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Ph.D. thesis

Multi-level Corruption Risk Indicators in the Italian Public Procurement

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Supervisor:

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"Clay lies still, but blood's a rover;

Breath's a ware that will not keep.

Up, lad: when the journey's over

There'll be time enough to sleep"

A. E. Housman, "*Reveille*"

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Summary

Abstract

This study develops an original corruption risk indicator at the Italian procurement level and estimates the correlation between the profile of contract suppliers and the corruption risk indicator in question. This corruption risk indicator relies on a residual approach following a two-stage, semi-parametric procedure. First, public work contracts are benchmarked to investigate the relative efficiency of each public work execution based on two predefined variables – cost overrun and time delay – using a data envelopment analysis (DEA). Second, DEA efficiency scores are regressed on environmental and contract-level determinants of inefficiency – excluding corruption which is treated separately. Third, the estimate residuals provide estimates of the potential risk of corruption at the contract level. The aggregated results from an updated Italian public procurement dataset suggest that: (1) the risk of corruption associated with contracting authorities prevails in larger urban areas, especially in Lazio, Tuscany and Lombardy; (2) the risk of corruption in relation to the location of firms is higher in central regions (Abruzzo, Umbria and Lazio) and southern regions (Campania and Basilicata). Then, a risk-based assessment exercise is performed to profile suppliers. The corruption risk indicator is regressed on suppliers' financial and ownership data to identify patterns among firms winning risky contracts. Suppliers associated with high levels of corruption risk in public contracting are more profit-seeking, hold low levels of debts and on average need more days to pay their customers. Finally, suppliers involved in public work contracts at high risk of corruption are more likely to have legal and/or financial connections with off-shore jurisdictions and tax havens which might use financial and corporate secrecy to attract illicit financial flows.

Introduction

The public procurement market is the main means for governments to pursue citizens' needs. Public procurement is a powerful lever for achieving economic, environmental, technological and social goals. To achieve these goals, governments turn to the private sector for the supply of goods and services. A large amount of funds revolves around public procurement. In concrete terms, between 12% and 15% of a country's GDP is spent worldwide in this sector. For this reason, public procurement is also an area rife with corruption opportunities.

Corruption in public procurement occurs within an opportunity structure. Opportunities for corruption can emerge in all stages of the procurement chain, from needs assessment to contract implementation. Identifying corruption opportunities is key to estimating the overall risk of corruption at a procurement level and the correlation between the characteristics of contract suppliers and the risk of corruption in public procurement. According to this framework, this dissertation proposes an innovative methodology to develop multi-level risk indicators in public procurement, both with regards to public work contracts and private firms involved in corruption.

This analytical framework is applied to the case of Italy. Italian public works are analyzed to build a new corruption risk indicator at the contract level. As corruption is a source of inefficiency in contract management, a '*residual approach*' is adopted to develop a risk indicator. The corruption risk indicator is derived from inefficiency in contract execution, intended as the additional time and costs entailed by the actual realization of the public infrastructure. In this way, a new risk indicator of corruption in public procurement is developed, which allows comparing public contracts to determine more precisely which of them are more likely to experience corruption upon execution.

In the second part, a risk-based assessment exercise is performed to profile suppliers. To this purpose, some attributes of winning bidders are identified and empirically tested to raise corruption-related red flags at the firm level. It is suggested that suppliers involved in corruption act in a different manner than 'clean' businesses, which behave in the public interest. Suppliers involved in corrupt transactions act strategically to extract and distribute rents within the corruption network for the achievement of personal and/or political interests. Based on this assumption, suppliers involved in corruption are expected to differ from their peers in their financial performance and corporate structure. The identification and measurement of red flags at the company level provides

interesting insight into new, substantiated hypotheses for a more comprehensive assessment of publicly-funded firms.

This dissertation is highly explorative, as it reflects the inherent challenges of developing reliable and valid indicators of a phenomenon deliberately hidden by its actors through several mechanisms. The construction of multi-level risk indicators opens the path for the implementation of data-driven, anti-corruption strategies to support law enforcement and the judiciary authorities in preventing and/or detecting illegal behaviors in public procurement.

This study is organized as follows: the first chapter illustrates international and national legislation and describes the actual structure of the procurement market in Italy. The second chapter introduces a range of types and definitions of corruption and focuses on the determinants and impact of corruption in public procurement. The third chapter presents the theoretical and analytical framework used to assess the risk of corruption in public procurement. The fourth chapter develops the methodological approach and establishes a new risk indicator of corruption in public procurement. The fifth chapter focuses on suppliers, by identifying red flags at the firm level. The final chapter discusses future research paths and explains the importance of more precise and accurate open data as a key tool for advancing data-driven anti-corruption policies.

Chapter 1. Public procurement in the Italian context

This chapter introduces the main concepts discussed in this dissertation. The first section illustrates public procurement in legal and institutional terms. It provides a general description of public procurement, focusing on its role in modern economies and the laws a procurement entity must conform to (1.1). The second part briefly presents the Italian legislation, currently undergoing major revision due to the passing of new procurement laws (1.2). The last sub-section (1.3) provides an overview of the Italian public procurement sector.

1.1. The International Procurement Framework

Public procurement is broadly defined as the preparation, award and implementation/administration of contracts for goods, works and other services. Thus, public procurement does not only concern the narrow selection of a contract partner by a purchasing body and the actual engagement in a contract between the two, but also the entire process from needs assessment through to preparation and implementation (Transparency International 2006).

Procurement is a complicated – and sometimes opaque – process through which a large, if not the largest, percentage of public money is spent. Procurement spending worldwide averages between 12% and 15% of a country's GDP (Transparency International 2014), in line with the amounts European public authorities spend – approximately 14% of GDP – on the purchase of services, works and supplies.[1]

To be efficient, public procurement practices should attempt to reduce wasteful activities. By resorting to the private sector, such practices must be responsive to the demands of all stakeholders (Carpineti et al. 2006). It can be said that a country's public procurement system is efficient if it provides the required inputs to the delivery of public services – i.e., goods, civil works and services – at a low cost and of high quality (OECD 2016). To achieve this objective, most public procurement systems attempt to emulate the functioning of the market, primarily by requiring competitive tendering procedures for major acquisitions and by promoting transparency. Nonetheless, competition and transparency require clearly defined procurement rules and a credible system of sanctions to be enforced in case of abuses.

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[1] For more detailed information see: https://ec.europa.eu/growth/single-market/public-procurement_en

The procurement process is highly regulated by national laws and international directives/standards (EU directive n° 24/2014; OECD 2015), which delineate several key principles – competition, fairness, and transparency *inter alia* – to ensure an efficient and sustainable procurement system (Ware et al. 2007; Khaghaghordyan 2014). International and European standards and directives exist to enable countries to achieve procurement goals in terms of efficiency and sustainability. In Italy, the current Public Procurement Code (Legislative Decree n° 50/2016)[2] has adopted EU Directives n° 23/2014 and n° 24/2014.[3]

Competition is strongly encouraged in bidding for government contracts. Article 1 of the EU Directive n°24/2014 states that "*provisions* [for public contracts] *should be drawn up coordinating national procurement procedures so as to ensure that those principles are given practical effect and public procurement is opened up to competition*" (EU Directive n° 24/2014). Competition in procurement can either be open (all the potential suppliers fulfilling the requirements can bid and compete for the tender) or restricted (if competition is limited to firms shortlisted or invited by the procuring entity). In most cases, competition engenders better quality at a lower cost – the desired outcome of a well-functioning system (Ganuza 2007). Nonetheless, the relationship between competition and corruption is disputed. A higher number of bidders does not automatically imply lower levels of corruption as competition and corruption opportunities might increase jointly under specific market conditions (Celentani and Ganuza 2002). The presence of cartels reduces firms' incentives to provide new or better products and services at competitive prices (Conley and Decarolis 2016). Thus, state institution should be aware of the potential drawbacks of promoting competition without a credible monitoring and sanctioning system to promote fairness and accountability.

To strengthen competition, public procurement seeks to promote transparency. Through transparency, governments provide services to citizens by due course of law, rather than seeking to increase the private wealth of government officials and favor private interests (Transparency International 2013a). To achieve this goal, transparency must be guaranteed through the various stages of the procurement process by disclosing tender requirements and tender documentation (including bill payments) once the contract has been awarded (Art. 45, EU Directive n° 24/2014). Transparency has a desirable effect in increasing trust towards state institutions, especially among citizens and market operators with low levels of prior knowledge and low inclination to trust (Grimmelikhuijsen

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[2]
http://www.gazzettaufficiale.it/atto/serie_generale/caricaDettaglioAtto/originario?atto.dataPubblicazioneGazzetta=2016-04-19&atto.codiceRedazionale=16G00062
[3] A more comprehensive review of the Italian procurement law is given in the next section.

and Meijer 2014; Cicatiello et al. 2018). However, the simple disclosure of government contracts *per se* does not increase competition and efficiency. Ohashi (2009) has found that transparency might also facilitate repeated interactions among local firms, thus spreading collusive agreements and bid-rigging practices. Since transparency can sometimes have a negative impact on contract awarding procedures, it is important not only to pursue greater transparency, but also to ensure accountability of public decision-makers (Saussier and Tirole 2015; The World Bank Open Knowledge 2017)

Accountability means that public officials are responsible for the proper enforcement of rules and regulations that govern public procurement and, therefore, for the procurement decisions they make as well. Accountability requires the existence of a credible sanctioning system for violations of the rules, consistent with due process. This system enables governments and citizens to engage in a mutually responsive way. As Gaventa (2002, 2) has noted, "*this conceptually links accountability to a rights-based understanding of development following three principles:* i) *inclusive rights for all people;* ii) *the right to participation, and* iii) *the obligations to protect and promote the realization of rights by states and other duty bearers*". Bearing this in mind, the digitalization of government procurement data goes in the direction of: (1) encouraging the interest of citizens in the activities of the government and its local entities; (2) make the government accountable to citizens. Thus, the active engagement of both government and citizens is necessary to achieve any degree of accountability (Mungiu-Pippidi 2015).

A key element of this implicit social contract between the government and the citizenry is that the government is expected to spend taxes prudently and efficiently. This means that public procurement must be economically sustainable. The government should procure goods, works and services at a reasonable cost and with reasonably good quality – i.e., it should obtain good value for the money spent (Ware et al. 2007). Maintaining the sustainability of procurement, in both the short and the long run, reduces the waste or misallocation of public funds, creates opportunities for the purchasing bodies, increases the spectrum of the supply side and minimizes business risks (CIPS 2009).

Integrity, transparency and accountability are fundamental in ensuring sustainability and efficiency in procurement. If a public procurement system is efficient, the government obtains better value for its money. For this reason, rules and procedures should encourage the completion of the procurement process within a reasonable length of time, as well as the timely delivery of the goods, services and works procured (Carpineti et al. 2006). In this way, a procurement system should be able to complete public work projects

within the expected deadlines and budgets to create a more efficient and sustainable market.

1.2. Italian procurement regulation

International standards, EU directives, moral and ethical codes are considered the starting point for the formulation of a national regulatory framework. In this section, the Italian procurement legislation is introduced. The main focus will be on several technicalities, which are critical to understanding how Italian procurement works. Italian legal specifications are important to better understand the methodology used and the analysis carried out in this dissertation. In particular, this section provides legal references for tender objectives, contracting authorities, contract types, value thresholds, procedures and criteria for the adjudication of the contracts as well as qualification schemes for bidders.[4]

Public procurement in Italy is ruled by the Public Contracts Code (Legislative Decree n° 50/2016, which came into being on 19th April 2016, hereinafter referred to as the "Code"). The Code abrogated the former public contracts code (Legislative Decree n° 163/2006) and the implementing regulation (Decree of the President of the Republic n° 207/2010). Further modifications were introduced in May 2017 (Legislative Decree n° 56/2017) that implemented the so-called "secondary sources". Indeed, the Code does not provide for a consolidated implementing regulation, but rather for several secondary sources, such as Ministerial Decrees and guidelines issued by the National Anti-Corruption Authority (hereinafter referred to as "ANAC"). In this way, the Code implements the following EU public procurement directives: i) EU Directive n° 23/2014 on the awarding of concession contracts; ii) EU Directive n° 24/2014 on public procurement, and iii) EU Directive n° 25/2014, which coordinates procurement procedures for the award of the same contracts by entities operating in the water, energy, transport and postal service sectors.

The Code applies to public works, supply and service contracts and concessions awarded by contracting authorities and other awarding entities (e.g., State, regional or local authorities, bodies governed by public law, public companies, etc.). Contracting authorities must indicate a specific tender identification code (called "CIG") or alternatively, the unique project code ("CUP") before the advertisement and award of the contract. In fact, in the pursuit of transparency and fairness, contracts must be easily

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[4] This section (1.2.) reports the main Italian procurement legal features, considering the changes brought by the recent reform. More specifically, this brief summary of the Italian Public Contract Code is mainly based on the text "Italy. Public Procurement 2017" published by the International Comparative Legal Studies website.

identifiable in order to strengthen participation and competition in procurement.[5] The regulation on the transparency of financial transactions (Law n° 136/2010) – which regulates, inter alia, the transaction costs between the supplier and the contracting authority makes this – is compulsory, and the relevant obligations must be clearly included within each public contract to make the contract itself valid.

The Code also provides opportunities for *joint procurement*. Joint procurement refers to instances when two or more contracting authorities, working together, procure the contract. The European Commission encourages the use of joint procurement, since it leads to more efficient management of the procurement process, allowing for administrative cost savings and enabling the pooling of different skills and expertise between authorities (European Commission 2008). However, a recent study in the healthcare sector highlights how the use of joint procurement might entail the risk of concentrating all procurement into the hands of one subject over time, if the presence of multiple providers is not ensured in the market (Mennini et al. 2017).

Conversely, contracting authorities can execute an autonomous tender procedure, if qualified by ANAC to do so. Otherwise, non-qualified contracting authorities shall necessarily purchase works, supplies and/or services from or through a central purchasing body. In Italy, the most relevant purchasing body is *Consip*, a joint stock company owned by the Ministry of Economy and Finance (MEF).

Three main types of contracts are tendered by a contracting authority under the Code specifications:

  i)   public work contracts;
  ii) public service contracts;
  iii) public supply contracts.

Public work contracts include the execution or, jointly, the executive design and the execution of a work that satisfies the needs specified by the contracting body or by the awarding body. Public works refer to activities of construction, demolition, recovery, renovation, restoration, maintenance of works of a variety of public infrastructures including civil buildings, transport infrastructures, health infrastructures.

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[5] Italy adheres to the Government Procurement Agreement ("GPA"), whose purpose is to open tenders to international competition. Tenders should be designed following the principles of equal treatment, non-discrimination, mutual recognition, proportionality and transparency, and to ensure there is no discrimination against foreign products or suppliers.

Public service contracts generally involve the maintenance and servicing of equipment. Main activities include, *inter alia*, maintenance and repair services, management consulting, advertising services, IT and telecommunications services, transport services.

Public supply contracts, instead, are agreements to supply specified goods or services over a certain period of time, and they might refer to the purchase, hire or lease of a product (e.g., vehicles, computers).

All public tenders (work, service, or supply contracts) share the aim of using public resources to obtain value for money. To be efficient, public contracts are procured within an integrity framework that outlines tender procedures and bidding requirements in order to mitigate the potential effects of information asymmetries respectively during the awarding and execution phase (Ancarani et al. 2016).

Awarding procedures are drafted to ensure fairness and transparency and to guarantee the selection of the most efficient bidder. The Code establishes different types of selection procedures, either ordinary or special. Ordinary procedures include:

- *open procedures*;
- *restricted procedures*.

Ordinary procedures are characterized by limited discretionary powers for administrations in the selection of contractors (Baltrunaite et al. 2018). The subject of the contract – and its technical specifications – are accurately defined by the administration itself, so that bidders may only submit non-renegotiable offers. Open procedures require the contracting authority to publish a call for tenders and any interested firms to submit a tender according to the conditions and requirements set forth by the call. Restricted procedures assume the contracting authority solicits or invites firms to submit a request to participate in the tender. Bidders are shortlisted if they meet the requirements of the call.

On a general basis, open procedures ensure better competition and impact on the overall efficiency of the contract (Fazekas and Kocsis 2016). Nonetheless, several studies have questioned the positive impacts of open procedures, based on the widespread abuses in time and costs that characterize the execution phase of public work contracts under competitive procedures (Bajari et al. 2009; Fiorino et al. 2018).

Special procedures include:

- *competitive procedure with negotiation;*
- *negotiated procedure without previous publication of the call for tender*;
- *competitive dialogue procedure*.

In competitive procedures with negotiation, the contracting authority publishes a tender notice which is open to all bidders, but only qualified ones are invited to negotiate the contract. Negotiated procedures without previous publication of the call for tender require awarding authorities to consult the private sector and negotiate the terms of the contract with one or more firms. In the competitive dialogue, the contracting authority publishes a call for tender in which there is a list of both the requisites to be met by the competitors and the evaluation criteria of the bids. In this case, the contracting authority conducts a dialogue with interested firms before inviting the chosen candidates to tender.

Each procedure is adopted only upon the occurrence of specific and exceptional conditions. The negotiated procedure without a call for tender is usually adopted under exceptional circumstances, such as reasons of extreme urgency or if only one market operator possesses specific skills or certifications that are required to execute the contract. A competitive dialogue is adopted when the scope of the contract includes complex financial and legal regulations, or if there was a previous, irregular tender submission.

Negotiated procedures are characterized by significant discretionary powers for the administration, as the contracting authority consults potential suppliers and negotiates contractual conditions with one or more of them. Several papers investigate the effects of discretion in contract awarding, with different results. Coviello et al. (2017) have found that discretion increases the probability that the same firm repeatedly win. However, discretion does not deteriorate performance (Coviello et al. 2017). On the contrary, according to Baltrunaite et al. (2018) increased discretion is associated with a higher likelihood that the winner of the tender is a politically-connected, less efficient firm (Baltrunaite et al. 2018).

The awarding procedure also specifies the selection criteria, which are:

- the most economically advantageous tender criterion;
- the lowest price criterion.

The most economically advantageous tender criterion consists of the best quality/price ratio. This criterion specifically considers both the economic and technical aspects (e.g., quality, price, technical merit, functional characteristics), allowing the awarding authority to pursue the best trade-off. Such criterion is mandatory for some sectors or contracts. The lowest price criterion can only be used under certain circumstances – i.e., when the value of services and supplies is below the EU-threshold, and their technological or innovative content is not significant. It should be noted that, prior to the Code's reform, the lowest price criterion was the main criterion used by contracting authorities to award

a public contract. This criterion has been questioned due to its high correlation with contracts which experienced cost overrun and contract delays upon execution (Decarolis 2014). Nonetheless, the misuse of discretionary power by public officials or bureaucrats could also provide incentives to opportunistic firms, especially politically-connected ones. For this reason, the use of discretionary power might be supported by stricter provisions on conflict of interest (Baltrunaite et al. 2018).

Regardless of the specific case, procedures or criteria, bidders are invited or accepted if their firms meet specific requirements. The bidders' qualification process is highly regulated to ensure integrity, fairness and transparency. Italy has introduced the qualification system for firms with the Presidential Decree n° 34/2000, modified by the Presidential Decree n° 207/2010, and now replaced by the Legislative Decree n° 50/2016. The qualification system stresses the technical, financial and management requirements necessary for the purpose of granting public work contracts, and mandatory for tendered public works worth more than € 150,000 (Ancarani et al. 2016). Namely, three sets of requirements must be met by all bidders to obtain the *Società Organismi di Attestazione* certification (hereinafter referred to as SOA) to participate in any public procurement procedure:[6]

i) *general morality requirements*: directors and administrators of bidding firms should not have been convicted for crimes against the public administration (and related offenses, including involvement in organized crime and financial/tax crimes);

ii) *economic and financial capacity*: bidding firms should be equipped with suitable technical equipment and hold a positive net worth. Bidders who face bankruptcy cannot participate in procurement because of the high risk of compromising the public investment due to pending financial obligations;

iii) *technical professional skills*: the director of works must be in possession of qualifications or a minimum of five years of professional experience as a construction manager.

Norms, procedures and the use of qualification schemes should encourage the completion of the procurement process within a reasonable length of time, as well as the timely delivery of the goods, services and works procured. Changes to contract specifications and timeframe (including extensions), in fact, are not expressly ruled by the Code. In principle, the conditions outlined in the tender documentation are binding for compliance with the principle of equal treatment of competitors. However, a certain

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[6] The SOA certification qualifies firms to negotiate public contracts by work types and reserve price.

degree of flexibility is allowed for minor changes to the tender specifications and timeframe – i.e., if additional works are necessary to complete the public infrastructure. Clearly, no modifications should alter the overall nature of the contract. In this regard, the Code states that technical and economic changes should not be allowed, because they may cause a significant degree of inconvenience or result in a cost increase for the contracting authority.

Nevertheless, budget adjustments appear to be more common than they likely should. Indeed, the Italian system of public procurement is characterized by an abuse of these practices, as has been repeatedly reported by a few studies (Guccio et al. 2012; Decarolis 2014; Guccio et al. 2014). This study attempts to address this issue, by identifying those factors (including the impact of corruption) that reduce the efficient management of a contract and result in cost overrun and time delay. Beforehand, this chapter shortly describes key aspects of the Italian procurement market.

1.3. The structure of the market

Public procurement in Italy accounts for 10-12% of the annual government expenditure in % of GDP (ANAC 2018), and it is carried out at all levels by a pool of over 30,000 contracting authorities, including national ministries, national agencies and publicly-owned companies.

Between 120-140,000 public contracts are issued every year, according to ANAC data regarding contracts for an amount greater than or equal to € 40,000 (ANAC 2016; 2017b; 2018). Over the last years, public service contracts have been growing in relation to the total number of public contracts tendered (from 37 to 40%), while public work contracts have decreased (from 31% in 2015 to 24% in 2017 out of the total number of contracts procured). Public supply contracts have also been increasing in the last three years (from 33% to 36%) (See Figure 1).

About 20% of public contracts are managed by central purchasing bodies, among which *Consip* is the largest purchaser over the period 2015-2017. Central entities were responsible for over 30% of the total expenditure on public contracts over three years. At the regional level, Lombardy on average procured 12% of the contracts commissioned, followed by Veneto, Emilia Romagna and Lazio. Lombardy is also the region which managed the largest share of public funds involved in procurement activities – over € 47,000 billion in the last three years – followed by Lazio, Tuscany, Campania and Sicily (Figure 2).

Figure 1. Contracts issued by type.

2015-2017
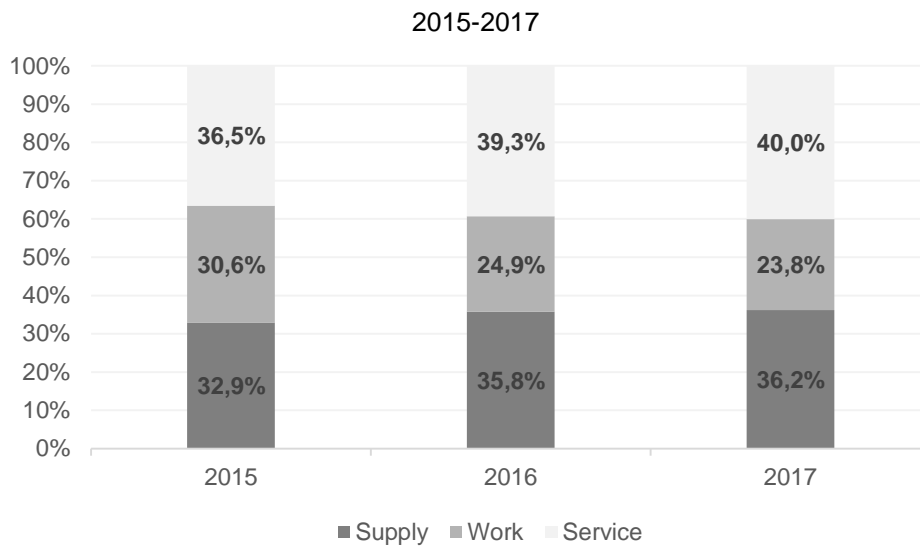
Source: Author's own elaboration of ANAC data

Figure 2. Public Contracts by Competent Office

% of total number of contract and total amount of contracts' value (avg. 2015-2017)
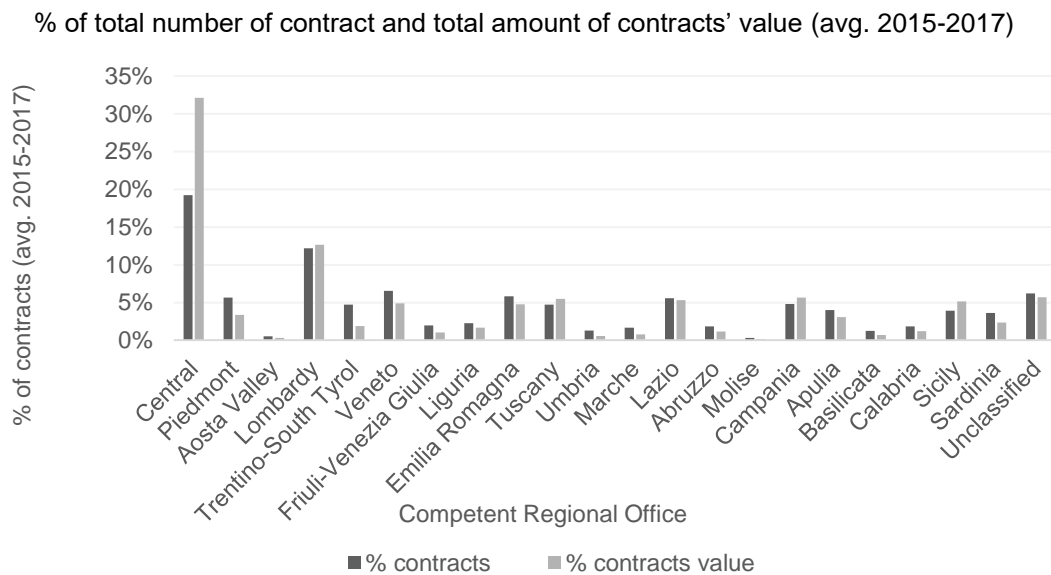
Source: Author's own elaboration of ANAC data

Municipalities managed most of the public contracts procured. Of the total amount of contracts procured between 2015 and 2017, municipalities managed the largest share – about 25-30% – followed by public entities engaged in the healthcare sector (about 20%). Regional and provincial offices, as well as ministries, overall tendered between 5-10% of public contracts. Nevertheless, central agencies on average controlled large projects (more than € 500,000 by contract – Figure 3).

The share of public contracts by reserve price has remained stable over time. The majority of contracts awarded between 2015 and 2017 had an initial tender price below or equal to € 1 million (about 90%), 55% of which are contained within a range that goes from € 40,000 up to € 150,000. Contracts tendered with an initial price higher than € 5

million correspond to less than 2-3% of the contracts tendered yearly (see Figure 4). It should be noted that € 5 million corresponds to the European threshold that allows public work contracts to be awarded at the European level (while for public services and supplies the same threshold is approximately € 150,000).[7] The low rate of public contracts above € 5 million might explain the low share of contracts noticed at the European level (less than 20% of the total number of public contracts), and the low number of foreign bidders being awarded Italian public contracts (about 1%) (European Commission 2016).

Figure 3. Average Contract Value by Competent Office

Average values (2015-2017)
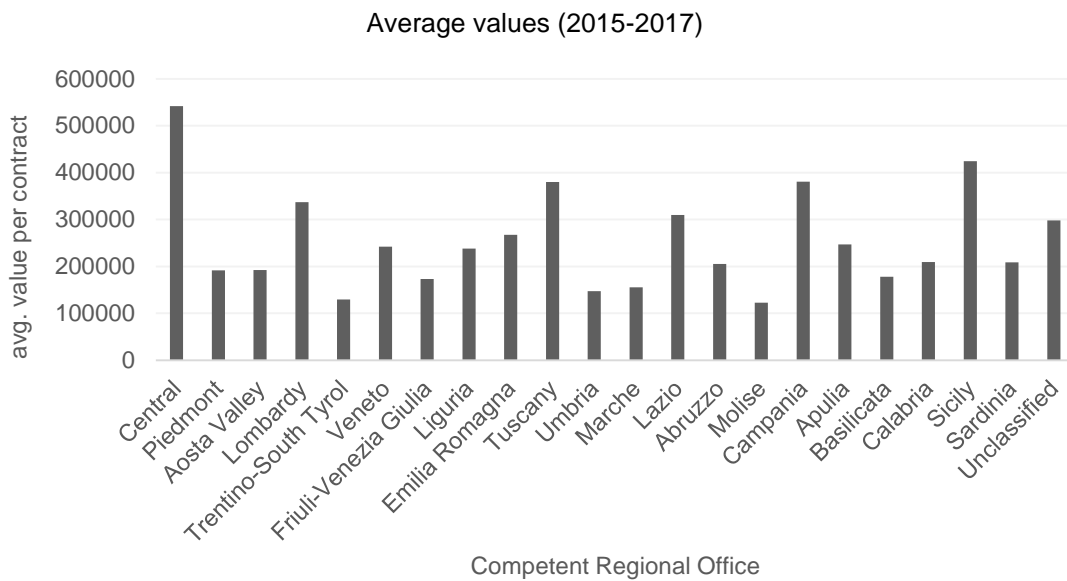
Source: Author's own elaboration of ANAC data

Figure 4. Public contracts by reserve price (excluding direct contracting >€ 40,000)

2015-2017
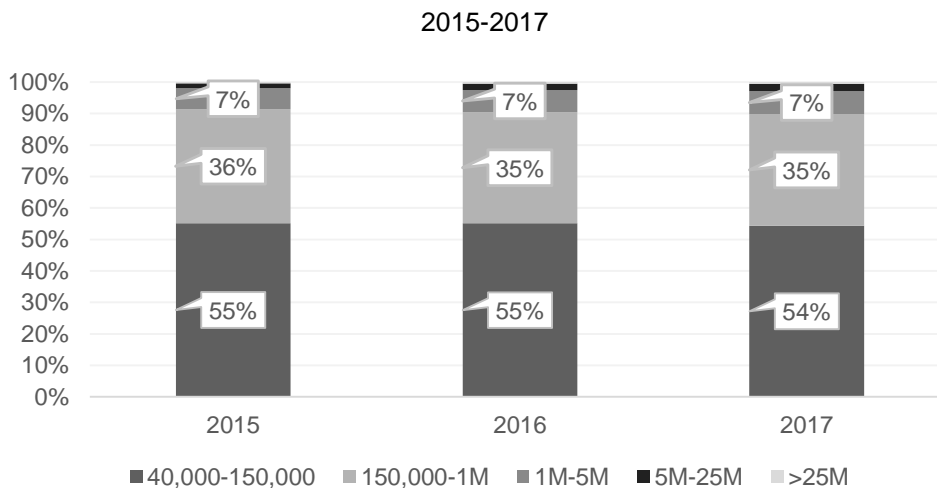
Source: Author's own elaboration of ANAC data

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[7] The EU threshold is € 5,548,000 for public works; € 144,000 for public services and supplies issued by central purchasing bodies; € 221,000 for public services and supplies issued at the regional level.

Of the total amount of contracts issued between 2015 and 2017, only 25-30% of are awarded through competitive procedures (either open or restricted). Italian contracting authorities heavily use negotiations, especially in its form without publication of contract notice, which accounts for 36-40% of procurement contracts. Negotiations have been increasing after the introduction of the new Italian Procurement Code in 2016 (Legislative Decree n° 50/2016), which favors the adoption of discretionary procedures upon awarding (Table 1). The Code also supports the use of the most economically advantageous tender criterion – rather than the lowest price criterion – as a reference criterion to award public contracts. These recent changes also impact the share of single-bid contracts, which according to recent European estimates are about 30% of the total number of contracts awarded at the EU level (Mungiu-Pippidi et al. 2015).

Table 1. Public contracts by type of procedure.

2015-2017

Type of procedure	2015	2016	2017
Open	29.1%	23.5%	25.4%
Restricted	1.4%	2.0%	1.7%
Negotiated with call for tender	2.2%	4.5%	5.2%
Negotiated without call for tender	36.9%	38.6%	40.7%
Direct contracting	28.6%	24.9%	21.2%
Other	1.8%	6.5%	5.9%

Source: Author's own elaboration of ANAC data

Chapter 2. Corruption: concept, determinants and costs

The second chapter introduces corruption and its detrimental influence on public procurement. First, it reviews current definitions and typologies of corruption (2.1.). Then, it discusses its determinants and economic, political and social consequences, with a focus on the public procurement side (2.2.).

2.1. Definition of corruption

2.1.1. Conceptualizing corruption

As a complex criminal phenomenon, corruption is difficult to define. Indeed, corruption is defined differently according to official laws, to how it affects the public and/or the private sphere, and to how it is perceived by public opinion. Corruption is a multi-faceted phenomenon; it changes over time in the public perception and many of its characterizations are normatively charged and context-dependent (Johnston 2009; Lisciandra 2017).

In legal terms, corruption is an act performed with the intent of gaining an advantage inconsistent with official duty and the rights of others. Corruption includes bribery, but it is a more comprehensive concept, as an act may be corrupt without the involvement of a third person/entity (i.e., in the case of misfeasance). The Italian penal code addresses most facets of corruption in great detail (Italian Penal Code Art.314 and following).

Aside from the legal framework, a multitude of approaches and definitions have been proposed in the literature. Heidenheimer and Johnston (2009) distinguish three main complementary approaches:

i)   perception-based definitions (particularly used in perception studies);
ii) definitions with a focus on corruption by public officers;
iii) definitions which focus primarily on the market and private actors.

Perception-based definitions rely primarily on the role of citizens in democratic countries. "*Citizens are the ultimate authorities in democratic nations and the ones who by their complacency and their collision may contribute to corruption taking place or who by their vigilance and integrity may assist authorities in monitoring public officials*" (Gardiner 2009, 25). Whereas the theoretical literature dismisses the public opinion approach unceremoniously, this approach has been adopted without much hesitation in many corruption studies (Heidenheimer 2009; Transparency International 2018). In fact, most

international comparisons are based on subjective opinions (Kurer 2015). However, definitions based on public perception suffer from two major limitations: (1) they are subject to change over time; (2) they differ depending on context, meaning that the perception of the phenomenon is not homogeneous.

State-oriented definitions are certainly more homogeneous in defining corruption as "*the misuse of public office for private gain*" (Rose-Ackerman 1999), which places corruption within a bureaucratic context and implies the payment of a bribe. In accordance with Rose-Ackerman, Nye (2009, 289) defines corruption as "*the behavior which deviated from the normal duties of a public role because of private-regarding influence or pecuniary or status gains*".

Scholars agree that corruption is much more complex than a simple act of misconduct for personal gain. The idea of "*corruption as deviant behavior from normal duties*" leads to major variations in what different countries perceive to be corruption. In fact, the "*normal duties*" of a functionary may change from one country to another. For example, by examining culturally rooted phenomena in some countries, it becomes clear that the moral codes of different societies vary in the extent to which social interactions are accepted as "normal" behavior (Nelen 2014).

From this perspective, little attention is paid to the private actor and its presence in the corrupt environment (Brown 2006). The prevalence of private-centered definitions arises from Latin American countries, where major scandals at the beginning of the XXI century involved large corporate groups. Thus, Argandoña (2003) has claimed that corruption occurs when a manager or employee exercises a certain power or influence over the performance of a function, task or responsibility within a private organization or corporation. Although corruption is certainty not limited to the private sphere, it might appear as *"an extra legal institution used by individuals or groups to gain influence over the action of the bureaucracy*" (Leff 1964, 8).

Thus, it appears that, although there are plenty of definitions for the concept of corruption, there is no definitive consensus. The complexity of encompassing all facets of corruption does not lead to a universal and broader definition of the term, even though it is very much a universal concept. Rather, the content of corruption depends primarily on prevailing norms and conventions (e.g. the UN Convention Against Corruption). This explains the paradox that, although the term corruption is readily understood and broadly applied, there is hardly any agreement as to what does and does not dictate corruption (Kurer 2005). To improve the comprehension of the phenomenon of corruption, the

object of analysis is distinguished into several types, which are presented in the next section.

2.1.2. The various forms of corruption

There is no comprehensive, universally accepted definition of corruption. Many specific forms of corruption are generally understood and applied in a range of numerous academic and legal works, although not all forms of corruption are specifically addressed by penal codes.

The first distinction is between "grand" and "petty corruption" (United Nations 2004). Grand corruption describes corrupt behaviors that pervade the highest levels of government, determining huge losses in term of economic and political stability and sustainment. Petty corruption is sometimes described as administrative corruption and involves exchange of very small amount of money or the granting of small favors. The main difference between grand and petty corruption is that the former involves the distortion of central agencies, while the latter develops at different contexts of governance, which do not automatically involve the presence of high-level public officials. Within this distinction, Jain (2001) has introduced a third category, "legislative corruption", which refers to the manner and to the extent to which the voting behavior of legislators can be influenced.

The second typology is public versus private corruption, which depends on whether the actor who abuses the entrusted power is a public official (e.g., a politician or a civil servant) or a private party (e.g., a company executive). In this sense, depending on whether the public official is a civil servant or a politician, public corruption can be further distinguished between administrative (or bureaucratic) and political corruption (Klitgaard, 1988). The first one generally affects the legal implementation of laws, regulations, and/or policies, while political corruption mainly concerns their formulation (Heidenheimer & Johnston, 2009). In administrative corruption cases, civil servants may act "according to the rules" (e.g., they receive a bribe to accelerate an authorization process) or "against the rules" (e.g., they are corrupted to break the law) (Pope, 2000).

On the other hand, private corruption involves only individuals operating in the private sector, with particular reference to managers or employees who choose to act to their own benefit and contrary to their duties and responsibilities (Argandoña, 2003). Another scenario is the so called "State capture", when governments lose their autonomy to act in furtherance of public goals. This scenario usually refers to systemic private corruption, i.e. when private interests significantly influence a state's decision-making process to their own advantage (Hellman et al., 2000). Nevertheless, state capture might also be

restricted to public corruption if the parties involved are political elites that appropriate some parts or functions of the state and use their resources to the benefit of the group while harming the public good (Grzymala-Busse, 2008).

The third traditional distinction is between passive and active corruption (United Nations 2004). Active corruption refers to the act of offering or paying a bribe, or more generally to the attempt of influencing the behavior of the other agent through illegal instruments. Passive corruption refers to the requesting or receiving of a bribe. Capasso and Santoro (2018) suggest that active corruption corresponds to the demand of a bribe, while in passive corruption the agent has the bargaining power and sets the amount of the bribe.

Bribery is usually considered as a synonym of corruption, but it is specifically the act of conferring a benefit or reward in order to influence a decision or action of a public official in an improper way (United Nations 2004). Bribe can take a variety of forms: cash, company shares, insider information, political favors or the promise of future employment. However, not all acts of corruption result in the payment of bribes. It is also important to distinguish bribes from gifts. Although the relation between bribes and gifts can change in accordance with the cultural setting, in many instances, bribes can be distinguished from gifts. A bribe implies reciprocity, while a gift should not (Tanzi 1998).

Embezzlement is another form of corruption. In the context of corruption, embezzlement involves the fraudulent appropriation of money or property for personal gain by an individual entrusted to safeguard assets in another's interests (e.g., governments, organizations, or companies) (OECD 2008). Embezzlement is conceptually close to fraud, which implies the use of deception to convince the owner of funds or assets to surrender them to an unauthorized party. However, in the first case, embezzlement implies the diversion of funds held by a public or private official because of his/her office, while in the second case, the property stolen belongs to the victim.

Broadly, embezzlement is a type of abuse of power (or abuse of function) which is the performance of an act by a public official, in violation of laws, for the purpose of obtaining an undue advantage for themselves or for another person or entity (United Nations 2004). Abuse of function usually flourishes in contexts characterized by high levels of conflict of interests, e.g., when a public official uses their discretionary powers to purchase services from a company in which she/he holds a personal interest.

Trading in influence (also known as influence peddling or traffic of influence) is another form of corruption implying the use of personal connections with influential people to obtain preferential treatments. It is generally defined as a situation where a person misuses his/her influence over the decision-making process for a third party (person,

institution or government) in return for its loyalty, money or any other material or immaterial undue advantage (OECD 2008) Trading in influence is somehow not distinguishable as a single corrupt act, as all influencing practices are interrelated to one another to influence the decision-making of the entire system (Slingerland 2011).

Apart from this general distinction, there are many different definitions and conceptualizations of corruption which vary according to cultural, legal and political elements. Even within the approaches and typologies presented above, there is no universal consensus on which acts should be considered (or not considered) as corruption. For this reason, any operative definition of corruption should be tailored to the specific area of interest of a study, avoiding generalizations that fail to cover the several facets of this phenomenon (Johnston 1996).

The difficulty in defining corruption lies also in the fact that corruption is a social phenomenon that continues to evolve, both in terms of its type and extent. Corruption is affected by various determinants, which encompass social and cultural settings, institutional and organizational structures, political environments and economic and structural policies (Serra 2006; Treisman 2007). All these social changes shape the circumstances in which corruption manifests and how corruption is understood and defined.

In public procurement, the presence of corruption implies the misallocation of public funds, which should be allocated to comply with public interests. In the case of corruption, the two main agents – the contracting authority and the supplier – agree on maximizing their rents and their personal benefits to the detriment of the community and/or the competitors. Corruption in public procurement can emerge in a variety of forms (e.g., bribery, abuse of power, embezzlement) and at different stages of the procurement process, from contract awarding to contract execution. As a result, corruption in procurement usually determines a diversion of public funds. It derives that corruption can be identified by "following the money", which means by analyzing those public bodies which are paying more than what has been allocated to complete a public infrastructure project or to provide a public service. Inevitably, there are different forms in which corruption occurs in procurement, and only in some of them does the corruption involve the payment of a bribe or cost overruns. However, given the difficulties of conceptualizing this phenomenon, which also implies a difficulty in measuring it, it is necessary to adopt a strategy to address and target corruption. Before addressing questions relating to its measurement, the next sections briefly introduce the determinants and the negative consequences of corruption in the public procurement sphere.

2.2. **Corruption: causes and consequences**

2.2.1. The determinants of corruption

Corruption is determined by many factors, including economic factors, political and administrative capacity, judicial systems and socio-individual drivers. In the literature, causes of corruption have been extensively investigated. However, according to both theoretical and empirical investigations, there is still contrasting evidence on some causality nexus and even on the signs of correlation (Lisciandra 2014). The extent and the sign of the relationship between corruption and its causes can change depending on the level of analysis. Specifically, some of the macro-level (e.g., country-level) relationships among corruption and its drivers might not be valid within countries at sub-national level (i.e., the relationship between government spending and corruption). Moreover, overlaps between causes and consequences of corruption are also acknowledged.

Economic factors comprise a wide range of economic variables, such as income or economic policy variables. Economic development is a significant predictor of corruption, although several studies have questioned the relationship between income growth and corruption. Richer countries tend to have less corruption than poorest ones (Serra 2006; Fiorino et al. 2012). Several studies have found that lower perceived corruption correlates closely with higher economic development (Treisman 2007). Nonetheless, income distribution in developed countries might increase the risk of corruption (Paldam 2001), even if Brown et al. (2005) find no evidence that greater income inequality increases corruption.

Corruption impacts foreign trade, usually curbing investments (Seldadyo and de Hann 2006). Foreign investors and/or competitors usually target less corrupt countries to run their businesses (Kenny and Crisman 2016). According to Treisman (2000), an increase in import share leads to less corruption. Likewise, economic freedom is also found to lessen corruption. Broadman and Recanatini (2000) show the existence of a positive relationship between entry barriers and corruption; that is, the greater the barriers to entry and exit faced by firms, the greater the distortions existing in the competitive environment, the more widespread is corruption.

On the political end, political stability and democracy seem to reduce the likelihood of corruption. Democratic institutions exert a certain control on corruption only when they have been continuously held for decades (Serra 2006). Political participation and political competition increase the ability of the population to monitor and legally prevent politicians from engaging in corrupt behaviors (Seldadyo and de Hann 2006). Press freedom lowers

the probability for corruption to occur as it is a highly effective mechanism of external control on corrupt practices (Brunetti and Weder 2003). Furthermore, democratic regimes lead to more inclusivity, i.e. a higher share of female workforce, which decreases the likelihood of corruption (Swamy et al. 2001).

The impact of government size on corruption is controversial. One view is that the expansion of government provides more opportunities for rent-seeking, thus increasing corruption (Rose-Ackerman and Palifka, 2016). Tanzi (1998) argues that extensive governmental involvement in economic activity, especially through investment projects and procurement spending, increases the number of corrupt acts, although this largely depends on the efficiency of the public sector. Public investment requires large amounts of money. This provides opportunities for officials to misuse public funds if there is no effective supervision. In poorly managed countries, corruption leads to increased public investment, but also results in largely ineffective investments, reducing the pull effects of public investment on economic growth (Chen et al. 2018). The opposite view is that larger governments promote checks and balances in governmental departments, so government expansion will reduce opportunities for corruption (Fisman and Gatti 2002).

The impact of governmental decentralization is also disputed. On the one hand, a decentralized government lowers corruption. Local governments compete to attract labor and investment through optimizing the business climate, thus increasing competition between jurisdictions, motivating government control and reducing corruption (Fisman and Gatti 2002). Additionally, it is easier for citizens to monitor bureaucrats in a decentralized government. On the other hand, according to Brown et al. (2005), a federal structure is more conducive to corruption. Corruption may be higher at the local level because the relationships between private agents and public officials are closer and more frequent, and because the potential briber only needs to influence a segment of the government (Tanzi, 1998; Treisman 2000). However, Lessmann and Markwardt (2010) assume the influence of decentralization on corruption depends on the effectiveness of social supervision.

On an administrative level, the level of civil servants' wages has a clear negative relationship with corruption levels. An increase in wages significantly lessens corruption; it attracts more talented staff to the public sector, thus increasing the government's ability to control corruption (Klitgaard 1988). By increasing civil servants' wages, the opportunity cost of corruption will increase, leading a rational public official to forego some rent-seeking opportunities (Chen et al. 2018). Furthermore, bureaucratic promotion based on merit decreases the extent of corruption, while the presence of nepotism and patronage

affects the quality of the bureaucracy, thus increasing opportunities for corruption (Charron et al. 2017).

Rule of law also plays a key role in preventing and fighting corruption. Greater degrees of legislative and regulative complexity increase episodes of corruption (Lisciandra 2014). Conversely, the rule of law can limit corruption in two ways. First, a good legal system places more attention on protecting property rights and prompting government transparency, thereby limiting bureaucrats' corruption. Second, corrupt behaviors are more likely to be found and punished in countries with stronger law enforcement and effective judicial systems (Chen et al. 2018)

Along with economic and political factors, social and individual factors are also important to understand and measure the extent of corruption in a society. Even for social determinants, however, controversy still exists. Generally, higher education is beneficial in reducing corruption. Better educated citizens are more responsible and more critical towards corruption (Chen et al. 2018). Increasing levels of education can strengthen: (a) people's awareness of government supervision and their anti-corruption consciousness; (b) lower acceptance of corruption. On the contrary, Fiorino et al. (2012) have found that more education can also increase the ability of the private and public actors to bypass and evade regulations.

Finally, trust results to be helpful in fighting corruption since it helps bureaucrats to better cooperate with each other and with private citizens (Della Porta and Vannucci 1997). Rothstein and Uslaner (2005) support the negative association between trust and corruption. Concerned with the causality, they claim that trust lowers corruption while the opposite causality is less robust. Despite the positive impact of trust on mitigating corruption, some types of trust can also be a facilitator for corrupt transactions. Since corrupt deals cannot be legally enforced, it requires trust among the partners that their favors will be reciprocated (Lambsdorff 2006a).

2.2.2. The negative impacts of corruption

This section investigates the negative effects of corruption on the socio-economic and institutional system. Corruption produces either indirect or direct costs to the society and the economy of a country (Lisciandra 2014). Some of the consequences listed in this section overlap with the causes described in the previous section because of the contrasting evidence on some causality nexus.

Corruption negatively impacts economic growth (Mauro 1995; Aidt 2009; Lisciandra and Millemaci 2017) by distorting market mechanisms and by generating inefficiencies, which reduce overall competitiveness, trade and foreign direct investment (Søreide 2002).

Kenny and Crisman (2016) have found that corrupt countries lack exposure to foreign competition, as foreign investors usually target less corrupt countries to run their business. However, Dreher and Gassebner (2013) have found evidence that corruption facilitates firms' entry in highly regulated economies by speeding up the slowness of an inefficient bureaucracy. On the contrary Kaufmann and Wei (1999), in analyzing the relationship between bribes, time spent by management in paperwork and cost of capital, have found that firms paying larger bribes are those which lose more time on paperwork as a result of negotiation with public officials.

On the institutional side, the existence of check-and-balance mechanisms across different branches of government, an adequate level of transparency and a degree of competition in the political system promote a sense of accountability (Lederman et al. 2005; Serra 2012). Conversely, the absence of a sense of civic engagement and accountability at various institutional levels reduces trust in public institutions (Lederman et al. 2005; Mungiu-Pippidi et al. 2015). As a result, a political and institutional system becomes more vulnerable to corruption, as firms begin to bribe politicians to determine policy (Søreide 2002; Fazekas and Tóth 2014a). Thus, it is evident that corruption has a negative impact on political participation: corruption undermines citizens' belief in the political system and the legitimacy of democracies (Gaventa 2002) and may increase tolerance for the use of violent means to achieve political ends (UK Department for International Development 2015).

Corruption in the public sphere also impacts the quality of public goods and services purchased (Rothstein 2011; Charron et al. 2014). This problem is particularly acute in infrastructure and construction projects, where productive inputs (e.g., construction materials) tend to be replaced by lower-quality supplies to generate extra-rents to be extracted during the implementation of the public work (UK Department for International Development 2015). While an agent must typically choose between various clients, in cases of corruption, the decision is biased in favor of those clients who pay the largest bribe, rather than those who provide the highest quality (Lambsdorff 2006a). Burguet and Che (2004) have demonstrated the detrimental effect of corruption by studying a corrupt public officer's willingness to rig his/her evaluation of bids in exchange for bribes. The authors argue that the inefficiency cost of bribery is in the same order of magnitude as the agent's manipulation capacity. If the agent has substantial manipulation power, bribery makes it costly for the efficient firm to secure the win and thus, an inefficient firm is likely to win the contract.

Corruption also alters the labor market. Corruption acts as a disincentive to participation and fosters the recruitment of unsuitable human resources, which affect productivity and

distort investments (Mauro 1995). It also increases the extent of the informal economy. Murphy et al. (1991) show how profits from corruption are invested in further activities of rent-seeking and not in productive activities. This explains why countries with higher rates of corruption tend to be those with the lowest rates of private investment (Mauro 1995) and/or foreign direct investments with respect to GDP (Wei 2000), and a larger size of the informal economy (Chen et al. 2018).

Corrupt agreements increase the costs incurred by society and the negative impact on different spheres and/or settings of the day-to-day functioning of a society. Although it is difficult to measure the exact cost of corruption due to its secretive nature, it has been estimated that between 10% and 30% of the investment in publicly funded construction projects may be lost through mismanagement and corruption (CoST 2012). Within the EU, corruption is estimated to cost €120 billion per year (PWC 2013), which represents approximately 1% of the EU's GDP. This is only slightly less than the EU's 2014-2015 annual budget, which amounted to around €143 billion (European Commission 2014b, 2015). Globally, the World Economic Forum and the World Bank estimate that corruption costs more than 5% of global GDP ($2.6tn) annually, and that more than $1 trillion is paid in bribes annually (World Economic Forum 2012).

From this brief overview, corruption clearly bears very high costs in terms of opportunities, freedom and rights. Corruption consumes economic resources and weakens social bonds. Even worse, endemic corruption becomes part of every citizen's way of thinking – a shortcut to achieve personal and private interests. For these reasons, it is imperative to understand, measure and target corruption. To this purpose, the next chapter summarizes previous studies which highlight criminal opportunities emerging throughout the public procurement chain, within a theoretical framework which is based on the identification and analysis of corruption risk in public procurement.

Chapter 3. Corruption risk assessment

This chapter illustrates the theoretical approach adopted in this dissertation. Section 3.1. proposes economic and criminological theories to frame corruption in the public procurement. Section 3.2. provides an extensive review of the corruption opportunities which emerge in all stages of the procurement chain. Section 3.3. introduces existing corruption measurements and presents the research gaps on the matter.

3.1. Theories of corruption

The study of corruption in public procurement involves researchers from different disciplines, especially economists with an interest in public finance. While empirical works on this topic are quite relevant in terms of size and content, theoretically there is much less debate on corruption. The slow development of corruption theories, despite the high number of corruption studies in both economics and political science, is also a consequence of the difficulty in providing definitions tailored to one specific domain (Lisciandra 2017). Procurement studies are generally conducted (1) on the basis of a critical approach to the role of the state and its governance – i.e., institutional theories (Lambsdorff 2007) – or (2) by focusing on the rational choices of individuals who exploit corruption opportunities for personal gain – i.e., the economic theory of crime (Becker 1968) or agency theory (Laffont and Tirole 1993). The former studies how corrupt behaviors are modeled by culture, structures and cognition within the organization. The latter examines the role that regulation and other incentives plays in reducing criminal opportunities. Rational choice theories also lay the foundations of crime opportunity theories (Felson and Cohen 1980, Clarke 1980, Brantingham and Brantingham 1993), which argue that offenders commit crimes rationally if the attractiveness of the illegal opportunity is higher than the attractiveness of the social behavior or conduct. The integration of these different approaches gives rise to an interesting interpretation of how institutions should foster prevention throughout a deeper understanding of (1) high-risk opportunities emerging along the procurement chain that can influence asymmetric information, and (2) the positive incentives that can reduce asymmetric information among agents involved in the procurement process.

3.1.1. Agency theory

Becker (1968) developed the rational choice framework to explain why people commit crime. Under this framework, an individual looks at the expected gains and losses from

crime and compares them with the gains and losses from staying out of crime. The individual is rational and chooses to commit a crime if the net expected gains from crime are greater than the net gains from not committing crime. Becker's rational theory has been expanded and incorporated in several theoretical approaches, including agency theory. Agency theory declares that modern societies are characterized by the existence of very structured hierarchies in which individual relationships are structured around delegation. In such a situation, the principal-agent problem occurs when one person or entity (the "agent") takes decisions and/or actions on behalf of, or that impact, another person or entity (the "principal"), in the absence of complete information about the agent itself (Laffont and Tirole 1993). Laffont and Martimort (2002) observe that the agent is selected based on his/her specialized knowledge and the principal can never hope to completely check the agent's performance. Accordingly, delegation is particularly problematic because information about the agent is imperfect, which can bring the agent to:

i) conduct an act based on private information ignored by the principal (adverse selection);
ii) conduct an act unobserved by the principal (moral hazard).

Informational asymmetries create an imbalance of power in transactions that can incentive adverse selection or moral hazard. In public contracting, adverse selection categorizes principal-agent models in which an agent already owns private information before a contract is written, which limits the selection of the most efficient contractor. In this case, the principal is not aware of former informal deals signed by the agent. Moral hazard is typically defined as "post-contractual opportunism". In this case, the agent – which has different interests from the principal's – acts opportunistically based on information unknown to the principal. For example, the contractor does not carry out the work in a way that was expected according to the contract. It usually occurs when a supplier provides misleading information (e.g., in relation to production costs) and changes its behavior after the deal is signed (Cox et al. 1996). Both moral hazard and adverse selection exist in circumstances where agents are motivated to act in their own best interests, which are contrary to those of their principals because of (1) unaligned goals or (2) different aversion levels to risk (Laffont and Martimort 2002). In this scenario, the principal-agent relationship gives rise to opportunistic behaviors if:

i) the agent has an informative advantage;
ii) the principal's and the agent's objectives do not coincide;
iii) the agent has low morality.

It follows that preventive strategies should attempt to reduce the opportunistic behavior of the agent by increasing the level of risk perceived by the agent itself. In this sense, different preventive efforts must be combined to reduce dysfunction and promote integrity and accountability. On the one hand, prevention strategies should be designed to increase the probability of detection and sanction. In this sense, enhancing the collaboration between watchdog agencies and professionals can reduce information gaps and make anti-corruption actions more effective (Khoman 2017). On the other hand, prevention strategies should provide the principal with more knowledge to select the agents who are best endowed in morality and skills necessary to run procurement activities efficiently (Ancarani et al. 2016). In order to select the most efficient contractor, the Italian procurement system has introduced a qualification system which stresses the technical, financial and management requirements necessary for the purposes of granting public work contracts.

This qualification system has beneficial effects on the functioning of the procurement system (Estache and Iimi 2012). Ancarani et al. (2016) have found evidence that fully qualified firms are more efficient in the execution of public work contracts than not-fully qualified firms. Nonetheless, several scholars have recognized that qualification does not provide disincentives for firms to act opportunistically. Spagnolo (2012) suggests the use of reputation as a mechanism to reduce the moral hazard of opportunistic firms. Reputational factors may rule out distortion in contract awarding, allowing to select the most efficient contractor and provide the supplier with the correct incentives (Doni 2006; Ancarani et al. 2016). Reputation is relevant in the assignment of a contract to the most skilled firm, and it can have positive effects on public procurement outcomes (Calzolari and Spagnolo 2016; Fiorino et al. 2018).

3.1.2. Crime pattern theory

Sutherland was the first to introduce the term "*white-collar crime*", defined as "*a crime committed by a person of respectability and high social status in the course of his occupation*" (Sutherland 1952, 183). Scholars have built upon Sutherland's definition to investigate and understand both white-collar crimes and white-collar criminals. Currently, despite the relevant impact of this approach, many researchers have argued in favor of abandoning it and switching to a perspective that relies more on the mechanisms or the *modus operandi* in the offenses (Felson and Clarke 1998). Specifically, one strand of literature by Benson et al. (2009) observes that all forms of white-collar crime occur within an opportunity structure. This means that a set of conditions must be in place for the offence to be committed.

Within the opportunity theory framework, three major theories have laid the foundations for the study of criminal opportunities: routine activity theory (Felson and Cohen 1980), situational crime prevention theory (Clarke 1980) and crime pattern theory (Brantingham and Brantingham 1993). These theories address how crime opportunities are formed by immediate environments, and then discovered and evaluated by potential offenders. It should be noted that all opportunity theories embrace different perspectives, and are all influenced by previous theories (i.e., social learning, rational choice and interactionism). According to Cloward and Ohlin (1960), for example, criminal opportunity impacts criminal behavior due to its influence on the development and maintenance of a delinquent subculture in a "social learning process". The above-mentioned theories all have a common background and patterns. One is related to the environment – also called "*network*" – where the criminal activities are committed. These networks provide offenders with a "place" to access their victims or the resources of their victims (Clarke and Eck 2003).

Crime pattern theory is conceptually better suited to pursuing the objectives of this dissertation. According to this theory, offenders become aware of criminal opportunities as they engage in their normal, legitimate activities (Brantingham and Brantingham 1993). The opportunity structure for any particular white-collar crime is dependent on the "*nodes*" and "*paths*" used by the offender. The nodes of a white-collar criminal include the business or organization they work within, and any other outside agency, organization or peers with whom the white-collar criminal is associated. The paths refer to the mechanisms used or exploited to break the law for personal gain (Brantingham and Brantingham 1993; Felson and Clarke 1998; Benson et al. 2009).

In public procurement, the nodes concern either the private firm winning the public contract or the contracting authority awarding the tender. On the one hand, the private firm can exploit its personal or political ties with the contracting authority in order to extract rents from the public contract (Goldman et al. 2013). On the other hand, the private company can be part of a collusive agreement in which connected firms bid together to ensure the contract to a pre-selected bidder within the collusive network (Conley and Decarolis 2016). In the first case, the nodes include the two main actors: the supplier and the contracting authority. In the second case, the nodes refer to the private sector in its entirety.

The paths do not just refer to the type of corrupt act involved (e.g., bribery, trading in influence or conflict of interest), but also to those legal artifices that a company may use to hide fraudulent and/or opaque schemes. For example, a company can hide its structure behind a corporate veil (OECD 2001) or by implementing other strategies that

make it more difficult for law enforcement and judicial authorities to monitor and prevent illegal activities. Therefore, it is important to recognize that the opportunity structures of a firm are often connected with a legitimate business activity. Public officers and/or bureaucrats can also act strategically to gain benefits for themselves. For example, a politician can decide to award a contract to a specific bidder in exchange for the promise of future employment (Fazekas et al. 2015).

From this perspective, opportunities may be characterized as attractive or unattractive from the standpoint of a certain agent (or group of agents). The degree of attractiveness of opportunity is determined by at least four factors (Benson et al. 2009):

i) the actors' perception of the potential gain. An actor decides to be involved in corrupt schemes if he/she perceives the benefits of his/her choice to be higher than the costs;

ii) the perception of potential risks, such as the likelihood that a criminal act will be detected and the severity of the sanctions that would be invoked if detected;

iii) the compatibility of the opportunity with the ideas, rationalizations and beliefs of the actors;

iv) the evaluation of an illicit opportunity in comparison with other licit opportunities the actor is aware of, which influence the actors' entire opportunity structure (Hollinger and Clark 1983; Benson et al. 2009).

Thus, a decrease in the attractiveness or availability of legitimate opportunities will increase the attractiveness of illegal opportunities (Coleman 1987).

As a result, corruption in public procurement can be regarded as the intersection of at least two processes. The first is a legitimate process that is followed or employed in the public or business world, and the second is an illegitimate process that is "parasitic" to the first. Prevention involves adjusting the legitimate process to stifle individuals' ability to act illegally in relation to it (Benson et al. 2009).

3.1.3. From theories to prevention

The two theories described above circumscribe the phenomenon of corruption in public procurement to the rational action of the agent, identified in the supplier to which a public contract is awarded. The agent acts in a known environment/system. In this environment, the agent evaluates possible illegal opportunities to commit a crime based on personal information, which are unknown or unobserved by the principal. This information influences (1) the agent's degree of morality and (2) its attraction to criminal behaviors. If the perception and evaluation of the benefits is greater than the perception and

evaluation of the costs, the agent will be inclined to take advantage of the illegal opportunities to obtain a personal advantage.

Illegal opportunities can arise throughout the entire process, from the pre-award stage to the contract implementation phase. The agent exploits the criminal opportunity according to the information it owns, to obtain the maximum rent from the awarded contract. In order to extract the rents – or distribute the rents among the corrupt network – the actual costs declared for the realization of the public contract must be greater than the real costs borne by the private firm (Fazekas et al. 2016). This implies that the agent rationally has the intent to delay the delivery of the public contract or increase the economic demand, e.g., through the submission of false invoices or through misreporting techniques (Passas 2007), or through manipulation of the system by falsely inflating needs (Transparency International 2013b).

A sound preventive strategy requires the identification of the features of the settings that allow the crime to occur. In fact, control and prevention depend on how the crime is performed by the agent within the range of structural opportunities. To address corruption in public procurement, the first preventive action is to analyze all 'environmental opportunities'. Environmental opportunities can provide the agent with asymmetric information, i.e., confidential information regarding tenders can place some bidders at a greater advantage during the pre-awarding stage. A deeper understanding of the corruption opportunities emerging along the procurement chain helps the monitoring activities of institutional agencies and watchdogs, and the identification of positive incentives that can reduce asymmetric information among agents involved in the procurement process. The next section explores the corruption opportunities emerging along the procurement chain.

3.2. Identification of corruption risk

Corruption in procurement occurs when one or two corrupt agents involved in a legitimate process encounter attractive illegal opportunities to increase their personal gain (Benson et al. 2009). Corruption manifests in different forms, including bribery, facilitation payments and collusion, conflicts of interest, bid-rigging and trading of influence (Wickberg 2013). Each of these forms of corruption can arise in one (or more) phase(s) of the procurement process, regardless of sector or scale.

Thus, the identification of illegal opportunities in each stage of the procurement chain is the first step to provide an overall assessment of the risk of corruption in public procurement. Indeed, each stage has specific vulnerabilities that expose the entire

procurement process to corrupt activities (Caneppele and Martocchia 2014). The procurement cycle unfolds over three main stages, each of which engenders different types of corruption risk:

- the needs assessment phase and bid-design phase (pre-tender);
- the award phase (tender);
- the contract implementation and the final accounting and audit phase (post-tender).

3.2.1. *The needs assessment and bid-design phase*

The needs assessment, bid-design, award and implementation phases of procurement are much more strictly regulated than before, also due to the implementation of the EU Directive on Public Procurement (e.g., EU directive n° 24/2014), which determines the types of procedures that must be implemented for contracts of a certain value to ensure the competitive nature of the process.

The first phase (the needs assessment and bid-design phase) involves addressing the public and business needs, preparing the tender documentation and advertising the tender, *inter alia* (The World Bank 2016). The needs assessment phase is an internal step to establish the public needs and objectives and to arrange the allocation of financial resources in the short term. In this phase, procuring entities often need to consult with the private sector to determine the available solutions – a process known as market research. After conducting market research, the procuring entity chooses the selection procedures and specifies the technical criteria for the evaluation of offers. Subsequently, in the bid-design phase, the tender documents are prepared. The tender documents specify the chosen requirements, including any conditions regarding quality or safety standards. To ensure competition and promote transparency, procuring entities should advertise the call for tenders so as to receive the maximum number of offers and guarantee private sector suppliers' access to tendering opportunities.

In this phase, the contracting authority is entitled to manage the entire process. Negligence, inattention or errors at this stage can create many opportunities for corruption, even more so in situations where conflict of interest is not fully regulated and criminalized by the law. In such cases, corrupt individuals can manipulate the system by falsely inflating needs, or deliberately skewing cost estimates or provision for errors (Transparency International 2013b). Early communication with the private sector can be risky if only a few suppliers are consulted during the market research process, limiting not only competition but also the opportunity to extract the best value for public money (The World Bank 2016). Access to confidential information regarding tenders can place

some bidders at a greater advantage. This is exactly how corrupt informal networks win public contracts in seemingly fair competitions (Fazekas et al. 2013). The risk at this stage is that the tender is designed in such way that it favors a particular bidder rather than addressing a specific need. Furthermore, the tender can be constructed with the aim of discouraging the participation of non-corrupt competitive bidders (Transparency International 2013b). Either a tender can implicitly nominate the favored suppliers, or it can require too many technical specifications (Ferwerda et al. 2017). Among the known corrupt practices in public procurement, Søreide (2002) argues that the most recurrent ones involve the pre-selection of a favored bidder through hidden violations of ordinary procurement rules.

Once a tender process is open, the tender provider can still dissuade competitive bidders by maintaining a lack of transparency within the contracting process and by circulating private information to favor a particular client (Ferwerda et al. 2017). The simple act of publishing the necessary announcements is far from sufficient to prevent the risk of corruption: accuracy, completeness and clarity of information are essential (OECD 2009). Public procurement tendering is open and transparent only if the necessary tender documents are easily and cheaply accessible. If documents are difficult or expensive to obtain, a number of potential bidders may be excluded, or at least discouraged from competing (Fazekas et al. 2013). Finally, even a small omission or error can have considerable consequences. For example, categorizing a call for tender in the wrong economic sector (according to CPV nomenclature) can effectively exclude potential bidders (Fazekas et al. 2013).

3.2.2. The award phase

In the award phase, the procurer puts forward a call for tender. Bidders issue the requested documents, as well as their economic and technical proposal. The procurement officer subsequently evaluates all proposals and determines to whom the contract will be awarded. Procuring entities must justify their decisions in accordance with the criteria outlined in the first stage. Once the best bid has been identified, the contract is awarded, and the bidders are informed of the procuring entity's decision (in both cases of acceptance and rejection) before the contract is executed. According to EU Directives, losing bidders can appeal within 10 days before the contract is signed (European Commission 2014a). If they do so within this period, the tender is suspended until the reviewing body issues its ruling. It is worth noting that, due to privacy laws and trade secret considerations, their chances of success are rather low (Fazekas et al. 2013).

In this phase, corruption risks remain high, as it is more difficult for law enforcement to monitor and detect criminal activities. In particular, the process of scoring is difficult to control for external bodies, especially in the case of subjective evaluation criteria (Fazekas et al. 2013). If scores are given to benefit a 'desired' company, this clearly infringes upon the principle of fair competition and poses serious risks of corruption. There is also a risk of corruption when evaluation criteria are not clearly stated in tender documents, as this provides no grounds upon which to justify the decision of awarding the tender to a certain supplier (Ferwerda et al. 2017). As such, evaluation criteria can be tailored to a specific supplier, compromising both transparency and fairness (equal opportunity). Other risks at this stage might be related to a failure to provide adequate public notice (benefiting insiders) about contract awards and the acceptance of late proposals or the rejection of legitimate ones (Transparency International 2013b).

3.2.3. *The contract implementation and final audit phase*

In the contract implementation phase and final audit, the winning bidder must provide the works or services as per the contract, within the agreed timeframe and at the predetermined cost. Local authorities oversee the fulfilment of the contract. Monitoring and reporting are two key activities in pursuing the proper allocation of funds and detecting irregularities in contract execution. For this reason, during contract implementation and once the implementation period ends, public authorities or independent authorities should conduct financial and performance audits (Transparency International 2014).

Fraudulent activities in execution of a contract usually take the form of contract modifications, cost overrun or time delays (Ganuza 2007; Guccio et al. 2012; Fazekas and Dávid-Barrett 2015; OECD 2016). Extra income can be generated through the submission of false invoices or through misreporting techniques (Passas 2007). If any deviations are not the result of negligence or contractual obligations, then a contract must be officially modified and announced in the Public Procurement Gazette. The most recurrent techniques to extract personal rents from a contract are: the renegotiation of costs and time required to complete the tender (Guccio et al. 2012), the production of a good which does not meet the contract specifications (EU Court of Auditors 2015) and the subcontracting out of services to third parties in opaque circumstances (Fazekas and Dávid-Barrett 2015). Due to such risks, adopting clear and transparent limits for contractual changes, in procurement laws or in the actual contracts, serves as an effective safeguard against post-tendering manipulations (Transparency International 2006; Wickberg 2013). In this phase, financial and technical audits can also raise several

issues in terms of corruption opportunities. Deficient separation of financial duties and/or lack of supervision of public officials can lead to false accounting, cost misallocation and advanced interim payments (OECD 2016). Each of these opportunities can encompass those organizational behaviors that can trigger dynamics of corruption and bad governance. The next section focuses on the existing measures of corruption and highlights the current estimation gaps that will be addressed in chapter 4.

3.3.   Measuring the risk of corruption

3.3.1. Subjective and objective indicators of corruption

Corruption is intrinsically secret and therefore difficult to measure. Two are the most widely known cross-country measures of corruption: Transparency International Corruption Perceptions Index (Lambsdorff 2006b) and the World Bank Control of Corruption Indicator (Kaufmann et al 2010). These two indicators rely on surveys that measure experts' and citizens' perceptions of the prevalence and nature of corruption.[8] Perception-based measures suffer from many shortcomings (Olken 2009; Escresa and Picci 2015):

- the type of corruption assessed through these surveys is not precisely defined;
- they measure first-hand experience of corruption, which are usually biased toward a certain type of corruption (bribery);
- they reinforce inferences made by experts and survey respondents, based conventional understandings of corruption in a "virtuous circle";
- they are not designed to allow country scores to be compared over time.

Alternative measures are represented by victimization surveys and bureaucratic quality indicators. Victimization surveys also investigate direct experience of corruption by questioning whether public officials have asked for or expected bribes from the respondent in the preceding year. Recently, the Italian national bureau of statistics (ISTAT) has introduced a series of questions in its 2015-2016 survey on the safety of citizens, in order to examine the phenomenon of corruption (ISTAT 2017a). Still, results from victimization surveys are affected by respondents' reticence in answering questions related to their participation in corrupt activities. Furthermore, the Quality of Government Institute (Charron et al. 2014) has developed an indicator based on a survey

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[8] Other perception-based measures include the Bribe Payers Index (BPI) and the Global Corruption Barometer (GCB), developed by Transparency International; the World Business Environment Survey (WBES) and the Business Environment and Enterprise Survey (BEEPS) developed by the World Bank.

administered to over 85,000 respondents about the extent to which they perceive and experience corruption, quality and impartiality in services such as education, healthcare and law enforcement, among other public-sector functions. Nonetheless, the quality of government indicators reflects differences among countries in bureaucratic capacity, but not in corruption levels.

Due to the shortcomings of the subjective corruption indices, many researchers adopt objective corruption indicators for measuring the extent of corruption. These indicators are mostly based on actual statistics, such as detected corruption cases, e.g., by using the number of complaints and/or convictions for corruption offenses committed by public officials as identified by the legal system. Yet, these indicators represent only a very small part of total corruption, since undetected corrupt behaviors will inevitably lead to underestimation of corruption. Within this type of objective indicators, Golden and Picci (2006) have developed an indicator which estimates the impact of corruption in the capability of Italian regions to transform financial resources into infrastructural endowments. In order to measure missing infrastructure, they compare existing infrastructure with the total monetary investment in each region. Golden and Picci attribute this gap to corruption. However, while the measure cannot specifically differentiate between corruption and inefficiency, it might overestimate the extent of corruption in a certain region, to the extent that (1) any inefficiency is genuinely not related to corruption and (2) some regions are significantly and systematically more or less efficient than others, again for reasons entirely unrelated to corruption (Heywood and Rose 2014). In a similar way, Olken (2009) has constructed a "missing expenditure" measure of a road-building project in rural Indonesia by estimating the price inputs for road construction and comparing these to official expenditures. As above, this indicator partially reflects corrupt behaviors, while it appears to measure the efficiency of the infrastructural sector instead.

Neither subjective nor objective indicators reflect the extent of corruption comprehensively and accurately, and many scholars have argued about bias in these indicators (Andersson and Heywood 2009; Heywood and Rose 2014). Thus, a third "generation" of corruption measurement has started to be developed, using open and big data. Third generation measures adopt a less subjective, transparent and reproducible methodological approach. They do not rely on a select group of experts to assess the level and nature of corruption. Hlatshwayo et al. (2018) propose two indices: (1) NIC, a cross-country news flow index of corruption; (2) anti-NIC, a cross-country, anti-corruption news flow index. Fazekas et al. (2016) have developed a cross-country risk indicator of corruption by analyzing public procurement announcements in 2009–14 in

the EU-27 (excluding Malta) and Norway. Clearly, corruption indicators leveraging a big data approach still need to be tested and validated as, in most cases, they illustrate dynamics only partially related to corruption. Despite some limitations, the use of big data has two main strengths:

- the indicators are based on micro-level data which allow multi-level aggregation;
- they allow for consistent temporal and cross-country comparisons.

The next section delves into the recent corruption indicators developed at the procurement level. Afterwards, it highlights the current shortcomings and the strategy adopted to overcome many of the limitations of current procurement-related corruption indices.

3.3.2. *Existing proxy measures of corruption in public procurement*

Corruption in public procurement is usually observed through case studies or on a perception basis. Available measures at the national and sub-national level – such as administrative or judicial statistics on offenders reported to the police, and subsequently prosecuted or sentenced – are considered as unreliable for corruption offences in public procurement, due to the high "dark numbers" and data variability (UNODC 2009).[9] Police data on corruption only encompasses a narrow segment of all corruption activities, typically connected to bribery. Moreover, the rulings expressed by judicial files cannot be generalized and used for comparative purposes. Regardless, neither police data nor judicial statistics prove to be useful for conducting a detailed analysis at the contract level.

The increasing availability of open and big data has provided researchers with the possibility to design new corruption indicators, usually through a deductive logical process (Arbia 2018). Fazekas et al. (2016) have combined tender-related variables associated with low performance in procurement and low competition to develop a composite risk indicator of corruption in procurement at the contract level. However, despite the presence of a transparent methodology, the indicator is difficult to replicate across countries, due to data availability concerns. Furthermore, numerous red flags have started to be identified and used as a proxy-measure of corruption (Auriol et al. 2016; Fazekas et al. 2016; ANAC 2013; Ferwerda et al. 2017; Gori et al. 2017), although

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[9] Dark numbers refer to undetected corruption acts.

most of them are primarily considered by the European Commission as measures of procurement performance (Flynn 2018).[10]

The majority of the red flags empirically identified in the literature consist of single indicators that assess the different types of procedure, selection methods and bidding behaviors that increase the risk of corruption at the contract-award level. Within this group of red flags, two are most commonly used and discussed: (1) the adoption of restricted or negotiated procedures (Auriol et al. 2016; Fazekas et al. 2016); (2) single-bid contracts (Fazekas et al. 2013; Mungiu-Pippidi et al. 2015; Doroftei 2016).

According to the literature, they both signify a lack of fair competition, which generally enables contracts to be awarded at higher prices than market value and facilitates the extraction of corrupt rents (Rose-Ackerman and Palifka 2016). The use of negotiations not only reduces competition, but also the opportunity to obtain the best value for public money. Competitors may consider a specific tender to be a 'done deal' for some favored company, and thus decide not to participate (Mungiu-Pippidi et al. 2015; Doroftei 2016). Despite these considerations, recent investigations have questioned their usefulness, suggesting that they might be the result of dynamics not related with corruption (i.e., market entry barriers or high concentrated sectors). Indeed, two large-scale investigations on Italian procurement contracts indicate that single-bidding is less likely in areas with a high presence of corruption (Milani et al. 2018), and that these flags should be redesigned so as not to overestimate the presence of corruption in public procurement (Melandri et al. 2018).

Other red flags measure the degree of transparency of the contracts procured. Ferwerda et al. (2017) have investigated the impact of publishing the contract award and the justification documents on the reduction of corrupt transactions, and found a strong, positive correlation between the two. Transparency prevents colluded firms from participating in transactions and has a positive effect on bidding levels by encouraging skilled firms to participate in procurement (Ochrana and Pavel 2013; Kenny and Crisman 2016). However, the mere introduction of rule-based and transparent practices in the qualification of bidders is insufficient to substantially weaken opaque relationships between government officials and firms (Ohashi 2009). Moreover, the use of this indicator suffers from a lack of generalizability, as it cannot be extended and replicated using the same methods in contexts characterized by different degrees of openness and transparency (Mendes and Fazekas 2017).

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[10] These indicators are: (i) one bidder, (ii) no calls for bids, (iii) joint procurement, (iv) use of discretionary awarding criteria, (v) speed of decision making over contract awards, and (vi) quality of information reported by the contracting authorities.

Alternative red flags examine the political connections of winning bidders to investigate how these connections affect a firm's market success (Goldman et al. 2013; Mironov and Zhuravskaya 2016). The proximity between a firm and the contracting authority enhances conflict of interest and increases the likelihood of corruption. Firms connected with high-level politicians in their own countries economically support political activities in exchange for procurement contracts. Therefore, they experience higher profit margins than their competitors, especially during election years (Fazekas and Tóth 2014a; Mironov and Zhuravskaya 2016). However, the possibility of developing this proxy is limited. The political connection between private companies and public officials is difficult to measure due to the lack of complete data regarding corporate boards of directors, politicians and bureaucrats. This risk indicator is also strongly tied to contexts characterized by a strong restriction of competition or the presence of oligopolistic industries, such as in former Soviet countries (Fazekas and Tóth 2014a; Mironov and Zhuravskaya 2014).

3.3.3. Measurement gap and research objectives

To date, several studies have focused on the identification of opportunities that increase the probability of corruption in the procurement process. Following the identification of risk opportunities, the attempt to generate new corruption risk measures in procurement has led to the development of a set of red flags at the contract level. Numerous red flags reflect the restriction of competition and the lack of transparency in contract awarding. For example, Auriol et al. (2016) have found that the use of exceptional types of procedure is associated with an increase in corruption in public tenders. Fazekas et al. (2013) have also detected a correlation between single bidding and corruption.

The wide range of indicators adopted within the literature relies primarily on single narrow indicators, which may not necessarily represent the primary vehicle for corruption. For example, on the one hand, single-bid contracts (Mungiu-Pippidi 2015) can signify a lack of fair competition or 'done-deal' contracts before awarding, but, on the other hand, they might be the result of dynamics not related with corruption, i.e., market entry barriers or highly concentrated economic sectors. More broadly, these single indicators can surely flag opaque circumstances (i.e. bidding behaviors increasing the risk of corruption), but taken as such they risk to overestimate or to misrepresent corruption in public procurement (Melandri et al. 2018; Milani et al. 2018).

Most of the risk indicators at the contract level fall short of addressing issues of representativeness, context-dependency, comparability, accuracy and time-dependency, which limits the possibility of capturing the phenomenon of corruption in procurement in a proper way. This study seeks to fill the current gaps in the research

through the development of a novel methodology based on the use of big data on public contracts in Italy, and to derive a more fitting estimate of corruption risks at the contract level in the Italian context (chapter 4). Moreover, this study addresses the risks related to bidders who win potentially corrupt procurements. Chapter 5 explores the possibility of developing firm-level risk indicators to flag characteristics indicative of firms associated with a risky contract. Therefore, the second aim of this study is to identify patterns of risk in the suppliers' profile (regarding either their economic performance or their ownership structure).

Chapter 4. Estimating corruption risk at the contract level

4.1. Introduction

In the execution of public works there are multiple factors leading towards sub-optimal results in terms of time delays and cost overruns, also referred to as inefficiency. Inefficiency can be explained by different drivers, inter alia: the complexity in design specification, inaccurate cost forecasting, optimism bias, opportunistic behaviors, and corruption (Bandiera et al. 2009; Finocchiaro et al. 2014). Yet, the additional time and costs for the execution of public works contracts can also be severely influenced by corruption, which may be difficult to detect and measure.

Current corruption indicators are often inadequate for understanding the determinants and impact of corruption (Heywood and Rose 2014; Fazekas and Kocsis 2017). On the one hand, audits of individual cases cannot be generalized due to their narrow scope and lack of representativeness. On the other hand, the identification of single red flags or composite indicators suffers from several weaknesses: (1) context-dependency of the data limits the possibility of replicating and comparing results across countries; (2) lack of accuracy exposes to the risk of overestimating or to misrepresenting corruption within the public sector; and (3) lack of time variation provides a static snapshot of the corruption risks. The limitations of available corruption risk indicators make it difficult to properly assess the impact of corruption on procurement outcomes.

In order to overcome some of the limitations of the existing measures, this chapter proposes an innovative transparent and practical methodology to derive a more fitting estimate of corruption risks at the contract level in the Italian context. The proposed measure rests on a thorough understanding of corruption in the procurement process and solely derives from objective open procurement data to allow for comparisons and replicability using pre-existing and accessible data on public contracts.

This chapter is organized as follows: Section 4.2. introduces the analytical approach proposed in this dissertation and it reviews the factors leading to sub-optimal results upon contracts execution. Section 4.3. presents the methodology to develop the corruption risk indicator at the contract level. Section 4.4. introduces the data and the results and Section 4.5. discusses the strengths and limitations of the research as well as future research and policy implications.

4.2. The analytical strategy

4.2.1. The residual approach

This study proposes an innovative methodology to measure the risk of corruption at the contract level by adopting a *residual approach*. Corruption in public procurement is treated as a source of inefficiency – one of the causes of sub-optimal results in contract management. Inefficiency in contract management indicates that public bodies are paying more than has been allocated to complete a public infrastructure. However, according to previous studies on the Italian context, cost overrun in contracts execution tends to be the result of "*passive waste*" ('pure inefficiency') rather than "*active waste*" (corrupt transactions) (Bandiera et al. 2009). There is no even trade-off between the two forms of waste, which suggests that corruption can be identified by inefficiency and not as a complementary phenomenon (Bandiera et al. 2009).

Therefore, to measure corruption, the first step consists in the identification of two indicators – widely investigated in the literature – to research inefficiency in contract execution, namely cost overrun and time delay (Ganuza 2007; Flyvbjerg 2008; Finocchiaro Castro et al. 2018). These two indicators may also flag the presence of corruption in contract management. Indeed, according to previous literature (Bandiera et al. 2009; Guccio et al. 2012; Finocchiaro Castro et al. 2018), corruption is one of the sources of inefficiency leading to cost overrun and time delay. These two indicators are combined to generate a new single indicator of inefficiency, which 'encloses' both inefficiency and corruption. Subsequently, this single indicator of inefficiency is explained by means of factors that only denote the presence of 'pure inefficiency' in contract execution. It is worth noting that the factors encompassing corruption are excluded from the specification. Once the specification is performed, the estimate residuals are extracted and treated to be considered as a proxy measure for corruption. Following this procedure, a new indicator of corruption risk in public procurement is generated.

4.2.2. Inefficiency factors in contract management: active and passive waste

Inefficiency in contract management is generally measured through cost overruns and time delays (Guccio et al. 2012; Finocchiaro Castro et al. 2014). Cost overruns are the additional costs incurred by contracting authorities above those agreed upon award of the contract. Delays refer to the discrepancy between the actual time for the completion of the work and the length of time agreed upon. The presence of delays may imply cost overruns when additional works are required. This happens when a delay is caused by difficulties occurring during the realization of the project, thus requiring a revision of the

contract (Decarolis and Palumbo 2015). Delays may, however, generate social welfare losses rather than costs incurred by the contracting authorities (Lewis and Bajari 2011). For this reason, there can be delays without cost overruns, and vice-versa.

Corruption in public procurement is one of the sources of inefficiency in public work contract execution. Corruption negatively affects project performance because it delays delivery times and increases infrastructure costs (Wells 2013; Locatelli et al. 2017). For example, at the Expo event in Milan in 2015, the realization of the main infrastructure, also known as "la Piastra", experienced an increase in costs for over €60 million due to corrupt agreements between the awarding body and the winning bidder (Barbieri and Giavazzi 2014; Milani et al. 2018). As stated in the previous chapter, corruption can emerge at different stages of the procurement stages. At the contract awarding phase, underbidding can also be a means through which to secure a bid, only to renegotiate the contract at a later stage (Chong et al. 2014). Higher rebates result in low quality of work, ex-post renegotiation and high variance in costs and rent extraction through subcontracting (Transcrime 2008; Decarolis 2014). Possible savings in contract awarding can be thwarted by collusive behaviors among bidders (Conley and Decarolis 2016; Reeves-Latour and Morselli 2017). In the case of collusion, prices tend to significantly increase after the cartel collapses (Estrada and Vazquez 2013; Conley and Decarolis 2016).

Unlike corruption, inefficiency is the result of a decision-making process that is hampered by individuals with different interests acting strategically in a way that results in poor results (Cantarelli et al. 2012). Contracting authorities might deliberately misrepresent information, for example, by underestimating the planned costs. According to Ganuza (2007), the level of complexity in design specification can affect the outcome of a project. For example, underinvestment in design specification may cause significant cost overruns during contract implementation. If cost estimates are inaccurate, then resources are used less appropriately. Inaccurate estimates make it difficult to manage large projects and often lead to cost overrun, which impacts the national GDP (Cantarelli et al. 2010; Locatelli et al. 2017). Poor initial design and inaccurate cost forecasting tend to require substantial changes in the execution stage. This is the result of a practice known as "*optimism bias*" (Flyvbjerg 2008). An optimistic design may represent an instrument for changing priorities across different projects. This can increase the number of works that are started even if, in the long run, many of them remain unaccomplished (Guccio et al. 2012).

Similarly, cost overrun may be due to rent-seeking activities. Firms can act opportunistically, and exploit contract incompleteness to obtain additional money, over

and above what has been agreed upon (Palguta and Pertold 2014). Procurement features connected with the nature of the contract (fixed price vs. cost-plus contracts) and with the contract awarding procedure (competitive procedure vs. negotiations) may also affect the strength of the firms' incentives to behave opportunistically (Bajari and Tadelis 2001; Estache and Iimi 2008).

Accordingly, contract indicators such as cost overrun and time delay embed two sources of inefficiency: passive waste and active waste. On the one hand, cost overrun can be determined by, inter alia, poor planning design, inexperience, and lack of suitable infrastructure for the realization of the project (passive waste). On the other hand, cost overrun can be caused by corruption (active waste). For this reason, to identify corruption this study tries to rule out all sources of passive waste from the indicators of cost overrun and time delay. Once the indicators do not exhibit traits of passive waste, it is possible to identify the traits of active waste, which refer to corruption.

4.3. The estimation method

4.3.1. Data Envelopment Analysis

The most effective instrument to measure the relative efficiency (and inefficiency) of contracting authorities in achieving the target results – with regard to time and cost – remains that of benchmarking their performance. In other words, for a given input of time and cost, best performers are those that minimize the actual time and costs. Data Envelopment Analysis (DEA) is used to benchmark the relative performance of each public contract.

DEA is an operational research technique, which is based on non-parametric linear programming with the objective of comparatively analyzing independent units in terms of their relative performance, without any assumption regarding data distribution. DEA identifies productive benchmarks as those decision-making units (DMU) that exhibit the lowest technical coefficients, i.e., the lowest input amount to produce one unit of output. In doing so, DEA allows for the identification of the best performer and for the comparison of each DMU with the best possible performer among its peers (Charnes et al. 1978). In this case study, each public work contract represents a DMU.

Considering that DEA represents a deterministic approach, any result deviating from full efficiency can be interpreted as inefficient. Inefficiency levels are measured as the distance between each observation unit and the defined best practice frontier. DEA formulation is here defined in accordance with previously applied studies in the Italian

context, using agreed time and cost as the input and the actual time and cost as the output (Guccio et al. 2012; Finocchiaro Castro et al. 2014; Guccio et al. 2014; Finocchiaro Castro et al. 2018; Cavalieri et al. 2017). An input-oriented constant return-to-scale approach (CRS) is adopted, which reflects the fact that output will change in proportion to the input. CRS approach is used because outputs are not expected to increase or decrease disproportionately to inputs.

More specifically, the DEA mathematical formulation (Simar and Wilson 2007; Cavalieri et al. 2016) is presented below. The public procurement chain is intended as a process where a number of input vectors – the time and cost agreed upon in the contract – $\{x_1, \ldots, x_n\} \in \mathcal{R}_+^N$ are needed to produce some outputs – the actual time and cost of realization of the public infrastructure – $\{y_1, \ldots, y_m\} \in \mathcal{R}_+^M$. This process is constrained by the possibility set Ψ, which is the set of potential values (x, y) of each input and output given by:

$$\Psi = \{(x, y) \in \mathcal{R}_+^{N+M} \mid (x, y) \ is \ feasible\} \tag{1}$$

The inefficiency level of each contract is measured by the distance between the observation unit and the best performer of Ψ. By replacing Ψ with the estimator $\widehat{\Psi}_{\text{DEA}}$, the equation is expressed in this way:

$$\hat{\theta}_{DEA}(x, y) = \inf\{\theta \mid \theta(x, y) \in \widehat{\Psi}_{\text{DEA}}\} \tag{2}$$

where $\hat{\theta}_{DEA}(x, y) \leq \theta(x, y)$.

As the calculation of inefficiency may suffer from data collection errors or factors attributed to chance, which can compromise the estimates (Dong and Featherstone 2006), several rules regarding the number of inputs and outputs that can be selected and their relation to the number of observations are followed (Sarkis 2002; Toshiyuki and Goto 2013). Bootstrap procedures are used for more consistent results, as suggested by Simar and Wilson (1999, 2007). Bootstrap procedures correct the obtained values by estimating a confidence interval that might contain the true efficient frontier. This technique provides additional noise to the estimator, with the objective of making the estimator more robust.

The bootstrap bias estimate can be calculated as follows:

$$\widehat{BIAS}_B = B^{-1} \sum_{b=1}^{B} \widehat{\theta_b^*} - \hat{\theta} \tag{3}$$

where $\widehat{\theta_b^*}$ is the DEA efficiency score for sample $\{b=1, \ldots, B\}$, where B is the total number of pseudo samples generated by bootstrap simulations, $\hat{\theta}$ is the estimate of θ and $\widehat{BIAS}_B$ is the bias estimation. The bias corrected DEA efficiency score $\hat{\theta}_{DEA\_CORR}$ is obtained as follows:

$$\hat{\theta}_{DEA\_CORR} = \hat{\theta} - \widehat{BIAS}_B = 2\hat{\theta} - B^{-1}\sum_{b=1}^{B}\widehat{\theta_b^*} \tag{4}$$

Once the inefficiency scores are calculated from the efficiency score of each lot (DMU), a regression analysis is conducted to investigate the impact of environmental variables and contract-level variables on bias-corrected inefficiency scores. It is assumed that the DEA scores can be regressed on a set of environmental variables in the following specification:

$$\hat{\theta}_{DEA}(x,y) = f(z_i) + \varepsilon_i \tag{5}$$

where $\hat{\theta}_{DEA}(x,y)$ represents the inefficiency scores calculated from the equation (2), z_i is a set of inputs (environmental and contract-level variables) and ε_i is a vector of error terms.

A truncated regression is performed in accordance with previous literature. Rather than the Ordinary Least Squares regression (OLS), the truncated regression is chosen in order to exclude from the second stage analysis those observations whose distance from the optimal frontier is equal to 0 (Simar and Wilson 2007; Périco et al. 2016; Finocchiaro Castro et al. 2018).[11] In addition, because traditional estimators yield biased estimates, due to the serial correlation of efficiency scores, Montecarlo simulations are used to ensure a feasible and consistent inference on the second-stage regression (Simar and Wilson 2007).[12] In particular, for the estimation of the specification, Simar and Wilson's first algorithm is followed (2007).

A regression analysis is conducted to isolate the corruption component (active waste) from inefficiency using a *residual approach*. To this purpose, the inefficiency factors identified in the literature are operationalized and included within the specification. Four categories of factors are distinguished to facilitate the identification and measurement of the inefficiency factors (the inefficiency factors are extensively described in the next section). It is important to note that only variables with a strong connection to inefficiency, both at the regional and the contract level, are included in this stage. Instead, corruption (in any of its manifestations) is not included in this specification. Indeed, if the inefficiency indicator does not include active waste, it becomes possible to identify corruption using the *residual approach*.

Furthermore, a sensitivity analysis is conducted with the following aims:

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[11] Alternatives regression models, such as Tobit (or censored) models are not considered as consistent; Simar and Wilson (2007) show that Tobit model estimation leads to the violation of the assumption of independence between the set of variables z_i and the vector of error terms ε_i.
[12] The technical details of the bootstrap procedures are debated by Simar and Wilson (2007), and reported also by Périco et al. (2017).

- to compare the findings from different specifications (truncated regression vs OLS regression);
- to test whether the results are driven by the selection of variables, by excluding one set of variables at a time from the final specification;
- to replicate the analysis using different samples and verify the extent to which the results are driven by the selected sample.

The different specifications are conducted to verify the internal consistency of the methodological approach adopted. Once the tests are performed, in the third phase, the estimation residuals are used as proxy measures of corruption in public procurement.

4.3.2. *Estimating corruption from second-stage truncated regression residuals*

Following the two-stage semi-parametric technique adopted to estimate the inefficiency scores for each DMU, residual scores from the second-stage truncated regression are transformed into a new indicator of corruption risk at the contract level. The residuals of a set of observed values are the difference between the observed value and the estimated value of the quantity being measured. In the second-stage regression, the inefficiency indicator from the DEA was regressed on the factors that increase inefficiency in contract execution. The factors included refer to different dimensions that can impact the overall inefficiency of a contract: the contract itself, the agents involved, and the environment. Since the corruption drivers were excluded from the specification, the estimate residuals are treated as a proxy measure of corruption. Indeed, the assumption here is that any inefficiency factor that does not embed any active waste should be included in the truncated regression model to better estimate corruption from the estimate residuals.

Therefore, the residual scores obtained are normalized (0-1). Scores indicate the relative risk of corruption for each lot, from low corruption risk (closer to 0) to high corruption risk (closer to 1). The scores produced can be aggregated at the territory level from micro-to macro-settings, to produce scores for municipalities, provinces and regions. This operation is key to monitoring and assessing areas highly vulnerable to corruption. In addition, corruption risk scores can be used to identify the least performing and most vulnerable contracting authorities, providing a new updated tool to assess their relative performance.

For robustness check, the corruption scores are validated in two ways: (1) they are compared with different environmental measures of corruption, (2) they are cross-checked with actual evidence of corruption collected from open sources. The first strategy compares existing measures of corruption with the one produced in this study.

Corruption measures at regional and provincial levels are retrieved from different sources, such as police records and judicial statistics, administrative statistics, victimization data, and available econometric estimates.

The second strategy cross-checks 250 randomly assigned cases with actual information from online sources. The cases were selected from different clusters of the corruption scores. To standardize this operation, a query was generated to cross-check contract information (description, awarding year, contracting authority name and supplier name) with keywords indicating that an illegal activity connected to corruption had occurred (arrest, arrest warrant, process, handcuffs, etc.).[13] Subsequently, the cases are classified into three categories: *white cases*, *grey cases* and *black cases*. The *white cases* indicate the public contracts to which no illegal activities are ascribed. The *grey cases* are characterized by the online presence of articles referring to illegal activities conducted by either the contracting authority or the supplier, but for which it is not possible to link the information to the contract itself or to the time when the contract was awarded. The *black cases* refer to public contracts for which an investigation has been initiated (against either the contracting authority or the firm). This category also includes contracts awarded during a period of time when the competent authorities detected serious irregularities in the awarding of public contracts by the contracting authorities. For both the query construction and the classification, a double-blind test was conducted. In this way, the two validation strategies described should provide consistent and robust evidence of the validity of this approach to estimate corruption risks in procurement.

4.4. A corruption risk indicator on Italian public contracts

4.4.1. Data on public contracts

The theoretical and analytical strategy described is applied to the MEF data on public works.[14] The database contains over 500,000 public works ("*Opere Pubbliche*", distinguished by the CUP code), and 300,000 calls for tenders ("*Gare Pubbliche*", distinguished by the CIG code). Roughly 60,000 tenders were awarded during the sample period (2007-2015). The sample size is further reduced to only include tenders for which information on the final date of completion and the final costs is available, bringing the total down to 9,691. The period of time considered excludes the tenders notified before the reform 163/2006, and those notified after the reform 50/2016. In

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[13] See Annex for further details on the query formulation.
[14] MEF data on public works are available at http://www.bdap.tesoro.it. Data downloaded on 15th March, 2018.

addition, only reserve prices greater than €40,000 are considered, to avoid including instances of direct contracting. These operations ensure consistency of the observations included within the sample. On the one hand, only contracts governed under the same procurement code are included; on the other hand, contracts directly awarded without a tender call are excluded.

At a first glance, a marked reduction in the sample – compared to the size of the ministerial database – is noticeable. The accuracy of information concerning public contracts typically suffers from many limitations, which reflect issues in data collection, data transmission, and data standardization before publishing (Fazekas 2017a). Many of the issues on the quality of the information and representativeness of the sample derive from external factors (i.e., the willingness of public functionaries to reporting the data, the standardization of the information, etc.), which limit the possibility of correcting sample effects. To mitigate sample biases, a semi-parametric analysis technique, which does not assume that data are normally distributed, is used.

A range of selection procedures to further reduce selection bias is also adopted. It has been noted that the contracts awarded between 2007 and 2015 differ in terms of contract length, which can create further bias. In fact, most of the contracts awarded in 2015 has yet to be finalized. To reduce this bias, only contracts with a maximum length of three years are included – regardless of the initial tender period – reducing the sample to contracts started between 2007 and 2013. In this way, it is possible to compare public works contracts of similar lengths. Moreover, the extent of contract delays also varies according to the initial tender year of contracts included in the final sample. In order to include only contracts finalized by the end of 2017 with a comparable delay span, the sample of tenders considered for the analysis is further delimited. To reduce the effect of delays – which influences the calculation of the efficiency scores – only contracts delivered with delays of comparable length are included in the final sample. It has been decided to include only delay of up to 253 days, which corresponds to the 95th percentile of the distribution of delays within the sample selected. In this way, it is possible to obtain a more balanced sample to run the analysis. Therefore, all the contracts in the sample have a maximum length of three years and must have been completed within a specific delay which cannot be larger than one year. Figure 5 displays an example of a three-year contract which began in 2013 and was completed with a delay in 2017.[15]

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[15] As the choice to limit the sample including contracts with a maximum length of three years and delay up to 253 days is arbitrary, the analysis is carried out on several samples of contracts to check for robustness (see section 4.4.3.) and the technical annex for further details.

Figure 5. Example of a contract from the final sample.
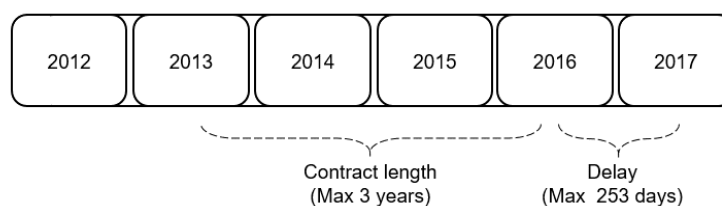
Source: Author's own elaboration

The final sample consists of 4,940 tenders that were awarded in Italy between 2007 and 2013. Contracts are distributed across all Italian regions. Tuscany (10%), Lazio, Lombardy, and Sardinia (9%) are the most represented regions, while Molise, Valle d'Aosta, and Basilicata are the least represented regions (1-2%) (Table 2). The correlation between the regional distribution of contracts of the final sample (N=4,940) and the regional distribution of the sample of contracts (with information on the final date of completion and the final costs) awarded from 2007 to 2015 (N=9,691) is verified, to check for consistency after the selection procedure. Results (r=0.95) indicate that the final sample does not differ from the previous one in terms of representativeness.

Table 2. Regional distribution of public work contracts
Full Database (2007-2015) and selected sample (2007-2013)

Regions	Full Database	Sample
Abruzzo	160	104
Basilicata	217	95
Calabria	372	204
Campania	197	108
Emilia-Romagna	765	375
Friuli-Venezia	293	174
Lazio	915	480
Liguria	360	184
Lombardy	852	451
Marche	305	161
Molise	151	50
Piedmont	559	283
Puglia	922	377
Sardinia	839	490
Sicily	554	252
Tuscany	946	502
Trentino-South Tyrol	226	98
Umbria	243	117
Aosta valley	49	26
Veneto	766	409
Total	9691	4940

Source: Author's own elaboration of MEF data

The number of contracts per region included in the final sample also correlates to the regional distribution of public work contracts presented by ANAC (2018) in the annual statistics (r=0.68) and reported in section 1.3. The selection represents a scenario close to reality.

Table 3 shows that the largest number of contracts is between 40,000 (38.2%) and 500,000 euros (43.9%) of tender values. Only 23 public work contracts have an initial value higher than € 5 million, thus published at European level.

Table 3. Distribution of the selected sample of public work contracts by reserve price

Thousands of euros

Reserve Price (class of)	Sample
40-150	1886 (38.2%)
150-500	2168 (43.9%)
500-1000	545 (11%)
1000-5000	318 (6.4%)
>5000	23 (0.5%)
Total	4940 (100%)

Source: Author's own elaboration of MEF data

The majority of the contracts has been procured by municipalities (about 65%), followed by provinces and state-owned firms (Table 4), and refers mainly to social infrastructures (40%) and transportation infrastructures (32%), as reported in Table 5. Moreover, more than 15% of contracts refer to environmental infrastructures which provide safe water supply, waste disposal, and pollution control services.

Table 4. Distribution of the selected sample of public work contracts by type of contracting authority

Type of contracting authority	Sample
Municipality	3183 (64.4%)
Province	469 (9.5%)
Region	139 (2.8%)
Ministry	34 (0.7%)
Local Health Agency	158 (3.2%)
Local Entity	239 (4.8%)
State-owned Firm	451 (9.1%)
Other	267 (5.4%)
Total	4940 (100%)

Notes: Province includes Metropolitan areas. Ministry include the Council of Ministers.
Source: Author's own elaboration of MEF data

Table 5. Distribution of the selected sample of contracts by type of public work

Type of public work	Sample
Civil Building (House)	36 (0.7%)
Environmental	754 (15.3%)
Cultural Heritage	105 (2.1%)
Energy	259 (5.2%)
Transportation	1586 (32.1%)
R&D	137 (2.8%)
Health	47 (1%)
Security	38 (0.8%)
Social Infrastructure	1978 (40%)
Total	4940 (100%)

Source: Author's own elaboration of MEF data

4.4.2. Computing DEA scores

The first step of the empirical analysis is to identify the inputs and outputs necessary to conduct a DEA analysis. To evaluate the efficiency of a contract, it is necessary to

determine the actual length and the actual costs for the realization of the public work. Efficient contracts fulfill contractual terms. Inefficient contracts may encounter delays and require additional financial resources. The volume of contracts that experience an increase in cost and time is relevant.

Table 6 provides summary statistics concerning the dataset. The share of contracts that required additional time to reach completion is approximately 15%, while cost overruns occurred in 88% of the contracts.[16] For the efficiency estimation, the planned time for infrastructure completion (days) and the costs envisioned for infrastructure completion (thousands of euros) are the inputs, while the actual time of infrastructure completion and the actual costs of infrastructure completion are the outputs. Public contracts have a minimum length of nine days and a maximum length of three years, while the average awarding price is about €350,000.

Table 6. Main statistics of time and costs variables.

Variable	Obs.	Mean	Std. Dev.	Min	Max
Time delay (yes=1, no=0)	4940	0.15	0.36	0.00	1.00
Cost overrun (yes=1, no=0)	4940	0.88	0.32	0.00	1.00
Planned Length (days)	4940	448.43	282.43	9.00	1,095.00
Actual Length (days)	4940	452.89	279.76	9.00	1,327.00
Planned Costs (€)	4940	3.53E+05	2.32E+06	23,100	1.57E+08
Actual Costs (€)	4940	4.58E+05	3.92E+06	25,000	2.70E+08

Source: Author's own elaboration of MEF data

To control for sampling variation, bootstrapping (500 replications) is used to correct the DEA estimates. Efficiency scores and bias-corrected efficiency scores are the product of the bootstrapped robust DEA. The main statistics are described in Table 7. The DEA identifies only three fully efficient units. This indicates that public works are not usually performed at optimal efficiency. The average efficiency is 0.8, while the minimum value is 0.58.[17]

Table 7. Main statistics from DEA

Variable	Obs.	Mean	Std. Dev.	Min	Max
DEA Score	4940	0.798	0.121	0.575	1.000
Bias	4940	0.000	0.004	0.000	0.271
Bias-corrected DEA Score	4940	0.798	0.121	0.573	1.000

Notes: 500 bootstrap replications.
Source: Author's own elaboration of MEF data.

DEA scores are also presented by class of reserve price. Table 8 shows that contracts tendered at higher values tend to be more efficient, especially when they are procured

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[16] According to AVCP (2006) two thirds of the public works completed by 2005 experienced adaptation costs. Recent studies confirm this issue (Cantarelli et al. 2010; Guccio, Pignataro, and Rizzo 2012; Decarolis and Palumbo 2015).
[17] In a recent study, colleagues performed the same analysis on a similar sample of Italian public works (n=5,597) noticed from 2000 to 2012 (Cavalieri et al. 2016). In that case, the mean efficiency is 0.85 with a variability of the estimated scores closed to our calculations. It provides the method with additional robustness.

at the European level. Exposure to foreign competition appears to be an incentive to discourage inefficient firms to stay out of the procurement market.

Table 8. DEA Efficiency score by class of reserve price

Thousands of euros

Reserve Price (class of)	Efficiency score (DEA)
40-150	0.792
150-500	0.798
500-1000	0.811
1000-5000	0.810
>5000	0.861
Total	0.798

Source: Author's own elaboration of MEF data

Furthermore, public work contracts tendered locally – either by municipalities and local entities – perform worst with respect to central agencies (especially Ministries) and State-owned firms. The DEA score for state-owned firms is quite high with respect to all other types of contracting authority as score approaches on average the best optimal frontier.

Table 9. DEA Efficiency score by type of contracting authority

Type of contracting authority	Efficiency score (DEA)
Municipality	0.779
Province	0.803
Region	0.791
Ministry	0.826
Local Health	0.800
Local entity	0.790
State-owned Firm	0.953
Other	0.781
Total	0.798

Source: Author's own elaboration of MEF data

4.4.3. Second-stage regression

In the first stage, the DEA generates efficiency scores. Therefore, inefficiency scores are calculated as the distance between one observation and the best performer. The inefficiency scores range from 0 (full efficiency) to 0.45, with a mean of 0.20, according to the DEA specification. The application of the DEA reveals the existence of relevant differences in the performance of public contracts. Performance differences can be determined by territorial drivers or contractual conditions. To explain such differences, the inefficiency scores are then regressed on environmental and contract-level predictors. Corruption – one of the main sources of inefficiency – is excluded from the specification in this stage and treated separately. Indeed, if the risk of corruption is identified by adopting the *residual approach*, it is necessary not to include corruption at this stage.

In addition to corruption-related factors, inefficiency in contract management can be explained by alternative drivers (Ganuza 2007; Bandiera et al. 2009; Cantarelli et al.

2012; Guccio et al. 2012; Finocchiaro Castro et al. 2018). To facilitate the identification and measurement of several of the main factors identified within the literature (see section 3.1.2.), these factors are grouped into four categories, each of which refers to a different "contract dimension". The identified dimensions and factors are classified and conceived in a tree-structure, which is depicted in Figure 6. As previously mentioned, the focus is on the determinants of passive waste, and corruption is not included within the analysis. Each dimension and, more specifically, each factor is operationalized into a set of proxy variables in order to allow for their measurement and analysis. Proxies were identified according to previous literature and data availability.

Figure 6. Dimensions, factors and selected variables of passive waste in contracts execution
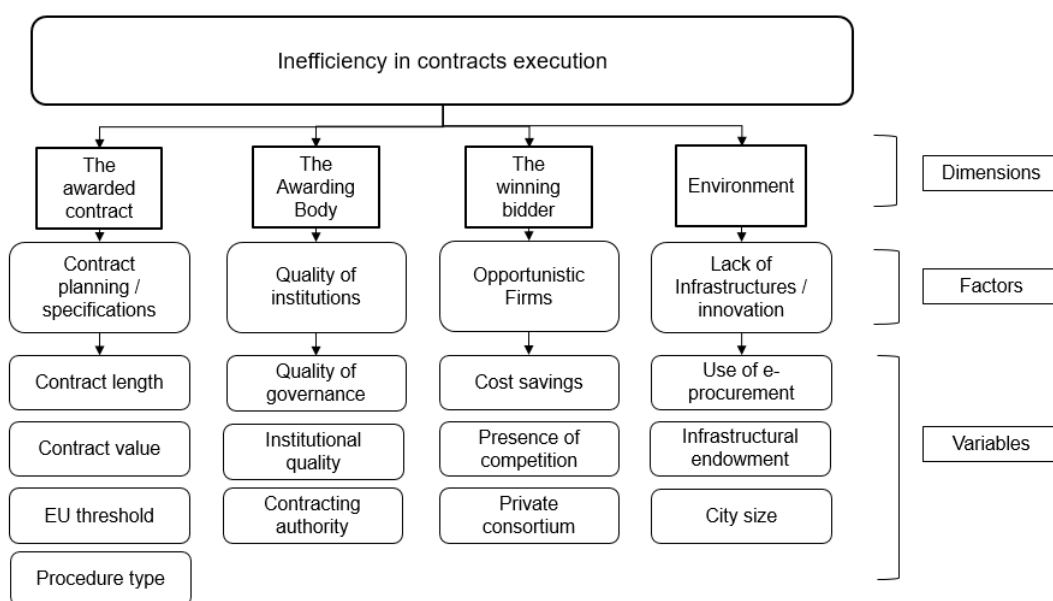
Source: Author's own elaboration

First, it is important to note that contract specifications might impact inefficiency. In the literature, inefficiency at the contract level is commonly associated with two dimensions: tender complexity and selection procedure. There is empirical evidence that a high level of complexity in design specification complexity affects tender outcomes (Ganuza 2007) and that large projects regularly spend more than originally agreed upon in the contract (Cantarelli et al. 2010). As a result, contract length (*Length_contract*) and contract initial value (*Lot_value*) are two proxies for complexity.[18] A dummy variable for contracts awarded above the EU threshold (*EU_threshold)* – thus published at European level –

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[18] Some studies (Finocchiaro Castro et al. 2014) measured complexity through the weighted composition index (WCI) of a work, calculated on the different sub-categories involved in the work, weighted for their relative amount. In this study the WCI cannot be calculated because the MEF dataset used for the analysis does not provide detailed information on the different sub-categories involved in the public work.

is also included.[19] Greater discretion in the selection procedures is associated with decreased efficiency, especially among contracting entities with lower administrative quality (Baltrunaite et al. 2018). Negotiations, rather than competitive procedures, can benefit a certain bidder by shortlisting corrupt bidders. The use of negotiations without a call for tender increases inefficiency and facilitates the pursuit of personal interests (Fazekas et al. 2016). Average Bid Auctions also incentivize bidders to rig the awarding of the contract, leading to the formation of cartels (Conley and Decarolis 2016). Thus, a categorical variable for procedure type is included (*Direct contracting, Cottimo_fiduciario, Open_procedure, Restricted, Negotiated*, and *Negotiated_woCall)* to assess which type results in higher inefficiency with regard to contract execution.[20]

Second, an inefficient contracting authority might produce a poorly designed and managed tender. The contracting authority might underestimate the economic resources needed to execute infrastructural projects (Flyvbjerg 2008). Public officers can also behave opportunistically by awarding contracts to firms owned by local politicians (Amore and Bennedsen 2013; Baltrunaite et al. 2018). Moreover, a political agenda can divert allocated resources to the detriment of other public infrastructural projects, causing a considerable waste of resources (Goldman et al. 2013). To capture these factors, indicators of institutional quality (*Institutional_quality*) (Nifo and Vecchione 2014) and quality of governance (*Quality_governance*) (Charron et al. 2014) are used. The former is a composite objective-based measure of institutional quality which comprises five dimensions, called: i) Voice and accountability, ii) Government effectiveness, iii) Regulatory quality, iv) Rule of law, v) Control of corruption (Nifo and Vecchione 2014). The latter is a survey-based indicator of quality of government at EU regional level capturing average citizens' perceptions and experiences with corruption, and the extent to which European citizens rate their public services as impartial and of good quality in their region of residence (Charron et al. 2014). As both indicators include corruption, they have been recalculated – following the same methodology proposed by the authors – without the presence of the corruption component.[21] Dummy variables for clusters of contracting authorities (*Central_authority*, *municipality*, *Local_health*, and *Stateowned_firms*) are also included.

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[19] The EU threshold for public works contracts is € 5,278,000 (European Commission 2014a).
[20] "*Cottimo_Fiduciario*" is a particular form of public contracting, limited to cases of urgency and to the acquisition of modest goods or services, admissible only in cases strictly regulated by the Code.
[21] The dataset for the construction of the Quality of Governance indicator (Charron et al. 2014) is available at: https://nicholascharron.wordpress.com/european-quality-of-government-index-eqi/;
The dataset for the construction of the Institutional Quality Index (Nifo and Vecchione 2014) is available at: https://sites.google.com/site/institutionalqualityindex/home

Third, contextual factors might play a role in determining the level of inefficiency. A lack of physical and economic infrastructures (i.e. transportation infrastructure) is correlated with poor results in contract implementation, which entails waste of financial resources (Golden and Picci 2006). Social and industrial innovation is also key to improving procurement. Previous research reveals that where advancement based on merit is the rule and favoritism the exception, governments attain better value for money spent (Mungiu-Pippidi 2015). In this sense, the use of e-procurement can be interpreted as an innovative way of managing public contracting, which also seems to benefit the works of the supplier (Purchase and Dooley 2010). The e-procurement usage rate (*E-procurement*) at the regional level is thus used as a proxy for innovation in procurement. With regards to the infrastructural endowment, the index of infrastructural endowment (*Infrastractural_index*) developed by Tagliacarne for the years 2012-2013 is used. [22] A measure for the population size (*Inhabitants_log*) is also included.

Finally, firms can act opportunistically to increase profits, extract rents from the contract and influence the political agenda. On the one hand, underbidding is a means to secure the win of the bid and, subsequently, to exploit the opportunity of a renegotiation with incomplete contracts (Chong et al. 2014; Decarolis and Palumbo 2015). On the other hand, the establishment of economic cartels reduces price variability and facilitates the awarding of contracts with lower discounts (Imhof et al. 2016). Cost savings in the awarding of contracts (*Rebate*) are calculated as a percentage of rebate from the initial tender value and measure price variability in contract awarding. A dummy for contracts awarded without rebates (*Rebate_null*) is included. The absence of cost savings in contract awarding might represent a single bidding situation.[23] In addition, a dummy for private consortium (*Consortium*) is included.

The full set of variables included in the second-stage truncated regression is listed in Table 10.

Before performing the truncated regression, three control variables are included to reduce sample bias and endogeneity: tender year, region, and the economic sector. The truncated regression excludes the three fully efficient observations from the estimation. In fact, as the inefficiency score of the three observations is equal to zero, it would be illogical to include these observations in the specification. Montecarlo simulations (1000 replications) are executed again to ensure a feasible and consistent inference on the second stage regression (Simar and Wilson 2007).

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[22] www.tagliacarne.it

[23] Data on the number of bidders are not available in a vast majority of cases.

Table 11 presents the results of different specifications. Specification (1) includes all the variables listed in Table 10. The results of specification (1) are benchmarked with other specifications to test whether the results are driven by the selection of variables. For this purpose, each specification excludes one set of variables at a time from specification (1). Specification (2) excludes the variables related to the contract awarded. Specification (3) excludes the variables related to the contracting authority. Specification (4) excludes the environmental variables. Specification (5) excludes the variables related to firms' bidding behaviors. Finally, specification (6) includes all variables but it is performed using the OLS estimator to test whether a different estimator produces different results.

Table 10. Main statistics of the determinants of the inefficiency scores.

Variable	Source	Type	Level/Detail	Obs.	Mean	Std. Dev.	Min	Max
Inefficiency	DEA	continuous	Contract	4940	0.202	0.121	0.000	0.425
Rebate	MEF	continuous	Contract	4940	0.175	0.111	0.000	0.890
Rebate_null	MEF	dummy	Contract	4940	0.041	0.199	0.000	1.000
Consortium	MEF	dummy	Contract	4940	0.043	0.203	0.000	1.000
Other	MEF	dummy	Contract	4940	0.005	0.072	0.000	1.000
Direct_contracting	MEF	dummy	Contract	4940	0.040	0.197	0.000	1.000
"Cottimo_Fiduciario"	MEF	dummy	Contract	4940	0.099	0.298	0.000	1.000
Open_procedure	MEF	dummy	Contract	4940	0.340	0.474	0.000	1.000
Negotiated	MEF	dummy	Contract	4940	0.040	0.197	0.000	1.000
Negotiated_woCall	MEF	dummy	Contract	4940	0.449	0.497	0.000	1.000
Restricted	MEF	dummy	Contract	4940	0.026	0.158	0.000	1.000
Institutional_quality	Nifo & Vecchione 2014	index	Regional	4940	0.654	0.255	0.000	1.000
Quality_governance	Charron et al. 2014	index	Regional	4940	0.343	0.227	0.000	1.000
E-procurement	OpenCoesione	index	Regional	4940	25.363	18.016	0.000	100.000
Infrastractural_index	Tagliacarne	index	Regional	4940	104.469	52.340	21.200	266.380
Stateowned_firms	MEF	dummy	Contract	4940	0.091	0.288	0.000	1.000
Local_health	MEF	dummy	Contract	4940	0.032	0.176	0.000	1.000
Central_authority	MEF	dummy	Contract	4940	0.130	0.336	0.000	1.000
Municipality	MEF	dummy	Contract	4940	0.644	0.479	0.000	1.000
Inhabitants_log	Istat	log	Municipality	4940	10.023	2.317	4.673	14.871
Length_contract	MEF	log	Contract	4940	5.835	0.833	2.197	6.999
Lot_value	MEF	log	Contract	4940	12.281	1.007	10.597	18.975
EU_threshold	MEF	dummy	Contract	4940	0.005	0.068	0.000	1.000

Source: Author's own elaboration

Table 11. Truncated regression second stage estimation results

Variables	Coeff. (SE) (1)	Coeff. (SE) (2)	Coeff. (SE) (3)	Coeff. (SE) (4)	Coeff. (SE) (5)	Coeff. (SE) (6)
Inefficiency (dependent variable)						
Rebate	0.061 **	0.067 **	0.033	0.041 *		0.048 **
	(0.023)	(0.010)	(0.022)	(0.021)		(0.017)
Rebate_null	-0.088 ***	-0.105 ***	-0.091 ***	-0.094 ***		-0.059 ***
	(0.014)	(0.013)	(0.014)	(0.013)		(0.007)
Consortium	-0.007	-0.005	-0.009	-0.006		-0.005
	(0.011)	(0.010)	(0.011)	(0.010)		(0.008)
Infrastructural_index	-2E-04 **	-2E-04 **	-2E-04 **		-2E-04 **	-1E-04 **
	(7E-05)	(7E-05)	(7E-05)		(7E-05)	(5E-05)
E-procurement	5E-04	4E-04	5E-04		5E-04	5E-04
	(5E-04)	(5E-04)	(6E-04)		(5E-04)	(4E-05)
Inhabitants_log	-0.006 ***	-0.006 ***	-0.011 ***		-0.006 ***	-0.005 ***
	(0.001)	(0.001)	(0.001)		(0.001)	(0.001)
Institutional_quality	-1.239 *	-1.066 *		-0.779	1.242 *	-1.094 *
	(0.509)	(0.523)		(0.481)	(0.528)	(0.429)
Quality_governance	-0.079 *	-0.080 **		-0.006	-0.072 *	-0.068 **
	(0.034)	(0.030)		(0.030)	(0.030)	(0.025)
Stateowned_firms	-0.338 ***	-0.343 ***		-0.359 ***	-0.336 ***	-0.117 ***
	(0.036)	(0.021)		(0.021)	(0.012)	(0.010)
Local_health	0.025	0.023		0.017	0.026	0.019
	(0.016)	(0.015)		(0.015)	(0.015)	(0.011)
Central_authority	0.029 **	0.026 **		0.022 **	0.027 **	0.018 **
	(0.009)	(0.008)		(0.009)	(0.009)	(0.007)
Municipality	0.016 *	0.015 *		0.023 **	0.017 *	0.012 *
	(0.008)	(0.007)		(0.007)	(0.007)	(0.006)
Length_contract	0.009 **		0.008 **	0.007 *	0.009 **	0.008 **
	(0.003)		(0.003)	(0.003)	(0.003)	(0.002)
Lot_value	0.007 *		0.006 *	0.005	0.007 **	0.004 *
	(0.003)		(0.003)	(0.003)	(0.003)	(0.002)
EU_threshold	-0.082 *		-0.097 *	-0.084 *	-0.080 *	-0.055 *
	(0.049)		(0.038)	(0.036)	(0.036)	(0.026)
Procedures	YES	NO	YES	YES	YES	YES
Years	YES	YES	YES	YES	YES	YES
Sectors	YES	YES	YES	YES	YES	YES
Regions	YES	YES	YES	YES	YES	YES
_cons	1.191 **	1.228 **	0.260 **	0.776 **	1.148 **	1.093 **
	(0.395)	(0.403)	(0.062)	(0.374)	(0.374)	(0.328)
SEs of regression	0.122	0.123	0.127	0.123	0.123	0.106
Obs.	4937	4937	4937	4937	4937	4940
Adj. R-squared	0.173	0.167	0.145	0.167	0.164	0.230
Wald (Prob. > chi2)	0.000	0.000	0.000	0.000	0.000	0.000

Notes: Bootstrap Standard Errors are reported in parentheses. Specification (1) includes all variables; specification (2) excludes the variable related to the contract awarded. Specification (3) excludes the variables related to the contracting authority. Specification (4) excludes the environmental variables. Specification (5) excludes the variables related to firms' bidding behaviors. Finally, specification (6) is performed using the OLS estimator.
*** Significant at the 0.5 percent level.
** Significant at the 1 percent level.
* Significant at the 5 percent level.
Source: Author's own elaboration of MEF data

The results are in accordance with previous studies and consistent across the different specifications. Two of the three proxies for firms' bidding behavior are significant, but in differing ways. Rebates (*Rebates*) are likely to be higher when inefficiency is higher. Underbidding opens the path to renegotiation due to budget constraints during contract execution (Decarolis and Palumbo 2015). The relationship between inefficiency and cost savings has also been confirmed in a couple of recent study on Italian public contracts (Ancarani et al. 2016; Milani et al. 2018). Moreover, the latter study empirically supports the inverse relationship between the absence of cost savings (*Rebate_null*) in contract awarding and inefficiency (Milani et al. 2018), which is confirmed in the specifications presented in Table 11.

Infrastructural endowment (*Infrastructural_index*) is negatively associated with inefficiency in all the specifications presented. Lack of infrastructure entails the waste of financial resources in contract implementation (Golden and Picci 2006). Northern areas are characterized by high levels of infrastructural endowment, due to lower levels of inefficiency in public spending with respect to Southern Italy (Golden and Picci 2006; Mastromarco and Woitek 2006). Surprisingly, the use of e-procurement (*E-procurement*) does not appear to influence the level of efficiency in contract management.

The two variables used for measuring the complexity of the contract (*Length_contract* and *Lot_value*) are also positively associated with inefficiency.[24] Long and expensive public works are more likely to suffer delays or budget increases during the contract implementation phase (Baldi et al. 2016). Restricted auctions and negotiations are likely to occur on a regular basis during highly complex projects (Bajari et al. 2009). However, the selection procedures (*Procedures)* do not systematically determine an increase in inefficiency. Indeed, procedure types are not significant. On the other hand, public infrastructure noticed at the European level (*EU_threshold)* decreases the risk of inefficiency in contract execution, which was also expected.[25] Exposure to foreign investments and foreign competitors increases the overall efficiency in procurement, as some territories may

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[24] The linear correlation between *Length_contract* and *Lot_value* is 0.46. To account for multicollinearity within the specification (1), alternative models have been conducted using centering techniques. Results are presented in table 18 in the technical annex. Moreover, it should be noted that specification (2) does not include both variable, and the significant variables preserve the sign and the significance.

[25] Alternative specifications have been conducted without the presence of the *EU_threshold* variable. The exclusion of the variable does not change the overall results.

lack the technical capacity to complete complex development projects and may require foreign exchange and foreign expertise to compensate for these shortcomings (Kenny and Crisman 2016).

Furthermore, high levels of inefficiency are related to poor institutional quality (Charron et al. 2014; Nifo and Vecchione 2014). Regions characterized by high levels of civic and political engagement and high administrative capacity (*Quality_governance* and *Institutional_quality*) have to ability to manage contracts more efficiently. Furthermore, results indicate that the involvement of central authorities (*Central_authority*) and municipalities (*Municipality*) increases the probability of inefficient contracts, while state-owned firms (*Stateowned_firms)* are more efficient. On the one hand, municipality shows to be significant and with the expected sign. Previous research (Finocchiaro Castro et al. 2014; Guccio et al. 2014) shows that local governments do not seem to be under sufficient and effective pressure to behave efficiently in the execution of public works. On the other hand, with regards to central authorities, findings are in contrast with the results from a previous study (Finocchiaro Castro et al. 2014).

A sensitivity testing is also performed by replicating the analysis using different samples to verify the extent to which the results are driven by the selected sample. Table 12 presents the specification (1) (also presented in Table 11) benchmarked with other specifications performed on different samples:[26]

- the specification (1b) excludes from the final sample the public work contracts awarded by the main national road-construction company ANAS;
- the specification (1c) includes public work contracts awarded between 2007 and 2013 and completed with a delay of up to 365 days (instead of 253 days);
- the specification (1d) includes public work contracts awarded between 2007 and 2013 with a maximum length of two years (instead of three);
- the specification (1e) includes contracts awarded between 2007 and 2014 with a maximum length of 2 years;
- the specification (1f) includes the full dataset of contracts awarded from 2007 to 2015 with information on the final date of completion and the final cost.

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[26] For each sample (except for the specification (1f), the maximum delay considered corresponds to the 95th percentile of the distribution of delays within the sample selected.

Table 12. Truncated regression second-stage estimation results on different samples

Variables	Coeff. (SE) (1)	Coeff. (SE) (1b)	Coeff. (SE) (1c)	Coeff. (SE) (1d)	Coeff. (SE) (1e)	Coeff. (SE) (1f)
Inefficiency (dependent variable)						
Rebate	0.061 **	0.066 **	0.060 **	0.057 *	0.087 ***	0.092 ***
	(0.023)	(0.021)	(0.020)	(0.023)	(0.019)	(0.017)
Rebate_null	-0.088 ***	-0.093 ***	-0.086 ***	-0.085 ***	-0.071 ***	-0.074 ***
	(0.014)	(0.013)	(0.013)	(0.014)	(0.011)	(0.010)
Consortium	-0.007	-0.006	-0.008	-0.007	-0.006	-0.003
	(0.011)	(0.010)	(0.010)	(0.011)	(0.009)	(0.009)
Infrastructural_index	-2E-04 **	-9E-05	-2E-04 **	-2E-04 **	-2E-04 ***	-2E-04 ***
	(7E-05)	(6E-05)	(6E-05)	(7E-05)	(6E-05)	(5E-05)
E-procurement	5E-04	6E-04	4E-04	0.001	2E-04	2E-04
	(5E-04)	(5E-04)	(5E-04)	(6E-04)	(5E-04)	(4E-04)
Inhabitants_log	-0.006 ***	-0.005 ***	-0.007 ***	-0.006 ***	-0.007 ***	-0.008 ***
	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)
Institutional_quality	-1.239 *	-1.335 *	-1.230 *	-1.660 **	-1.223 *	-0.639
	(0.509)	(0.516)	(0.519)	(0.572)	(0.503)	(0.308)
Quality_governance	-0.079 *	-0.083 **	-0.077 **	-0.118 ***	-0.078 **	-0.068 **
	(0.034)	(0.019)	(0.029)	(0.033)	(0.026)	(0.023)
Stateowned_firms	-0.338 ***	-0.157 ***	-0.330 ***	-0.268 ***	-0.292 ***	-0.306 ***
	(0.036)	(0.036)	(0.021)	(0.022)	(0.020)	(0.024)
Local_health	0.025	0.025	0.025	0.048 **	0.028 *	0.004
	(0.016)	(0.014)	(0.014)	(0.016)	(0.013)	(0.012)
Central_authority	0.029 **	0.022 *	0.028 **	0.041 ***	0.027 ***	0.025 ***
	(0.009)	(0.009)	(0.009)	(0.010)	(0.008)	(0.006)
Municipality	0.016 *	0.015 *	0.015 *	0.033 ***	0.021 **	0.014 *
	(0.008)	(0.007)	(0.007)	(0.008)	(0.006)	(0.005)
Length_contract	0.009 **	0.009 **	0.009 **	0.011 **	0.011 ***	0.005 *
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.002)
Lot_value	0.007 *	0.004	0.007 *	0.007 *	0.005	0.006 **
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.002)
EU_threshold	-0.082 *	-0.088 *	-0.095 **	-0.069	-0.085	-0.084 **
	(0.049)	(0.036)	(0.036)	(0.059)	(0.046)	(0.028)
Procedures	YES	YES	YES	YES	YES	YES
Years	YES	YES	YES	YES	YES	YES
Sectors	YES	YES	YES	YES	YES	YES
Regions	YES	YES	YES	YES	YES	YES
_cons	1.191 **	1.270 **	1.174 **	1.476 **	1.162 **	0.796**
	(0.395)	(0.340)	(0.340)	(0.441)	(0.389)	(0.291)
SEs of regression	0.122	0.121	0.121	0.121	0.122	0.127
Obs.	4937	4603	5045	3973	5879	9678
Adj. R-squared	0.173	0.175	0.178	0.181	0.183	0.185
Wald (Prob. > chi2)	0.000	0.000	0.000	0.000	0.000	0.000

Notes: Bootstrap Standard Errors are reported in parentheses. Specification (1) refers to the final sample; specification (1b) excludes the public work contracts noticed by the main national road-construction company ANAS from the final sample; specification (1c) includes contracts awarded between 2007 and 2013 completed with a delay ≤365 days; specification (1d) includes contracts awarded between 2007 and 2013 with a maximum length of 2 years; specification (1e) includes contracts awarded between 2007 and 2014 with a maximum length of 2 years; specification (1f) includes the contracts awarded between 2007 to 2015 with post-award information.
*** Significant at the 0.5 percent level.
** Significant at the 1 percent level.
* Significant at the 5 percent level.
Source: Author's own elaboration of MEF data

The results are consistent across the different specifications. On a general level, most of the significant variables preserve the sign, and in most of the cases the significance, even after changes in the sample size.

4.4.4. A new corruption risk indicator

Following the two-stage semi-parametric technique, estimate residuals from specification (1) are transformed into a score of corruption risk at the contract level, hereinafter referred to as "Corruption Risk Indicator".[27] The Corruption Risk Indicator establishes the level of corruption risk of each public contract. Using these new risk scores, public contracts are compared to determine which ones are more likely to experience corruption in contract execution. Risk scores are also aggregated into different indices at different disaggregation levels: by region, province and municipality.

It is important to note that the corruption risk scores at the territory level are assigned to the place where the contracting authority (and alternatively, the winning bidder) is registered. Unfortunately, information regarding the place of contract performance is not available in the database. This means that for public entities operating on all national territories (e.g., the main road-construction firm incorporated in Rome) the score is assigned to the municipality, province, and region in which the contracting authority is registered (Rome, in this case). As large state-owned companies operating throughout the national territory are commonly established in the largest cities, especially in Rome, the risk of corruption in these areas could be partially overestimated. For this reason, corruption risk indicators – presented in Table 13 and Figure 7 respectively – are aggregated at the regional and provincial level according to the place where the contracting authority is registered (hereinafter referred to as CRI-a index) and to the place of incorporation of the suppliers (CRI-s index).

For each region, the regional average of the residual scores is calculated and normalized to obtain values from 0 (low risk of corruption) to 1 (high risk of corruption). Results shows that the risk of corruption is distributed across the peninsula, although according to the CRI-s index, the risk of corruption is highly concentrated in central regions. Lazio, Tuscany and Lombardy rank at the top of the CRI-a index. It is interesting to note that there is a higher risk of corruption in large urban centers (Rome, Milan) – partially because of overestimation.

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[27] Specification (1) is chosen based on the value of the Adj. R-Squared (0.173).

Conversely, southern regions (Molise, Campania) and central regions (Abruzzo, Lazio and Umbria) rank at the top of the CRI-s index. Sardinia, Piedmont and Trentino-South Tyrol appear less risky in both the risk indicators. Emilia Romagna and Abruzzo, two areas affected by earthquakes during the analysis period, present completely different scores according to the type of indicator, despite the resonance of numerous scandals related to reconstruction in both areas. Regions characterized by the historical presence of mafia-type criminal organizations also obtain a medium-high score in both rankings.

Table 13. Regional Corruption Risk Scores. 0-1

Scores are aggregated by contracting authority and winning bidder

| Regions	CRI-a	CRI-s
Abruzzo	0.010	1.000
Basilicata	0.042	0.399
Calabria	0.050	0.241
Campania	0.049	0.511
Emilia-Romagna	0.072	0.188
Friuli-Venezia Giulia	0.028	0.132
Lazio	1.000	0.454
Liguria	0.067	0.245
Lombardy	0.102	0.149
Marche	0.046	0.273
Molise	0.041	0.759
Piedmont	0.035	0.114
Apulia	0.083	0.176
Sardinia	0.000	0.156
Sicily	0.038	0.302
Tuscany	0.112	0.242
Trentino--South Tyrol	0.018	0.000
Umbria	0.104	0.575
Aosta Valley	0.057	0.253
Veneto	0.050	0.207

Source: Author's elaboration of MEF data

Results are also presented at the provincial level. In Figure 7, provinces are classified according to the level of associated corruption risk. The graphical representation of the CRI-a index (on the left) shows that Rome, Rieti and Frosinone (all provinces in Lazio) exhibit high levels of corruption risk. Provinces such as Siena (Tuscany), Milan (Lombardy), Bari (Apulia) and Vibo Valentia (Calabria) are also near the top of the ranking. According to the CRI-s index (on the right) most of the central provinces, Caserta (Campania) and Palermo (Sicily) record high risk values. At the bottom of the two rankings, the presence of some Southern provinces is surprising, namely Caltanissetta (Sicily), and Avellino (Naples), especially in relation to the regional average score of the regions to which they belong, which are typically influenced by the rooted presence of mafia groups particularly interested in

extracting rents from procurement contracts (Vannucci 2006; Caneppele 2014). Moreover, the presence of Bolzano is to be expected (it ranks at the bottom of the ranking according to both risk indicators). The autonomous province of Bolzano is usually characterized by high levels of quality of life (Il Sole 24 Ore 2018) and good efficiency in the management of public resources, according to previous studies (Golden and Picci 2006; Cavalieri et al. 2016).

Figure 7. Provincial Corruption Risk Scores. 0-1

CRI-a index (left) and CRI-s index (right)
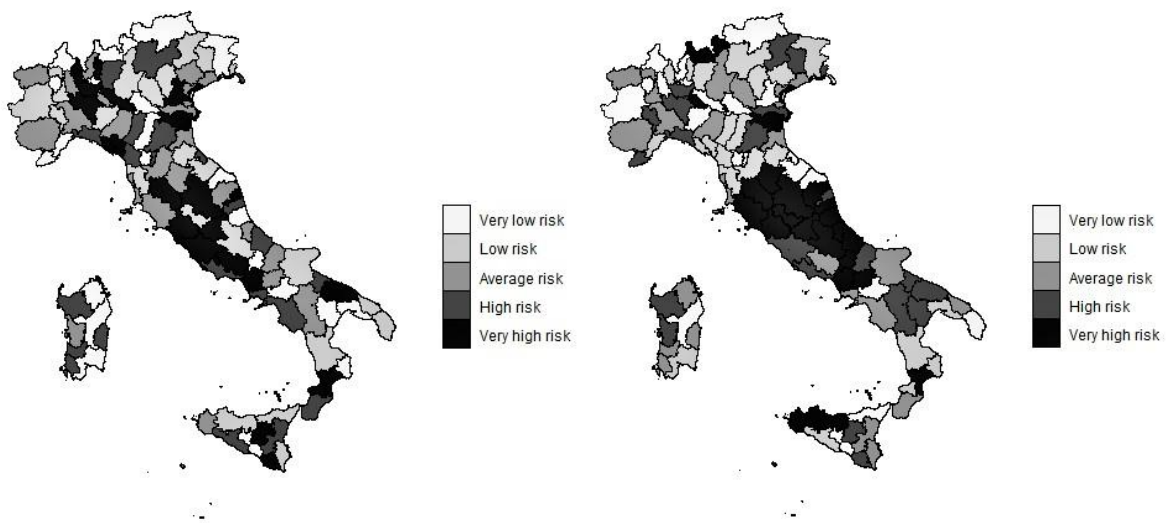
Source: Author's own elaboration of MEF data

Using the same aggregation strategy, results can also be combined at the municipality level and at the business sector level. Comparing the performances of contracting authorities, areas and economic sectors through the construction of one or more ranking systems is key to assess their riskiness and to identify those contracting authorities (areas and economic sectors) which potentially 'deserve' in-depth investigation (ANAC 2018).

4.4.5. Validation of indicators

The external robustness of the Corruption Risk Indicator is validated by adopting two different strategies. First, the Corruption Risk Indicator is compared at the regional and provincial levels, considering different environmental measures of corruption. Environmental measures of corruption are collected from different sources to encompass the many facets of corruption. Embezzlement and malfeasance rates for every 100,000 inhabitants are

calculated using official police data. The rate of Regional Administrative Court (TAR) procedures on irregularities committed within public procurement is gathered from administrative sources. Two indirect indices of corruption are retrieved from the studies by Golden and Picci (2006) and Nifo and Vecchione (2014). The former estimates the impact of corruption in the capability of Italian regions to transform financial resources into infrastructural endowments. The latter is a composite indicator that summarizes data on crimes committed against the public administration, the number of dissolved local administrations and the aforementioned Golden and Picci Index. Moreover, the number of families who have experienced corruption at the regional level is retrieved from the first-ever victimization survey on corruption held by the Italian Bureau of Statistics (ISTAT 2017a). To conclude, from the latter data, an estimate of corruption crimes is computed based on the ratio between the corruption acts experienced over the last three years by each family in a given region (reported in the ISTAT victimization survey) and the reported number of crimes associated with corruption (from police data) over the period 2013-2015. The obtained estimate is a 'multiplier', i.e. an estimate of the cases of corruption that did not emerge. Therefore, the estimate of 'latent corruption' is multiplied for the number of corruption crimes reported to the police in a given year for each region (or province) for the entire period 2009-2015. Finally the regional and provincial average is computed to estimate the total number of corruption crimes committed in that period in that specific region (or province).[28]

The correlation matrix (Table 14) presents the *Pearson's r* for the two regional Corruption Risk Indicators and the alternative environmental measures of corruption indicated above. Most of the correlations are significant at the 99.9%. The CRI-a index is highly correlated with the rate of administrative procedures presented at TAR (*Tar_procedure,* r=0.7*)* and the rate of experienced corruption (*Victimization,* r=0.7). It is also highly and positively correlated with the estimate of corruption crimes, both at the regional level (*Corruption_crimes,* r=0.8) and at the provincial level (r=0.6). The CRI-s index is positively and statically significant with the rate of experienced corruption (*Victimization,* r=0.5), the Golden and Picci index (*Golden_picci,* r=0.3) and the regional estimate of corruption crimes (*Corruption_crimes,* r=0.3). Given the results of the correlation matrix, it is possible to conclude that the Regional Corruption Risk Indicators are robust.

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[28] Additional details are provided in the Annex.

Table 14. Correlation among the Corruption Risk Indicators and environmental measures of corruption. Regional values.

Scores are aggregated by contracting authority (left) and winning bidder (right)

Environmental measures of Corruption	CRI-A	CRI-A
Victimization	0.69	0.52
Tar_procedures	0.69	ns
Emblezzement_rate	0.50	ns
Malfeasance_rate	0.37	ns
Golden_picci	ns	0.31
Nifo_Vecchione	ns	0.20
*Corruption_crimes**	0.76	0.26

Notes: All significant p<0.001; *at provincial level, r=0.60.
Source: Author's own elaboration

Furthermore, an 'evidence-based methodology' is applied to counter-check the indicator (ranked from top to bottom) with open-source information. If the Corruption Risk Indicator is indeed robust, then it should capture several cases of real-life corruption, in the right tail of its distribution. This hypothesis is verified by selecting the first 100 and the last 50 contracts, according to our Corruption Risk Indicator, and 50 randomly selected cases around the 50th and 75th percentile. Information regarding 250 public contracts is inputted in a query, together with keywords that refer to corruption or associated activities. Online research can return one of three possible scenarios.[29] First, the query does not generate information inherent to the search. Second, the query returns sensitive information, but without any clear evidence that corruption occurred during the contract period. Third, the query returns clear information of ascertained corruption concerning the contract, or information on systemic corruption established during that period and involving one of the two main actors.

The results of the online research are classified into three corresponding groups:

1. *White cases* (no online information);
2. *Grey cases* (presence of a criminal record – e.g., tax crimes, crimes against public administrations - not strictly related to the contract);
3. *Black cases* (presence of trials, arrest warrant, pre-trial investigation strictly related to the contract).

For example, a huge, partly abandoned urban project, in the province of L'Aquila is classified as a *black case* due to severe irregularities in the execution of the contract, proven by the

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[29] More details on query formulation are provided in the Annex.

investigation.[30] A case of maintenance work on civil buildings in which the Regional Prosecutor's Office targeted the contracting authority for funds received on behalf of the municipalities from 2010 to 2012 is classified as a *grey case*.[31] The same procedure is replicated for all 250 selected cases. Upon completion, a double-blind test is conducted to categorize the observations into the three categories outlined above. Performance of a double-blind test ensures consistency in categorization.

In line with expectations, the share of *white cases* increases progressively as the Corruption Risk Indicator approaches 0. Table 15 reports the relative distribution. As further expected, the *black cases* are more numerous within the first group, and residual within the last two groups. Within the first group, 64% of the observations are either *grey* or *black cases*. The presence of false positives is lower than expected, even though *white cases* are the most represented in all four categories. However, the share sharply increases as the Corruption Risk Indicator approaches lower scores. The best confirmation of the model's robustness is the fact that false negatives among *grey* and *black cases* are exceedingly minimal: only about 12% considering both types.

Table 15. Validation from Online Evidence.

	White cases	Grey cases	Black cases
High corruption risk (n=100)	36%	35%	29%
75% (n=50)	56%	24%	20%
50% (n=50)	78%	14%	8%
Low corruption risk (n=50)	88%	6%	6%

Source: Author's own elaboration

4.5. Discussion

4.5.1. Strengths and shortcomings

The tests conducted support the applied methods and the results produced. Despite this, this method is not exempt from limitations. The following discusses both the strengths and weaknesses of our approach.

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[30]http://inchieste.repubblica.it/it/repubblica/rep-it/2012/04/03/news/berolaso_l_aquila-32679555/;
https://www.ilfattoquotidiano.it/2017/06/10/terremoto-laquila-il-miracolo-new-town-cade-a-pezzi-inagibile-un-alloggio-su-10-destra-e-sinistra-si-tirano-le-casette/3644073/
[31] http://www.nove.firenze.it/b307171945-corte-dei-conti-indagini-sugli-incassi-di-casa-spa.htm

The applied methodology has different strengths. In the first place, it is a transparent methodology with its own internal coherence, both from a theoretical point of view and with respect to analytical development. For this reason, this methodology is easily replicable and adaptable to other data and other contexts. Thus, it overcomes the obstacle of replicability. Generally, the existing corruption measures suffer from context-dependency, which makes these indicators difficult to replicate across countries (Balsevich and Podkolzina 2014; Fazekas et al. 2016). This proposed methodology overcomes this difficulty by developing corruption risk scores at the contract level based on two predefined and standard inputs and outputs that are commonly available across countries (planned and actual length of contract, planned and actual cost).

It is also possible to work with data of varying levels of detail, especially microdata. In this study, the methodology is applied to examine the overall efficiency in the execution of public contracts. However, this approach has also been applied to the study of bank performance (Périco et al. 2016) and the efficiency of teaching in elementary schools (Siti and Mahmudah 2017). This makes this approach flexible to different types of data. Treating data at a micro-level also allows for different levels of aggregation. In this study, the Corruption Risk Indicator is aggregated on different territory levels (regional and provincial) and according to different information regarding the location of contracting authorities and firms. The two indicators produced allow for a territorial analysis of the risk of corruption in Italian procurement. Similarly, scores can be aggregated on a contracting authority basis to assess the overall performance of the public authority, as well as, on a business sector level to identify economic activities that would deserve further investigation by enforcement agencies.

The DEA methodology itself is a very powerful benchmarking technique (Sherman and Zhu 2006). For each contract, corruption scores are produced on the basis of predefined and standard inputs and outputs to analyze its performance. The comparison can be extended on several levels if the score at the micro-level is the result of the comparison of decision units of similar characteristics. Moreover, the belief is that the repeated use of this methodology on samples of public contracts over time might also overcome one of the common issues with corruption indicators: the lack of "time-sensitivity". For time-series analyses, the most commonly used corruption indicators are generally perception-based ones (Transparency International 2018). However, these indicators are not able to capture

changes over time, because of the variation in data sources between years and changes in methodology. Since these indicators cannot capture changes over time, it is impossible to perform year-to-year comparisons (Lambsdorff 2006b; Andersson and Heywood 2009). Through further refinements of this methodology, and with the use of a larger database, one could try to develop risk indicators that are able to capture changes in corruption over time.

There are also several limitations to this approach, although attempts were made to minimize the impact of these limitations on the final result. Open data on public contracts represents the new frontier to analyze the performance of contractors and suppliers in the management and execution of public works. Although open data provides a considerable amount of information on a micro-level (i.e., single transactions, public contracts), this information is often partial or incorrect. Indeed, it is sometimes necessary to work with unbalanced databases, which are characterized by a selection bias. Of the population of contracts procured between 2007 and 2015 (over 60 thousand), only 15% contained the information necessary to conduct a DEA analysis (N=9,691), i.e., date of completion and final cost. This limitation is primarily the result of external causes – mostly to do with the way data are collected and inputted – which reduce the possibility to find solutions to the selection bias issue. Selection bias also affects the consistency between sample observations. In the sample used, the contracts between 2007 and 2015 differ in terms of average contract length. As this inconsistency can, in turn, affect the DEA estimate, only contracts with a maximum length of three years, issued between 2007 and 2013 and completed by the end of 2016 have been included in the final sample. Moreover, a threshold for the maximum possible delay in the performance of contracts, including only delays of up to the 95% of their distribution, is also included. This means the all public works included in the sample were formally concluded by the end of 2017. However, estimates have been also conducted on the complete dataset (and on alternative samples) to check for robustness. Furthermore, it should be noted that all steps taken to improve the balance of the sample do not have any impact on the degree of representativeness of the sample itself (r=0.95).[32] Moreover, this operation has a second implication: it excludes extreme outliers from the DEA analysis, which would bias the estimate (Sarkis 2002).

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[32] The relative regional distribution of the first sample extracted is compare with the relative regional distribution of the final sample used for the analysis and the regional distribution of public contract data presented by ANAC (2018).

Another important limitation concerns missing and/or omitted information. It has been noted that big data may exhibit deficiencies in quality. Of the over 60,000 contracts procured from 2007 to 2015, 85% do not indicate final cost or date of successful completion. Regarding the 4,940 sample observations used for analysis, in 75% of cases the number of participants was not reported, and in 31% there is no indication of the awarding criterion chosen. Fortunately, the name of the supplier is available in almost all observations (99%). Missing values impact research outputs, by reducing both the number of observations (and variables) of interest and the available options for calculating the Corruption Risk Indicator. For example, the regional Corruption Risk Indicators are computed based on contracting authority location and supplier location, because the place of contract execution is missing. Otherwise, a third alternative score could be produced, which would provide an even more detailed indication of the territorial risk in Italy. In addition to missing information, omitted variables in the second stage regression can impact the overall design. Several drivers of inefficiency are difficult to measure; thus they are not included in the second-stage truncated regression model. The productivity level of a firm is one of the omitted factor that might explain the overall efficiency of a contract. To overcome its (complex) measurement, controls for economic sectors and regions/provinces were included. The use of controls should minimize the impact of the omitted variable on the overall result. Indeed, more suitable environmental variables should be included to correctly estimate corruption based on the second-stage regression.

Furthermore, the methodology assumes that corruption is a source of inefficiency and that it can be identified by inefficiency. However, corruption and inefficiency are related phenomenon and, as such, it is not easy to separate the two. Both corruption and inefficiency can emerge under the same conditions. According to previous literature (Bandiera et al. 2009; Finocchiaro Castro et al. 2018), highly inefficient contexts are also characterized by a greater presence of corruption, which means that the dynamics are highly correlated. By adopting a *residual approach*, there is a risk to explain corruption partially, with the inclusion of variables – in the second-stage regression – that capture both phenomena. Thus, the risk remains present even if variables strictly related to corruption are excluded from the truncated regression, as in the analysis here conducted. Furthermore, the consequences of the presence of corruption in the public procurement do not systematically result in cost overrun or time delay. For example, corruption in procurement can guarantee the repeated

awarding of contracts to the same company, even if it does not imply any increase in costs and time to realize a public infrastructure. Therefore, there is missing information that can explain distortions in the measurement of corruption here chosen. Nevertheless, the results suggest that this strategy does identify corruption.

A final consideration concerns heteroscedasticity in residual distribution. The Corruption Risk Indicators relies on estimate residuals, which are transformed into a new corruption risk indicator at the contract level in public procurement. To validate results, robust residuals should be normally distributed.[33] Different tests were conducted, which suggest that residuals are practically normally distributed. However, to minimize error terms and afford further robustness – in addition to the Montecarlo simulations – control variables and environmental variables were included in the second-stage regression.

4.5.2. Research and policy implications

The main aim of this research was the construction of an indicator of corruption risk in the Italian public procurement. To this purpose, a transparent and standardized methodology was developed to overcome the main limitations of the existing corruption indicators: context-dependency, limited possibility of generalizing data for comparative purposes, and replicability (especially outside the reference context). The development of the Corruption Risk Indicator has made it possible to synthesize a complex and multifaceted phenomenon in a single-risk score at the contract level. The strength of this approach is that the phenomenon of corruption is not only understood as the payment of a bribe, but in any form in which corruption distorts the good management of a public contract. Another advantage is that the score, or the aggregated indicators produced, are not only useful to monitor and evaluate the risk of corruption, but also as an integration for socio-economic and crime analysis.

The synthetic score at the micro level is aggregated to different levels to identify the geographical areas most at risk (in terms of regions, provinces and municipality) and the most corruption-prone contracting authorities. On such a basis, it is possible to compare the performance and overall risk within a country. Risk mapping has revealed greater risk associated with Lazio, Tuscany and Lombardy on one hand (CRI-a index), and with

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[33] The graphical distribution of the estimate residuals is provided in the annex.

Abruzzo, Lazio and Campania on the other hand (CRI-s index). However, there is heterogeneity in the results even within the same geographical area (see Figure 7). A careful interpretation of the results has highlighted that high-value contracts are usually linked to the recurring presence of a few state-owned firms, some of which operate throughout the national territory. These companies work primarily in the building and road construction sector, or in water collection and purification. Further investigation is required to assess their performance and to identify whether their recurrence is due to entrenched corrupt relationships between the actors mentioned in the contract.

From the results of the specifications, it is possible to deduce the strength of the factors that negatively affect efficiency. Poor quality of institutions and limited infrastructural endowment denote lower barriers to inefficiency. The results also indicate that inefficiency increases in complex public works. In-depth research should be conducted to deepen our understanding of the relationship between inefficiency and inefficiency factors, aimed at identifying possible countermeasures that can also be applied in the operational field. On the preventive side, public authorities must be more stringent with costs and time forecasting. Indeed, contracting authorities would benefit from the support and monitoring of third-party authorities, especially if they operate in areas characterized by a lack of social infrastructure and inadequate levels of efficiency.

Although there are several limitations relative to data quality, this assessment exercise has revealed that consistent results can be obtained when working with open data on public contracting. The belief is that the constant improvement of the data produced by the governmental institutions (e.g., MEF, ANAC) will facilitate further refinement in the analyses and their results. Finally, it is important to emphasize that the generation of new databases on public contracting (i.e., Opentender,[34] Contrattipubblici[35]) and corruption risk indicators at a procurement level can greatly support the efficiency of procurement activities while helping to prevent and discourage the manifestation of corruption in public procurement.

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[34] https://opentender.eu/
[35] https://contrattipubblici.org/

Chapter 5. Estimating red flags of corruption at the firm-level

5.1. Introduction

The theoretical framework described in chapter 3 suggests that corruption risks in public procurement should be evaluated broadly in its different risk dimensions (Fazekas et al. 2016). The winning bidder represents one key dimension. Winning bidders act in the public interest, as a vehicle from public procurement to the citizenry, producing and distributing services and/or goods, which have been purchased. Nevertheless, suppliers might be accountable for corrupt transactions, which through they seek to generate income, at the expenses of third companies and the health of the public administrations (Lambsdorff 2002). Through corruption, companies could obtain a *de facto* monopoly situation to retain business, obtain secret information, facilitate trade or investment or create demand for goods that otherwise would not have been purchased (Søreide 2002).

The need to prevent corruption leads lawmakers to ensure that open and transparent tenders, where bidders have equal treatment, are procured on a regular basis. To discourage the formation of corrupt agreements and to reduce corrupt practices, Italy has introduced several "soft law mechanisms" including a qualification system for firms bidding for public works contracts, under specific conditions (Presidential Decree n° 34/2000, now replaced by the Legislative Decree n° 50/2016). Soft law mechanisms benefit both participation in public contracting (Jiang 2009) and the formation of a set of shared rules of conduct (Boschetti 2016).

To date, several studies have focus on the role of bidders' qualification on tender outcomes. The qualification system stresses the technical, financial and morality requirements necessary for the granting of public contracts in public procurement and it is designed to mitigate asymmetric information problems in contract awarding so to achieve efficiency and 'value for money'. Qualification is a mandatory process for public works worth more than € 150,000 and directly affects the suppliers' choice of bidding, including forming a consortium with other firms or the use of subcontracting (Valbonesi and Moretti 2015).[36] Evidence

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[36] A firm that is not qualified to complete all of the tasks in a given contract has to take into account a "mandatory subcontracting" agreement with another firm that is qualified to execute the task.

suggests firms' qualification has beneficial effects on the functioning of the system and positively affects the performance of the contract (Valbonesi and Moretti 2015; Ancarani et al. 2016). However, because qualification does not provide incentives to firms in the implementation of the contract (Fiorino et al. 2018), several studies claim the need to consider suppliers' past performance – also referred to as reputation – as a possible additional selection criterion (Decarolis et al. 2016). The assessment of past performance has a positive effect on public procurement outcomes (Calzolari and Spagnolo 2016; Fiorino et al. 2018), allowing selecting the most efficient contractors and providing the supplier with the correct incentives to deliver public works within the time and costs agreed upon in the contract (Doni 2006).

Conversely, only few studies focus on the need to profile suppliers to better understand how firms exploit legal mechanisms to weaken audits and to ensure that corrupt rents are extracted from procurement contracts. In this chapter, the winning bidder is analyzed differently by exploring supplier-level red flags based on the financial and corporate information of the winning bidder, regardless of its qualification. Using linear regression modeling, this chapter aims at raising new hypothesis on the correlation between firms' attributes and corruption risk at the contract level, measured through the Corruption Risk Indicator developed in the previous chapter. The assumption is that private firms involved in corruption differ from their peers in their financial performance and corporate structure, because of the different goals in respect to procurement. Corrupt firms are often established and managed strategically to participate in the execution of corrupt contracts, with the goal of reallocating procurement rents among the actors involved in the fraudulent scheme. Accordingly, this chapter deals with the identification of some red flags at the firm level to support suppliers' evaluation in public contracting with additional data-driven risk indicators.

This chapter is organized as follows. Section 5.2. reviews existing studies dealing with the identification of potential firms' level characteristics correlated with the corruption risk in public procurement. Section 5.3. introduces the data and the methodological approach. Section 5.4. presents the results and section 5.5. discusses the strengths and limitations of the research as well as future research and policy implications.

5.2. Identifying red flags of corruption at the firm level

Identifying risky firms based on publicly available data is an inherently challenging exercise. While the literature on identifying contract-level risks is growing, there is little discussion on the type of bidders involved in these corrupt practices. This is surprising, as corrupt practices often aim at favoring a specific bidder over competitors, independently of the contractual framework (Galang 2012). Worldwide, the public procurement system has experienced an increased use of procurement outsourcing methods, such as sub-contracting and joint ventures, in alternative to traditional competitive patterns (Baltos et al. 2018). These legal practices, based on the sharing of corporate social responsibility, may be defined by narrow business interests aiming to reduce the interests of external stakeholders (Banerjee 2008).

The baseline assumption is that private firms which benefit from corruption are often established and managed strategically to participate in the execution of corrupt contracts and reallocate rents among the actors involved in the fraudulent scheme (OECD 2001; de Willebois et al. 2011). For example, firms can be set up shortly before the publication of the contract to the sole aim of rent-seeking (Fazekas et al. 2013), or to increase the chance of a connected firm to be awarded the contract (Handfield and Baumer 2006). As a consequence, firm-level red flags address the potential misuse of public contracts by winning firms to generate and share rents among the closed network involved in grand corruption (Fazekas et al. 2016).

It is worth mentioning that firm-level corruption patterns may show remarkable heterogeneity. Some risky patterns might have direct observable effects. For example, if money is diverted to enrich the owners of a particular supplier, firms should expect an increase in profits (Cheung et al. 2011), even higher for politically-connected firms (Amore and Bennedsen 2013; Cingano and Pinotti 2013; William et al. 2016). Nonetheless, there is no single set of firm attributes capturing a high risk of corruption. Consequently, several firm-level dimensions and indicators are empirically tested and evaluated to raise new hypotheses on the correlation between firms' attributes and corruption risk at the contract level.

The analysis proposed in this chapter relies on simple measures based on financial and corporate ownership information. As explained by Fazekas et al. (2016), a particularistic tie between the state and the supplier is a prerequisite in every corrupt transaction. Even the

simplest firm characteristics – such as the registered address or the profit margin – can proxy the probability of personal, and often political ties that are indicative of corruption. These simple firm characteristics can reveal a risk of corruption in a twofold way. On the one hand, they may favor corruption agreements, e.g. operating in a corrupt area may encourages firms to misbehave according to the predominant business culture (Galang 2012). On the other hand, these characteristics simply reflect the outcome of corrupt agreements, e.g. firm profits increase after the realization of the corrupt transaction (Cheung et al. 2011; Ayaydin and Hayaloglu 2014).

5.2.1. Financial information

A firm's financial information represents the main annual financial data typically published by all company types, including turnover, profit rate, return on assets or liquidity. The links between involvement in corruption and companies' financial performance are ambivalent. On the one hand, stable corrupt networks can guarantee high profits to the companies involved in the network. On the other hand, organized crime groups can establish shell companies - without interest in making profits - to divert public funds from public contracting (Transcrime 2008). This is not surprising, as the motives and techniques of rent allocation affect how firm's financial performance develops in response to government favors (Fazekas et al. 2013). Although the risk factors cover a broad range of situations, not all of these risks are relevant in all circumstances, and some may be of greater or lesser significance in entities of different size or with different ownership structure. For this reason, this exploration is aimed at identifying some recurrent patterns among the firms exposed to higher corruption risk in public procurement. More specifically, for the purposes of this study, the focus is on single indicators of firm profitability, firm liquidity and firm indebtedness.

Firm profitability measures are by default related to company size and to the business sector in which the firm operates. Depending on how corruption is organized, the correlation between corruption, firm efficiency and profitability varies a lot. The evidence from developed economies shows that return on assets and profitability increase significantly through winning public contracts due to political connections (Amore and Bennedsen 2013; Cingano and Pinotti 2013; William et al. 2016). Involvement in bribery leads to increased turnover, through higher revenue from tailor-made public procurement contracts (Cheung et al. 2011). According to Kaufman and Wei (1999), illegal practices and payments could speed

the bureaucratic procedures and promote firms' short-term growth by facilitating transactions in the bureaucratic process. Furthermore, Søreide (2002) suggests corrupt companies are usually more profitable as a way to afford the payment of bribes, which often represent a significant cost to the firm.

Firm indebtedness measures indicate how firms finance their assets. Higher risks are posed when a firm seeks for more external funds for its capitalization. Indicators of firm indebtedness are also related to firm size: larger firms tend to be either relatively more capitalized or less indebted (Ferrando et al. 2015). Results from accounting studies suggest financial leverage is an interesting item to be analyzed in detecting financial fraud (Spathis et al. 2002; Persons 2011; Omar et al. 2017; Jofre and Gerlach 2018). However, there are much fewer studies examining the relationship between firms' indebtedness and corruption. Lemma (2015) finds that firms operating in a country perceived to be highly corrupt use higher levels of short-term leverage and lower levels of long-term leverage and debt. As a consequence, unusual leverage values may signal the presence of fraudulent agreements in highly corrupt countries. Furthermore, the level of credit availability can suggest either a strong political relationship between suppliers and contracting authorities (Faccio 2006; Hong-Van 2016), or the need for external funds and/or credits, which may derive from the integration of laundered illicit proceeds, to recapitalize the firm (Masciandaro 2000).

Firm liquidity refers to a firm's cash assets, and its propensity to invest. Cash is a facilitator for committing crimes (such as tax evasion and bribery) and for concealing the proceeds of crime. Due to its nature, cash is a bearer payment instrument which gives no details either on the origin of the proceeds or on the beneficiary of the exchange (van Duyne and Soudijn 2009; Riccardi and Levi 2018). High levels of cash make it harder for law enforcement to follow the audit trail (Europol 2015; Riccardi and Levi 2018). Accordingly, empirical evidence shows that companies involved in illegal schemes (in Italy, especially mafia-connected firms) register not only higher liquidity but also higher levels of current assets, which may be easy to manipulate from an accounting point of view and may conceal illicit inflows/outflows (Transcrime 2013; Di Bono et al. 2015).

5.2.2. Ownership information

Ownership information describes the structure of a firm, giving information on who actually effectively owns or manages a private company. The information refers to the publicly

registered direct owners of companies and those officials who are required to be publicly registered, such as members of the board of directors.

According to economic and criminological literature, widely to money laundering research, several risky patterns are related to the ownership and management structure of a firm. The use of complex company ownership structures – even without including foreign ownership – can be a way to hide ownership information. Riccardi and Savona (2015) show that "Chinese-box" schemes in company ownership are often used in mafia infiltrated companies and in corruption schemes too. Chinese-box schemes refer to companies characterized by a large number of "cross-shareholders" and connections with third firms. In this way, a firm can be represented by a strawman, while the beneficial owner would remain unknown. A higher degree of complexity makes it more difficult to trace the actual beneficial owners, who can more easily conceal illicit funds (Riccardi et al. 2016; Riccardi and Milani 2018). Moreover, business ownership anonymity poses a threat to the efficiency and fairness of procurement too. Business ownership anonymity conceals the potential conflict of interest of agents who are simultaneously procurement officials and stakeholders in anonymous companies (Palguta and Pertold 2014).

Corporations established in risky jurisdictions, characterized by a low level of financial transparency, are also helpful in concealing illicit flows and hiding beneficial ownership (FATF 2016; Riccardi et al. 2017). In particular, by exploiting trust and company service providers, a firm can run a business by hiding the real identity of the ultimate beneficial owner (Riccardi and Savona 2013). Although most of the functions pursued by trusts and company service providers can all be legitimate, under certain rules they can also be corrosive as they can help: i) provide opacity; ii) set up shell companies to take advantage of laxer anti-corruption and transparency standards, and iii) set up structures that render the owners unaccountable for their actions and obligations, including to tax authorities (EURODAD 2015). According to de Willebois et al. (2011), grand corruption often involves hidden owners in at least two ways: either using opaque jurisdictions to register a company (i.e. tax havens) or by simply failing to correctly register owners or ownership changes. The latter poses a serious risk for procurement sustainability, as ownership change is recurrent in corrupt procurement contracting (Fazekas and Kocsis 2015). A change of firm name during contract execution can be very suspicious. On the one hand, it may signal an attempt

to clean up the firm's reputation after facing legal proceedings. On the other hand, it can flag the pursuit of tax incentives or other facilitations.

5.3. A firm-level analysis of corruption red flags

5.3.1. Public contracting and firm data

The literature review allows the identification of a set of firm characteristics that might capture the potential misuse of public funds by a winning bidder. Before the operationalization of these concepts, the database is introduced on which the analysis is carried out. The database includes Italian public contracts awarded from 2007 to 2013. The database combines the data on Italian contracts used to develop the Corruption Risk Indicator (see chapter 3) with the firm-level information gathered by Bureau Van Dijk (BvD).[37] The database on public contracts contains information on 4,940 public works. The name of the winning bidder is available for 99% of the cases. However, for about 40% of contracts, it is not possible to collect supplier data from BvD.[38] Therefore, the sample is reduced to 2,877 observations and about 1605 suppliers.

Data limitation does not allow to assess the whole universe of suppliers in the sample. Thus, two different tests are conducted to assess whether the sample of observations – for which company data were available – was on average more or less associated with a corruption risk than the sample for which company data were not available. Indeed, if the two samples differ, it means that one of the two samples can predict corruption outcomes in a better way. It follows that the results would bias our estimate. In fact, on the one hand, our sample would include only firms highly correlated with corruption. On the other hand, the sample would exclude the firms most exposed to corruption risk. To test the differences between the means of the two samples, both the Cohen's d test and the Hedges' g test were conducted.[39] The estimates from both tests are lower than 0.01, suggesting that there is no difference in

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[37] BvD is a multinational data provider specialized in business information, which collects company data from official business registers across the globe. In the case of Italy, BvD collects business information from Cerved.
[38] BvD databases (Orbis and Aida) do not cover the entire universe of Italian private entities, but only those legal forms (i.e. limited companies) which are required to file ownership and financial information with the business registry.
[39] The two scores provide the difference between two means in standard deviation units (Coe 2002). The main difference between Hedge's g and Cohen's d is that Hedge's g uses pooled weighted standard deviations (instead of pooled standard deviations).

effect size among the two samples.[40] Therefore, the hypothesis that the two samples are statistically different is rejected, which allows to conduct the exploration at the firm level.

5.3.1.1. The dependent variable: Corruption Risk Indicator

The risk of corruption in public contracting is measured through the Corruption Risk Indicator developed in the previous chapter. The Corruption Risk Indicator assigns a risk score to each public contract, awarded from 2007 to 2013 in Italy. As the Corruption Risk Indicator refers to post-awarding data, it indicates the extent to which the presence of corruption leads to cost adaptations and time delays in the realization of the public work. On the one hand, it is important to underline that the corruption proxy does not refer to a specific corrupt transaction. It may randomly refer to bribery, embezzlement or any other corrupt activity that can take place in public procurement. On the other hand, it only flags the corrupt practices that are a source of inefficiency in the management of the contract, leading to cost overrun and time delay. In this study, the Corruption Risk Indicator is normalized to 0-1 and ranges from 0 (low corruption risk) to 1 (high corruption risk).

5.3.1.2. Independent variables: Operationalization of firm-level red flags

The firm-level red flags identified in the literature are operationalized in this section, together with the control variables included in the analysis. To reduce potential endogeneity in the regression analysis, the firm-level red flags based on financial data are operationalized considering only the period prior to contract implementation. For example, if a contract is awarded in 2012, the information at firm-level are collected for the years 2010-2012. With regards to ownership data, data are referred to the last available year instead. In this case, BvD does not collect historical data.

The profitability of the firm is measured by the profit margin (*ProfitMargin*). Profit margin is calculated as the average growth index of the firm's profits on firm turnover. Higher values indicate that the firm increased its profits in the period prior to the award of the contract. Firm indebtedness is measured by the leverage ratio (*Leverage*). The leverage ratio is calculated as the average growth of total debts over total assets for the years prior to the tender. Higher values indicate that the firm used more external capitalization to finance its assets. To

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[40] According to Cohen's d and Hedges' g, the effect size has an effect if d (and g) > 0.8 (large effect) or > 0.5 (medium effect).

measure firm liquidity, three different proxies are calculated: current ratio, trade debtors and trade creditors. The current ratio (*CurrentRatio*) is measured as the average ratio between the current activities of a firm and its total activities. Higher values indicate the ease with which firm assets can be turned into cash. Trade debtors (*TradeDebtors*) measure the average number of days to be paid by customers for goods or services provided. Fewer debtor days means that cash is being received faster from customers. Trade creditors (*TradeCreditors*) measure the number of days to pay a firm's customers. More creditor days means that cash remains in the firm for a longer time. These two proxies capture the cash cycle of a firm. It should be noted that the three liquidity proxies are calculated by considering the average values of the three years before contract execution, instead of the average growth index.

With regards to corporate ownership information, three different proxies are analyzed with reference to: i) the complexity of the firm's structure; ii) the firm's connections with opaque jurisdictions; and iii) ownership changes. The complexity and the opacity of the firm are measured according to two proxy variables, which have been already used in other studies (Gara and De Franceschis 2015; Riccardi et al. 2016; Riccardi and Milani 2018; Riccardi et al. 2018): the beneficial owner distance (BO distance) and the business ownership connections with risky jurisdictions.

The BO distance (*BO_distance*) is a proxy for the company's complexity. It represents the number of 'steps' which separate a company from its beneficial owner(s).[41] The greater the BO distance, the more complex the ownership structure, and the higher the corruption risk. To control and reduce the effect of multinational companies (which are more complex by its transnational nature) and to identify actual anomalies, the BO distance of each firm is weighted by its size, measured in total assets. Business connections with 'risky jurisdictions' (*RiskShareholders*) can be understood by considering the average level of risk and opacity of the nationalities of the shareholders of the firm. In order to calculate the exposure to opaque jurisdictions, each firm's shareholder is multiplied through an indicator of opacity

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[41] BOs in the BvD's definition are the individual(s) who ultimately own or control a company or other legal entity. BvD identifies them by reconstructing the ownership chain until finding natural persons holding above a certain shareholding. For the objectives of this study, it has been decided to set the minimum threshold at 10% of the shareholding at the first level of the company ownership chain and 10% at further levels. When BO distance equals 1, the company is directly controlled by its BO(s).

and low transparency (the Secrecy Score of the Financial Secrecy Index, henceforth FSS).[42] In particular, the score for each firm is weighted by the relevant value of the FSS of its shareholders, and again corrected with a measure of firm size to control for the presence of multinational companies.[43] Furthermore, ownership change (*ChangeName*) is observed using a dummy variable for firms who have changed their name during the tender period.

At the firm level, two more variables are included. Most of the financial indicators are related to the company size. For example, smaller firms are usually less in debt and less liquid (Ferrando et al. 2015). Therefore, to control for this aspect, firm total assets (*TotalAssets*) is included in the specification. A dummy variable to measure the distance between the supplier and the public administration is also included. Previous studies suggest that firm location can be indicative of corrupt transactions. On the one hand, local firms more often participate in tenders taking place in the same area due to the higher capability and possibility of monitoring the market, especially to target less valuable projects (Decarolis and Giorgiantonio 2015). Indeed, only in case of a project of a sufficient size, firms located far from the municipality might find it convenient to bid, due to the high costs associated to moving workers and assets (Baldi et al. 2016). On the other hand, Coviello and Gagliarducci (2010) find that in case of long-term political stability (majors winning in several consecutive elections), local companies tend to win with a higher probability, while the number of bidders decreases and the costs of government contracts increases. Therefore, a dummy (*Proximity)* is included for contracts awarded by firms registered in the same province of the contracting authority.

In addition, some environmental predictors of corruption are also included. The first environmental measure is irregular labor (*IrrWorkers*). Irregular labor is calculated as the percentage of irregular labor over the total workforce per region. Working off the books is usually connected with corruption (Fazekas 2017b), especially in the construction sector. On average, ISTAT (2017b) estimates that 4% of workers in Italy are irregular (average

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[42] The Secrecy Score is a component of the Financial Secrecy Index (FSI) developed by the Tax Justice Network. It is a composite indicator which evaluates different dimensions of secrecy in the financial sector and in the legislation of selected jurisdictions. More specifically, it evaluates: A) the level of banking secrecy; B) access to beneficial ownership information; C) corporate transparency; D) efficiency of tax and financial regulation; E) compliance with international standards; F) international cooperation (Tax Justice Network, 2015). The secrecy score has been preferred to other measures of risky jurisdictions (e.g. international or national blacklists) because of its independency and transparency of the evaluation methodology. In this study the acronym FSS is used.

[43] See technical annex for further details.

2001-2013), while increasing up to 13% in the construction sector (ISTAT 2017b; Riccardi et al. 2017). Irregular payments allow for lower remunerations and are also a well-acknowledged method to conceal illegal funds (Dell'Anno et al. 2007; Schneider 2012). A proxy for experienced meritocracy in the public sector is also included (*MeritocracyIndex*) and measured through the index developed by Charron et al (2017). Meritocracy has a strong impact on reducing corruption opportunities in the public sector (Dahlström, Lapuente, and Teorell 2012). Public sector meritocracy is usually related to high levels of economic development, lower corruption perception and a higher overall level of impartiality in the public sector (Charron et al. 2017). Finally, two proxies measuring the regional economic performance are included: i) a proxy for capital attractiveness (*CapitalAttractiveness*) measured as the ratio of the differences between exports and imports over the total amount of exports and imports in a given province (Riccardi et al. 2016); ii) the GDP per capita (*GDPcapita*). Indeed, previous studies suggest corruption reduces the investment ratio and net capital inflows (Lambsdorff 2003) and it impacts on GDP growth (Lisciandra and Millemaci 2017).

It should be noted that the environmental variables cover the years of the tender, when possible. However, the heterogeneity of the time reference should not pose major problems with regards to these variables, as it is reasonable to assume that the processes represented by these variables usually change in the medium to long term. The indicators proposed are summarized in Table 16.

Table 16. Main statistics of the predictors included in the OLS regression

Variable	Source	Years	Obs.	Mean	Std. Dev.	Min.	Max.
CorruptionIndicator	Thesis	Contracts year	4,940	0.364	0.137	0.000	1.000
ProfitMargin	BvD	Contracts year	2,275	0.000	1.000	-46.16	6.013
Leverage	BvD	Contracts year	2,595	0.000	1.000	-10.96	37.79
CurrentRatio	BvD	Contracts year	2,791	0.157	0.022	0.059	0.186
TradeDebtors	BvD	Contracts year	2,791	0.071	0.044	0.054	1.046
TradeCreditors	BvD	Contracts year	2,791	0.070	0.038	0.054	0.810
RiskShareholders	BvD	Last Av. Year	2,875	0.032	0.063	0.000	1.000
BO_distance	BvD	Last Av. Year	2,875	0.129	0.088	0.000	1.000
ChangeName	BvD	Contracts year	2,877	0.140	0.347	0.000	1.000
Proximity	BvD	Last Av. Year	2,876	0.124	0.329	0.000	1.000
TotalAssets	BVD	Contracts year	2,791	3.478	0.626	1.306	7.858
IrrWorkers	ISTAT	2001-2013	4,940	0.301	0.280	0.000	1.000
MeritocracyIndex	Charron et al.	2015	4,940	0.307	0.167	0.000	1.000
CapitalAttractiveness	Tagliacarne	2006-2012	4,940	0.000	1.000	-2.225	2.081
GDPcapita	ISTAT	2007-2015	4,940	10.152	0.285	9.548	10.85

Source: Author's own elaboration

5.3.2. Empirical strategy

The relationship between firm-level indicators and the Corruption Risk Indicator at the contract level is modeled through the OLS regression. The OLS regression makes predictions about the dependent variable based on the observed values of the independent variables, and it can be expressed as:

$$y_j = \sum \beta_i x_{ij} + .. + \varepsilon_i \tag{1}$$

where y_j represents the dependent variable (in our case, the Corruption Risk Indicator), x_{ij} represents the explanatory variable(s), β_i are the regression coefficients and ε_i are the residual terms of the specification.

It is worth mentioning that OLS regression is not used to make any causal inference between the Corruption Risk Indicator and the firm-level red flags. Rather, it is used to investigate whether a relationship between the Corruption Risk Indicator and the red flags at the firm level exists. Indeed, the aim is to explore if any of these indicators can be associated with corrupt practices in contract awarding (and implementation), on a regular basis. Clearly, some indicators can point in two directions, raising an endogeneity issue. On the one hand, they may favor corrupt agreements; on the other hand, they can simply reflect the outcome of the corrupt transactions. To reduce the reverse-causality bias, firm indicators are developed taking into consideration the years before contract awarding. The Corruption Risk Indicator is based on information referred to the contract execution, instead. The fact that the Corruption Risk Indicator and the firm indicators do not overlap over time should minimize the presence of endogeneity in the regression model.

It is also reasonable to assume that some companies may have long-standing particularistic ties (even before contract awarding) with the public administrations. This could cause further problems of endogeneity. However, even with this assumption, we might expect the potential effects of corruption on firm performance in the short term (a short procurement timespan is considered) to be quite similar to the results of this assessment exercise.

Another caveat of most of these firm-level indicators is that they do not only mark corrupt companies, but also highly efficient and well-managed firms. In order to minimize false positive results, control variables for business sectors, company size, proximity and year of tender are included.

5.4.   Results of the analysis at the firm-level

Table 17 below presents six different linear regression models. Specification (1) and (2) test the financial ratios. They differ since specification (2) also includes environmental variables. Specifications (3) and (4) test the ownership red flags. Specification (4) includes the environmental variables. Specification (5) includes all variables but excludes control variables for company size (*TotalAssets*) location (*Proximity*). The last specification includes all the financial and ownership-red flags operationalized. In all specifications expect for the Specification (5), control variables for company size (*TotalAssets*), location (*Proximity*), economic sectors and years are included.[44]

On a general level, the results highlight the presence of a statistically significant correlation between the firm indicators and the Corruption Risk Indicator at the contract level. It is interesting to note that most of the significant red flags preserve their sign, and in most cases their significance as well, even after the introduction of the environmental variables. Environmental variables are also significant, in accordance with previous literature: irregular workers (*IrrWorkers*) and GDP capita (*GDPcapita*) increase as corruption risk increases, while meritocracy (*Meritocracyindex*) and capital attractiveness (*CapitalAttractiveness*) decrease as the risk of corruption increases.

Firm profit (*ProfitMargin*) increases significantly in specification (1) and (2), while it loses strength in specification (5) and (6), after the inclusion of the company ownership indicators. The results help raise some hypothesis. Involvement in corruption might lead to an increase in profit margin due to tailor-made public procurement contracts (Cheung et al. 2011; Ayaydin and Hayaloglu 2014) On the one hand, corruption can speed up bureaucratic procedures and promote firms' short-term growth by facilitating transactions in the bureaucratic process (Kaufmann and Wei 1999). On the other hand, more profitable companies could exploit their strong position in the market to create demand for goods or, in some case, to obtain a *de facto* monopoly situation to retain business (Søreide 2002).

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[44] To account for multicollinearity within the specifications, alternative models have been conducted using centering techniques. Results are presented in table 19 in the technical annex.

Table 17. OLS regression on firm-level red flags

Variables	Coeff. (SE) 1	Coeff. (SE) 2	Coeff. (SE) 3	Coeff. (SE) 4	Coeff. (SE) 5	Coeff. (SE) 6
Dependent variable: Corruption Risk Indicator (0-1)						
ProfitMargin	0.003 ***	0.001 *			0.001	0.001
	(0.001)	(0.001)			(0.001)	(0.001)
Leverage	-0.018 ***	-0.009 *			-0.009 *	-0.009 *
	(0.003)	(0.003)			(0.004)	(0.003)
CurrentRatio	0.302 *	0.152			0.177	0.164
	(0.146)	(0.134)			(0.136)	(0.135)
TradeDebtors	-0.357 **	-0.403 **			-0.427 **	-0.441 **
	(0.126)	(0.137)			(0.140)	(0.139)
TradeCreditors	0.310 *	0.297 *			0.289	0.259
	(0.153)	(0.147)			(0.149)	(0.150)
RiskShareholders			0.053 *	0.037	0.053 **	0.066 *
			(0.026)	(0.025)	(0.016)	(0.016)
BO_distance			0.025	0.030	0.205 *	0.174
			(0.067)	(0.075)	(0.091)	(0.093)
ChangeName			-0.010	-0.006	-0.010	-0.01
			(0.007)	(0.007)	(0.007)	(0.008)
TotalAssets	-0.008	-0.007	-0.005	-0.003		-0.006
	(0.006)	(0.006)	(0.005)	(0.005)		(0.006)
Proximity	-0.030 ***	-0.011 *	-0.032 ***	-0.011 *		-0.011
	(0.006)	(0.006)	(0.005)	(0.005)		(0.006)
IrrWorkers		0.154 ***		0.151 ***	0.154 ***	0.153 ***
		(0.016)		(0.015)	(0.016)	(0.016)
Meritocracyindex		-0.111 ***		-0.120 ***	-0.113 ***	-0.108 ***
		(0.018)		(0.017)	(0.018)	(0.018)
CapitalAttractiveness		-0.008 *		-0.009 **	-0.009 **	-0.008 *
		(0.003)		(0.003)	(0.003)	(0.003)
GDPcapita		0.235 ***		0.234 ***	0.235 ***	0.232 ***
		(0.016)		(0.014)	(0.016)	(0.015)
Years	YES	YES	YES	YES	YES	YES
Sectors	YES	YES	YES	YES	YES	YES
_cons	0.372 ***	-1.998 ***	0.364 ***	-2.003 ***	-2.026 ***	-1.984 ***
	(0.065)	(0.168)	(0.067)	(0.148)	(0.166)	(0.168)
Obs.	2275	2275	2789	2789	2274	2274
R-squared	0.072	0.204	0.069	0.207	0.201	0.203
Root MSE	0.133	0.123	0.133	0.123	0.123	0.123
Prob. > F	0.000	0.000	0.000	0.000	0.000	0.000

Notes: Clustered SEs are reported in parentheses.
*** Significant at the 0.5 percent level.
** Significant at the 1 percent level.
* Significant at the 5 percent level.
Source: Author's own elaboration

Quite differently, firms connected with contracts at high risk of corruption are more capitalized and less indebted. The leverage ratio (*Leverage*) is negative and statistically significant in specification (1), (2), (5) and (6). As the literature on this relationship is not abundant, the hypothesis is that the leverage ratio indicator can proxy the probability of personal or political ties that are indicative of corruption in procurement. Indeed, low levels of debt over total assets might suggest that the companies involved in corruption may receive direct funding from the public administrations, which allows maintaining a low level of indebtedness.

Concerning liquidity measures, trade debtors (*TradeDebtors*) and trade creditors (*TradeCreditors*) are significant but in differing ways. The two proxies are significant in specification (1), (2), (5) and (6). In specification (5) and (6), trade creditors are significant at the 90% statistical significance. The results indicate that firms involved in corruption receive customers' payments in a short term with respect to their peers. The results also indicate that these firms take longer to pay their customers. It is interesting to note that suppliers involved in public contracts that are usually executed with delays and additional costs are also those that take longer to pay their customers. This finding might flag the opportunistic behaviors of firms which participate in procurement to extract maximum rents from a contract.

Furthermore, the results suggest that there is a relationship between the risk of corruption and the level of firm opacity. The connection with opaque jurisdictions (*RiskShareholders*) is positively related with the risk of corruption in procurement in specification (3), (5) and (6) (complexity measured by the *BO_distance* – is also significant at the 5% level in specification (5) and at the 10% level in the final specification). The use of off-shore countries for corruption purposes is well-documented both in academic research (e.g., de Willebois et al. 2011) and from journalistic evidence (i.e. Panama Papers, Paradise Papers). The results support the hypothesis that firms involved in corruption might set up shell companies in opaque jurisdictions to take advantage of laxer anti-corruption and transparency standards (EURODAD 2015). Moreover, being incorporated in a tax haven is also helpful in concealing illicit flows and hiding beneficial ownership (Riccardi and Milani 2018).

Despite the explorative purpose of this analysis, the results seem to profile an 'identikit' of the suppliers involved in corrupt transactions. Firms associated with a high risk of corruption in public procurement appear to be more 'dynamic' than their peers, both from a financial

point of view (lower debts, greater profits and fewer trade debtors), and for their ability to establish particularistic ties throughout the country ("*proximity*" is negatively related with the corruption risk indicator, suggesting that firms are involved in corruption outside their province of origin). It is also interesting to note that these firms tend to have a more complex corporate structure, characterized by connections with opaque jurisdictions and tax havens. These connections with opaque jurisdictions could represent the channel through which public funds are diverted.

5.5. Discussion

5.5.1. Strengths and limitations

The analysis so far conducted supports the basic assumptions of this chapter. Despite this, the method is not exempt from limitations. The following discusses both the strengths and weaknesses of the approach adopted.

In the previous section, an explorative analysis of risk indicators at the firm level is presented. The basic assumption is that firms involved in corruption are different from their peers because they are established and managed strategically to extract and reallocate the procurement rents among the actors involved in the fraudulent scheme. The results support this assumption. Indeed, the findings indicate a statistically significant difference between the characteristics of the firms being awarded public contracts at high risk of corruption, with respect to the characteristics of the firms participating in well-managed contracts. As a consequence, the results show that firm characteristics can be linked to corruption in public procurement, and that, these firm-level red flags can address the potential misuse of public contracts by the winning bidders.

This approach is coherent within the analytical framework proposed in chapter 3, which suggests the possibility to develop a set of indicators at a different level which can be used jointly to determine the overall risk of a public contract. In this chapter, a set of indicators that can capture the supplier's process of generating, allocating and distributing corrupt rents from government contracts is identified and estimated. Moreover, this chapter integrates the results of the analysis produced to measure the risk of corruption at the contract level (chapter 4).

The red flags at the firm-level are based on simple measures (i.e., simple financial ratios such as profit margin, leverage) which are easy to operationalize. It follows that this simple methodology is easy to replicate. On the one hand, it allows the replication of the analysis on a different sample, to test the robustness of the red flags identified by the regression analysis. Indeed, it is important to replicate the analysis before stating any conclusions about a systematic correlation between these simple firm-level indicators and the risk of corruption on a large scale. On the other hand, the methodology is also applicable to other contexts. In fact, the supplier's risk indicators are not specifically tailored to the Italian context. It should be noted that the whole approach is in fact built on the need to develop a risk assessment methodology that is as much standardized as possible.

Obviously, these indicators are not exempt from limitations. The first shortcoming regards the availability of company data. Earlier, the difficulty of gathering information on companies was pointed out. The data provider (in this case BvD) does not cover the entire universe of Italian private businesses. For example, individual firms are usually not covered by BvD because they are not required to file ownership and financial information with the business registry. Nonetheless, information for about 1,600 companies being awarded with public contracts from 2007 to 2013 is collected and analyzed. In this respect, it is important to stress that the loss of information should not bias the analysis. To ensure this, before computing the analysis two different tests were performed to verify that the missing values did not affect the validity of the sample in use.

The second limitation refers to how red flags are operationalized. It is worth noting that the relationships between firm-level indicators and the risk of corruption are examined in an explorative manner. To the best of my knowledge, this is one of few studies dealing with the identification of corruption risks within companies, therefore, expectations and hypotheses about the relationship between these supplier-level indicators and corruption might not find previous evidence in the literature. For this reason, this study should be used as a starting point for future refinements. Further ambiguity related to the measurement approach is related to false positives. In most cases, the indicators can also capture dimensions that are not closely related with corruption in general. Accordingly, control variables for some environmental factors and business sector characteristics are included to reduce such bias.

The last limitation regards the issue of reverse causality in the specifications presented in Table 17. Reverse causality refers either to a cause-and-effect relationship contrary to a

common assumption or to a two-way causal relationship. In the approach adopted, cautious is exercised about the possibility of identifying causal relationships between the supplier red flags and the corruption risk indicator. Accordingly, some rule of thumb is followed to reduce such bias. For example, when operationalizing the companies' attributes, a different timespan is considered from the one employed for the analysis at the contract level. To reduce the reverse-causality bias, the supplier indicators are developed taking into consideration the years before contract awarding, while the Corruption Risk Indicator instead is based on information referring to contract execution. The fact that the Corruption Risk Indicator and the supplier indicators do not overlap over time should minimize the presence of endogeneity in the specifications presented. Further refinements might also try to identify different risky patterns at the firm level by also paying attention to the period right after contract implementation.

5.5.2. Research and policy implications

The empirical validation of the main assumption of this chapter is still in its infancy, but its development might interest both the academia and the public sphere.

To date, most of the available corruption indicators focus on measuring corruption risk related to public contracts and do not explore the risks connected to the firm involved in the corrupt scheme. Delving into the characteristics of the winning bidder can help to uncover several of the multiple facets of corruption in procurement. In this regard, the findings of this chapter help raise new hypotheses on the relationship between some supplier-level red flags and corruption (e.g., the relationship between profits and corruption or tax havens and corruption; the relationship between firm indebtedness and corruption). These new potential hypotheses would deserve further investigation. Future studies should attempt to provide further evidence, even about the direction of the relationship between corruption and firm-level red flags.

Other interesting insights could also emerge testing more information on firms' financial performance or corporate governance. For example, by combining data on firms' board of directors with data on politicians, bureaucrats or politically exposed persons, it would be possible to flag the political connections among the actors involved in procurement. Currently, this kind of studies are very scarce. The main limitation is, in fact, the availability of data that would allow the identification and measurement of the particularistic ties

between the public sector and private firms. It would also be of great help to conduct a systematic review of the business factors related to the risk of corruption so as to harmonize the theories under which these indicators are meant to be used.

Besides, the development and further testing of the indicators proposed can have clear policy implications. Firm-level red flags can help identify suppliers potentially rigging the tendering process. As suggested in the introductory section, current audit and monitoring mechanisms could be implemented with data-driven solutions to assess firm performance and to identify anomalies or risky patterns in the way companies are owned and managed. In this regard, the risk indicators at the firm level could also assist the evaluation and selection of the supplier in the pre-tender phase, even though, according to the Code, bidders should be evaluated based merely on technical aspects referring to both their financial and technical capacity.

Finally, the indicators at the firm level can be used jointly with other indicators (e.g. at tender or buyer level) to concoct a more complete overview of the risks in public procurement. For example, by checking whether high turnover growth is associated with a risk in contract awarding is a straightforward way of identifying the probability of personal or political ties, which can be indicative of corruption. In this way, multi-level risk indicators can assist law enforcement agencies, contracting authorities and auditors in their monitoring activities before and after the awarding of the contract. The 'informational power' of these indicators can be a basic tool to facilitate both the monitoring activities of the overseeing bodies, and the strategic management of clean businesses that need to defend their interests in the market at the expense of those companies who act strategically to divert public funds.

Concluding remarks

The analysis of the dynamics of corruption requires the use of precise and reliable measures to understand the relative weight of each of the numerous factors that can influence the level of corruption in a country (OECD 2016). Adequate measures are crucial to investigate the economic, social, political and moral costs of corruption (Lambsdorff 2006a; Lisciandra 2014; Uslaner 2015), to define appropriate policies and countermeasures (ANAC 2013), and to raise the level of awareness of the phenomenon in the public opinion and in the public administration (Transparency International 2018). Therefore, to fill the demand for reliable and valid corruption indices, this dissertation has dealt with the measurement of multi-level corruption risk indicators at the procurement level.

To develop a set of corruption risk indicators, this study has provided an applied theoretical and analytical approach which rests on a thorough understanding of the process through which corrupt rents are extracted from the procurement contracts and further distributed. Based on this approach, this study has built a novel methodology, which:

a) is solely based on objective indicators derived from open data;
b) allows for territorial comparisons within the Italian context;
c) allows for the identification of firms that are potentially involved in corrupt transactions;
d) can be replicated in other contexts using the same set of pre-existing data.

The results described in the previous chapters confirm that this approach can provide useful information to understand the level of corruption risk in the Italian procurement context. The findings partially reflect the effort of the judicial authorities and the police forces, as indicated by the robustness analysis carried out to validate the methodology. According to the results, the risk of corruption in Italy has no clear territorial pattern, although central – and some southern – provinces presents on average a higher risk of corruption in procurement.

A more careful interpretation of the results has also revealed that high-value contracts are usually linked to the recurring presence of a few state-owned firms, some of which operate throughout the national territory. These contracting authorities primarily work in the building and road construction sectors, and in water collection and treatment activities, confirming

previous evidence relative to the identification of corruption risks in the aforementioned economic sectors (Caneppele 2014).

Furthermore, the findings at the firm-level have also identified some recurrent firm-level patterns correlated with contracts at high risk of corruption. From a first assessment, firms associated with high risk-contracts act in accordance with their personal interests: they seek profits and are legally and/or financially connected with opaque jurisdictions or tax havens. Further research is required to understand whether these firms' characteristics can hide corruption-related misconducts aiming to divert public funds from procurement contracts on a regular basis. Additional research is also needed to consolidate the results of this dissertation, also owing to the fact that the development of multi-level corruption risk indicators is a challenging assessment exercise.

As these indicators are defined at the micro-level and are available over long periods of time, there are many possibilities for using this set of indicators to evaluate corruption risks, anti-corruption policies and market performance (Fazekas and Tóth 2014b; Fazekas et al. 2016). These indicators allow the implementation of a series of initiatives:

a) evaluating regions and provinces over time. For example, it is possible to track the average incidence of public procurement corruption over time and to observe if significant policy changes (i.e., the Law 190/2012 for evaluation and transparency of public administrations) impact the overall scores;

b) assessing large funding programs by evaluating similar public procurement tenders under different financing sources;

c) profiling public organizations and winning bidders involved in high-corruption risk networks to promote effective corruption countermeasures (i.e., the use of joint procurement mechanisms to enable the pooling of different skills and expertise between the authorities in disadvantaged or inefficient contexts);

d) supporting the conduction of risk-based audits of actors and transactions, by guiding the work of auditors and procurement officers in their monitoring activities as well as in the evaluation and selection of bidders.

An innovative aspect of the approach adopted in this dissertation lies in the fact that it is based on the analysis of open data. Open data on public contracting provide researchers not only with new sources, but also with the possibility to develop new approaches to the

generation and analysis of such data (Falcone 2018). One of the strengths of open data consists in the possibility of linking and integrating this information with other national or business platforms (Melandri et al. 2018), as carried out in this dissertation. The availability of such information is spreading. Governments have increased data accessibility and usability by lowering unnecessary entry barriers and by building open-access central portals (Transparency International 2017). However, governments should also promote initiatives to raise awareness and increase data literacy and capacity-building among potential data users (Transparency International 2017).

In this regard, some research and institutional initiatives have contributed to enhancing the awareness, collaboration and engagement of many anti-corruption organizations. Recent EU research projects have employed open data to improve the availability of data and risk indicators by creating a network of researchers, activists and organizations involved in the fight against corruption in public procurement. The 'Digiwhist Project' has developed a series of online portals to improve the efficiency of public spending across Europe, through the systematic collection, structuring, analysis and broad dissemination of information on public procurement and on mechanisms that increase accountability of public officials at a European level.[45] Among the outcomes of this project, it is worth mentioning the 'MET software', which integrates the data on public contracting awarded at EU level with a set of red flags to provide public authorities with a risk assessment tool to evaluate the degree of integrity of European public procurement procedures.[46] The project 'YourDataStories' also combines governmental open data with social networks and business information to meet the citizens' and businesses' needs by promoting open data use to enhance transparency and fight corruption.[47]

At the institutional level, a recent OECD report (2016) has outlined several national best practices that use open data and big data analytics to provide a broader understanding of corruption risks in procurement. For example, the Procurement Office of the Federal Ministry of the Interior in Germany has developed a central system which enables regional and local contracting authorities to directly provide data on each single procurement activity to the central system. This data flow allows the systematic elaboration of the

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[45] http://digiwhist.eu
[46] https://monitoringeutenders.eu
[47] https://yourdatastories.eu

information by central agencies, to check on the correct application of the procurement procedures and to arrange 'real-time' inspections in case of an emergency.

According to the aforementioned best practices, the development of risk indicators based on government and procurement open data has emerged in different contexts as a complementary method to traditional approaches for the prevention and curbing of corruption. However, as for novel approaches, there are still drawbacks to overcome before this approach can be effective on a large scale. With respect to the Italian context, the main limitations are related to the way open government data are standardized and the lack of adequate digital platforms to manage these data. Indeed, if on the one hand Italian institutions are pushing towards the need for more risk-based indicators to monitor procurement activities and prevent corruption (ANAC 2013), on the other hand, it is necessary to adapt the existing digital platforms to the characteristics of open (and big) data to improve the exchange of information among State administrations (Falcone 2018). To afford high standards, it is crucial to take an important step to fill the cultural gap in the management, structuring, collection and storage of data which is functional to the entire administrative system (Ponti 2016), as recognized by national authorities as well (ANAC 2017a).

To overcome this institutional gap, research initiatives such as the generation and structuring of open data (Melandri et al. 2018) and the development of risk indicators should not only have a scientific research objective, but also support the building and strengthening of public infrastructures for data exchange. In this sense, through the development of multi-level corruption risk indicators, this study has not only provided a better comprehension of the risks of corruption in the Italian context, but it has also highlighted current limitations in data quality and accuracy that could be overcome with better collaboration between research and public institutions. To conclude, the desire is that further refinements of these new risk-based tools to measure corruption, together with a better quality of institutional data, can lay the grounds for innovative, data-driven anti-corruption strategies.

Technical Annex

A.1. Second-stage estimation results with centered-variables

To control for potential multicollinearity in the second-stage truncated regression, three alternative specifications are conducted considering normalized variables through the so-called centering technique. The results for these models are reported in table 18.

Table 18. Truncated regression second-stage estimation results on different samples
Centered variables

Variables	Coeff. (SE) - FS	Coeff. (SE) – NO ANAS	Coeff.(SE) - FD
Inefficiency (dependent variable)			
Rebate_c	0.061 **	0.067 **	0.092 ***
	(0.021)	(0.021)	(0.015)
Rebate_null	-0.089 ***	-0.094 ***	-0.074 ***
	(0.013)	(0.013)	(0.007)
Consortium	-0.006	-0.006	-0.001
	(0.010)	(0.010)	(0.007)
Infrastructural_index_c	-2E-04 **	-9E-05	-2E-04 ***
	(6E-05)	(6E-04)	(5E-05)
E-procurement_c	4E-04	0.001	2E-04
	(5E-04)	(5E-04)	(4E-04)
Inhabitants_c	-0.006 ***	-0.005 ***	-0.007 ***
	(0.001)	(0.001)	(0.001)
Institutional_quality_c	-1.172 *	-1.127 *	-0.590
	(0.523)	(0.517)	(0.421)
Quality_governance_c	-0.080 **	-0.084 **	-0.070 **
	(0.030)	(0.029)	(0.022)
Stateowned_firms	-0.339 ***	-0.157 ***	-0.307 ***
	(0.021)	(0.019)	(0.015)
Local_health	0.024	0.024	0.004
	(0.015)	(0.014)	(0.011)
Central_authority	0.028 **	0.021 **	0.024 ***
	(0.009)	(0.009)	(0.006)
Municipality	0.015 *	0.015 *	0.013 *
	(0.007)	(0.007)	(0.005)
Length_contract_c	2E-05 **	2E-05 **	4E-06
	(8E-06)	(8E-06)	(4E-06)
Lot_value_c	6E-09	3E-09	2E-09
	(4E-09)	(4E-09)	(1E-09)
EU_threshold	-0.114 **	-0.103 *	-0.081 **
	(0.047)	(0.046)	(0.025)
Procedures	YES	YES	YES
Years	YES	YES	YES
Sectors	YES	YES	YES
Regions	YES	YES	YES
_cons	0.409 ***	0.436 ***	0.361 ***
	(0.080)	(0.079)	(0.065)
SEs of regression	0.122	0.121	0.127
Obs.	4937	4603	9678
Adj. R-squared	0.168	0.168	0.184
Wald (Prob. > chi2)	0.000	0.000	0.000

Notes: Bootstrap Standard Errors are reported in parentheses. Specification (FS) includes all contracts noticed between 2007 to 2013 with a maximum length of three years and delay of up to 253 days; Specification (no ANAS) excludes the public work contracts noticed by ANAS from the final sample; Specification (FD) includes the contracts awarded from 2007 to 2015 with post-award information.
*** Significant at the 0.5 percent level.
** Significant at the 1 percent level.
* Significant at the 5 percent level.
Source: Author's own elaboration of MEF data

A.2. Estimate of corruption crimes in Italy

The estimate of corruption crimes committed in Italy (*Corruption_crimes*) is computed following a two-step procedure.

As a first step, the "multiplier" M_j is calculated as follows:

$$M_J = \left(\frac{\left(\frac{\frac{\sum_{y \in Y_1} a_{j,y}}{|Y_1|} \times i_j}{100} \right)}{\sum_{y \in Y_1} z_{j,y}} \right)$$

where:

j = region

Y_1 = {2013, 2014, 2015}

$a_{j,y}$ = number of families in region j in year y

i_j = cases of corruption for 100 families in region j in the last 3 years (ISTAT 2017a)

$z_{j,y}$ = corruption crimes for which a criminal proceeding begins in region j in year y

As a second step, M_j is employed to compute the estimate of the total number of corruption crimes committed in a given year:

$$Corruption\_crimes_j = \frac{\sum_{y \in Y_2} \left(M_j \times z_{j,y_2} \right)}{|Y_2|}$$

where Y_2 = {2009, ..., 2015}

A.3. Evidence-based methodology and query formulation

The evidence-based methodology is applied to cross-check 250 public work contracts taken from the final Corruption Risk Indicator with information retrieved from online sources. To standardize this operation, the online search relied on a three-fold query systematically structured to collect online information related to public work contracts and any corruption-related crimes inherent to the specific public work contracts selected. The query incorporated keywords related to the three main categories (see Figure 8):

a) contracts information (e.g., year, type of activity, location);
b) authors' information (contracting authority and supplier);
c) criminal or illegal activities related to corruption or related crimes (e.g., corruption, bid rigging, criminal proceeding).

The Boolean operators "OR" and/or "AND" connected keywords pertaining to the same category, while the Boolean operator "AND" connected keywords from different categories. This query structure ensured to retrieve the information containing at least one term from each work category.

**Figure 8. Query structure**
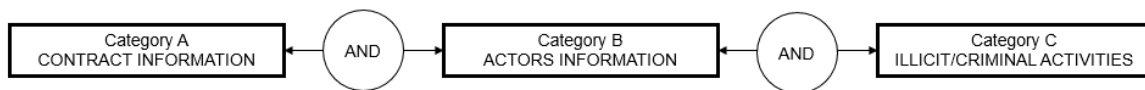
Source: Author's own elaboration

The online search returned one of three possible scenarios according to the type and relevance of the information retrieved:

1. *White cases* (no online information)
2. *Grey cases* (presence of criminal record involving one of the two main actors but not strictly related to the contract)
3. *Black cases* (judgement, arrest warrant, pre-trial investigation and other illegal or criminal activities strictly related to the contract).

A.4. Graphical distribution of the estimate residuals from second-stage regression

The Q-Q plot (Figure 9) compares the residuals distribution to the expected standard normal distribution. The plot comes very close to a straight line suggesting residuals are partially normally distributed. In fact, the Q-Q plot shows some skewness at both tails.
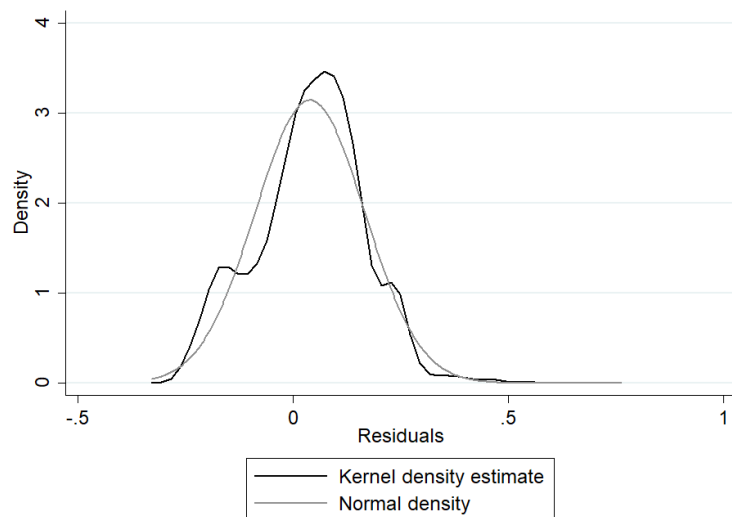
Figure 9. Residual distribution versus standard normal distribution

Grid lines are 5, 10, 25, 50, 75, 90, and 95 percentiles
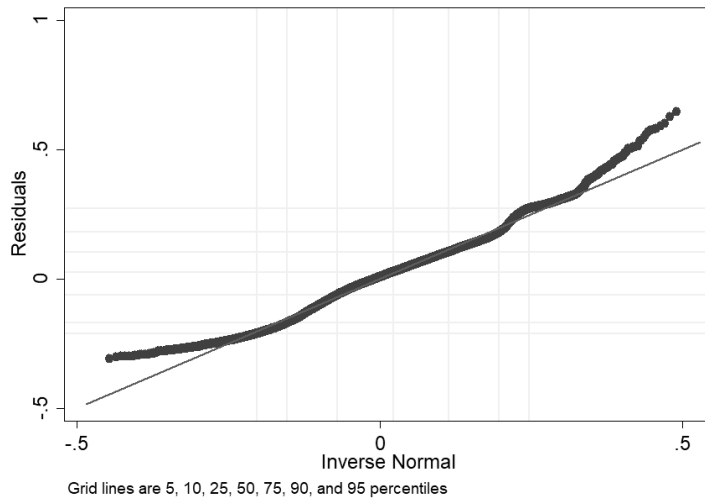
Source: Author's elaboration of MEF data

Furthermore, the estimated kernel density of the residuals are also checked and plotted (see Figure 10). They appear nearly normal.

Figure 10. Kernel density estimation with normal density

Source: Author's elaboration of MEF data

A.5. Firm's shareholders' links with opaque jurisdictions

For each firm, the volume of shareholders links with opaque jurisdictions, weighted by the firm size in order to control for the presence of multinational firms, is calculated as follows:

$$RiskShareholders_i = \frac{\sum_{j \in J_i}\left(x_{ij} \times FSS_j\right)}{a_i}$$

where

i = private firm

J_i = set of nationalities of shareholders in firm *i*

$j \in J_i$ represents a specific nationality within J_i

x_{ij} = number of shareholders of nationality *j* in firm *i*

FSS_j = Secrecy Score of the Financial Secrecy Index (Tax Justice Network 2015) of nationality *j*

a_i = value (euro) of total assets of a firm i

A.6. OLS regression on firm-level red flags with centered-variables

To control for potential multicollinearity in the OLS regression, alternative specifications are conducted considering normalized variables through the so-called centering technique. The results for these models are reported in table 19.

Table 19. OLS regression on firm-level red flags with centered-variables

Variables	Coeff. (SE) 1c	Coeff. (SE) 2c	Coeff. (SE) 3c	Coeff. (SE) 4c	Coeff. (SE) 5c	Coeff. (SE) 6c
Dependent variable: Corruption Risk Indicator (0-1)						
ProfitMargin	0.003 ***	0.001 *			0.001	0.001
	(0.001)	(0.001)			(0.001)	(0.001)
Leverage	-0.019 ***	-0.009 **			-0.009 *	-0.009 *
	(0.003)	(0.004)			(0.004)	(0.003)
CurrentRatio	0.317 *	0.162			0.177	0.144
	(0.148)	(0.138)			(0.136)	(0.132)
TradeDebtors	-0.324 **	-0.373 **			-0.427 **	-0.431 **
	(0.127)	(0.137)			(0.140)	(0.139)
TradeCreditors	0.382 *	0.355 *			0.289	0.280
	(0.147)	(0.144)			(0.149)	(0.149)
RiskShareholders			-1.129	-1.075	0.050 **	7.391 *
			(3.325)	(3.692)	(0.016)	(3.606)
BO_distance			0.071	0.054	0.205 *	0.200 *
			(0.056)	(0.065)	(0.091)	(0.090)
ChangeName			-0.011	-0.006	-0.010	-0.010
			(0.007)	(0.007)	(0.008)	(0.008)
TotalAssets	6E-10 *	3E-10	2E-08	2E-08		-1E+07 *
	(3E-10)	(3E-10)	(5E-08)	(5E-08)		(5E-08)
Proximity	-0.029 ***	-0.010	-0.032 ***	-0.010 *		-0.011 *
	(0.006)	(0.006)	(0.005)	(0.005)		(0.006)
IrrWorkers		0.155 ***		0.151 ***	0.154 ***	0.154 ***
		(0.016)		(0.015)	(0.016)	(0.016)
Meritocracyindex		-0.113 ***		-0.120 ***	-0.113 ***	-0.108 ***
		(0.018)		(0.017)	(0.018)	(0.018)
CapitalAttractiveness		-0.008 *		-0.009 **	-0.009 **	-0.008 *
		(0.003)		(0.003)	(0.003)	(0.003)
GDPcapita		0.234 ***		0.233 ***	0.235 ***	0.235 ***
		(0.016)		(0.014)	(0.016)	(0.016)
Years	YES	YES	YES	YES	YES	YES
Sectors	YES	YES	YES	YES	YES	YES
_cons	0.388 ***	-1.980 ***	0.348 ***	-2.032 ***	-1.995 ***	-1.989 ***
	(0.054)	(0.165)	(0.067)	(0.164)	(0.163)	(0.168)
Obs.	2275	2275	2789	2789	2274	2274
R-squared	0.071	0.203	0.069	0.207	0.201	0.204
Root MSE	0.132	0.123	0.133	0.123	0.123	0.123
Prob. > F	0.000	0.000	0.000	0.000	0.000	0.000

Notes: Clustered SEs are reported in parentheses.
*** Significant at the 0.5 percent level.
** Significant at the 1 percent level.
* Significant at the 5 percent level.
Source: Author's own elaboration

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