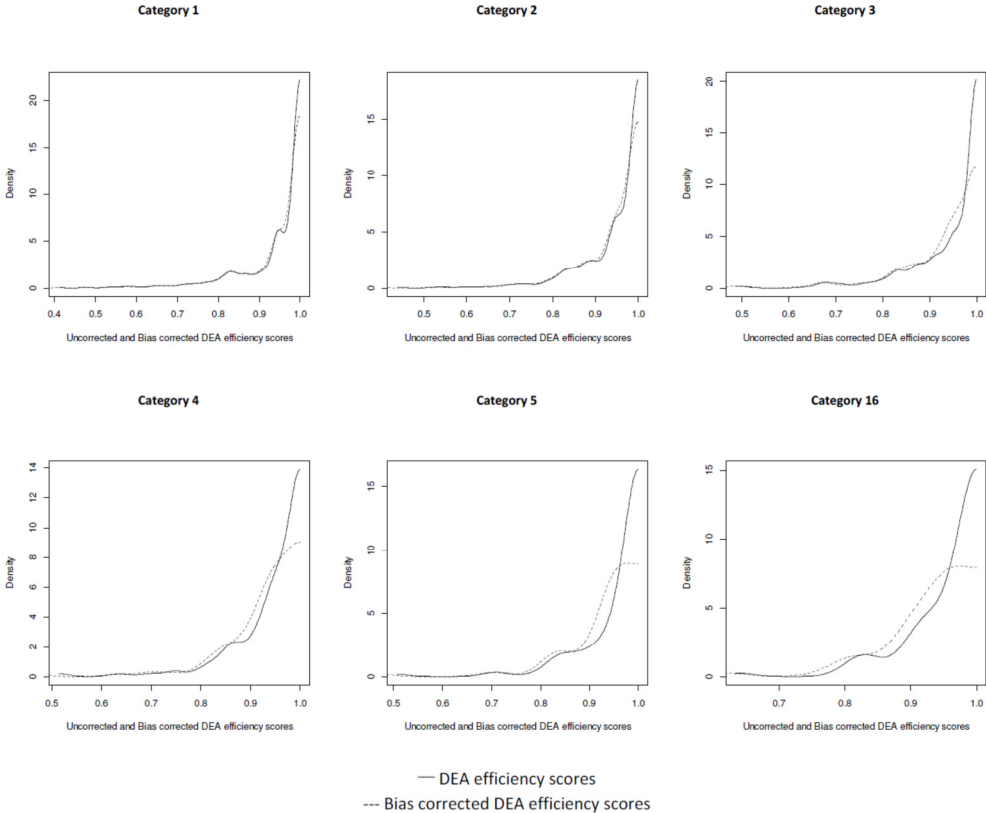
Source: Our elaboration on data provided by *Autorità per la vigilanza sui contratti pubblici di lavori, servizi e forniture* (AVCP), ISTAT, *Statistiche giudiziarie*, several years, and Golden and Picci (2005).

**Figure 3** – Cumulate distribution of DEA (Left) and bias corrected DEA efficiency scores (Right)



Source: Our elaboration on data provided by *Autorità per la vigilanza sui contratti pubblici di lavori, servizi e forniture* (AVCP).

**Figure 4 - 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:* Our elaboration on data provided by *Autorità per la vigilanza sui contratti pubblici di lavori, servizi e forniture* (AVCP).

**Table 4 – Bias corrected DEA efficiency scores distribution by ‘environmental’ corruption level in the area and by competition level**

Level of environmental corruption		Public work procedures				<i>(p-value)</i>
		Poorly competitive		Highly competitive		
		Mean	St. Dev.	Mean	St. Dev.	
<b>CORR_G&amp;P</b>	<i>High</i>	0.9202	0.0857	0.9178	0.1126	(0.3841)
	<i>Middle</i>	0.9277	0.0775	0.9242	0.0840	(0.4340)
	<i>Low</i>	0.9283	0.0814	0.9421	0.0781	(0.0410)
<b>CORR_PA</b>	<i>High</i>	0.9185	0.0925	0.9145	0.1130	(0.2841)
	<i>Middle</i>	0.9286	0.0767	0.9211	0.0878	(0.1340)
	<i>Low</i>	0.9340	0.0796	0.9391	0.0716	(0.1751)
<b>All</b>		0.9253	0.0814	0.9317	0.0815	(0.0917)

*Note:* The p-values of Mann–Whitney test of equality distribution of the efficiency scores across the relative subsamples in parenthesis

*Source:* Our elaboration on data provided by *Autorità per la vigilanza sui contratti pubblici di lavori, servizi e forniture* (AVCP), ISTAT, *Statistiche giudiziarie*, several years, and Golden and Picci (2005).

**Table 5** – Estimate results on determinants of efficiency scores (truncated regressions)

Variables	Bias-adjusted coefficient <sup>(a)</sup>						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Intercept	0.968*** (0.009)	0.971*** (0.009)	0.973*** (0.009)	0.975*** (0.007)	0.968*** (0.010)	0.964*** (0.009)	0.951*** (0.009)
CORR_PA	--	-1.94 <sup>-4</sup> *** (4.69 <sup>-5</sup> )	--	-1.09 <sup>-4</sup> * (6.77 <sup>-5</sup> )	--	-1.94 <sup>-4</sup> *** (5.01 <sup>-5</sup> )	--
CORR_G&P	--	--	-0.008*** (0.002)	--	-0.004* (0.002)	--	-0.007*** (0.002)
BIDDERS	2.74 <sup>-4</sup> *** (5.18 <sup>-5</sup> )	2.77 <sup>-4</sup> *** (5.17 <sup>-5</sup> )	2.75 <sup>-4</sup> *** (5.17 <sup>-5</sup> )	3.43 <sup>-4</sup> *** (6.53 <sup>-5</sup> )	3.71 <sup>-4</sup> *** (7.03 <sup>-5</sup> )	2.63 <sup>-4</sup> *** (5.19 <sup>-5</sup> )	2.41 <sup>-4</sup> *** (5.33 <sup>-5</sup> )
BIDDERS*CORR_PA	--	--	--	-1.72 <sup>-6</sup> * (1.02 <sup>-6</sup> )	--	--	--
BIDDERS* CORR_G&P	--	--	--	--	-7.46 <sup>-5</sup> * (3.69 <sup>-5</sup> )	--	--
REBATE	-0.003*** (1.80 <sup>-4</sup> )	-0.002*** (1.89 <sup>-4</sup> )	-0.002*** (1.92 <sup>-4</sup> )	-0.002*** (1.89 <sup>-4</sup> )	-0.002*** (1.92 <sup>-4</sup> )	-0.002*** (1.88 <sup>-4</sup> )	-0.002*** (1.70 <sup>-4</sup> )
REBATE*CORR_PA	--	--	--	--	--	0.011 (0.008)	--
REBATE* CORR_G&P	--	--	--	--	--	--	0.001 (0.003)
WCI	-0.013*** (0.004)	-0.012*** (0.004)	-0.012*** (0.004)	-0.012*** (0.004)	-0.011*** (0.004)	-0.012*** (0.004)	-0.012*** (0.004)
SUB	-0.008** (0.004)	-0.009** (0.004)	-0.011*** (0.004)	-0.009** (0.004)	-0.011*** (0.004)	-0.009** (0.004)	-0.011*** (0.004)
DISPUTE	-0.013* (0.008)	0.004 (0.007)	-0.0010* (0.06)	0.005 (0.007)	-0.008* (0.04)	0.004 (0.007)	-0.009* (0.05)
Control for year of award	yes	yes	yes	yes	yes	yes	yes
Observation	3,113	3,113	3,113	3,113	3,113	3,113	3,113

Source: AVPC, ISTAT, *Statistiche giudiziarie*, several years, and Golden and Picci (2005).

\* significant at 10%; \*\* significant at 5%; \*\*\* significant at 1%

<sup>a</sup> Double bootstrap truncated estimates (n=1000), as suggested in Simar and Wilson (2007), algorithm 1.