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Measuring Corruption Risk in Public Procurement over Emergency Periods

Michela Gnaldi[1] · **Simone Del Sarto**[1]

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Abstract
Times of crisis provide fertile ground for corruption because of looser regulatory frameworks, weaker oversight, and skyrocketing financing levels. Public procurement systems are particularly vulnerable to corruption risks over emergency periods as they are at the frontline of many country responses to crises. In this paper, we propose a curated selection of red flag indicators of corruption risk over crises and discuss a general measurement framework for their computation. The proposed approach exploits the time discontinuity introduced by a crisis and allows us to characterise and differentiate companies and/or contracting authorities with different degree of risk through statistical testing. The suggested framework is intended to accommodate the changing and far-reaching corruption risks induced by crises and mitigate them effectively.

Keywords Corruption risk · Emergency · Red flag indicators · Public procurement

1 Introduction

Corruption is a persistent phenomenon in both economically developed and developing countries. Controlling it by repressing and preventing fraud, malfeasance and misconduct is crucial for governments who need to allocate resources across competing priorities. Public procurement—the process by which public authorities purchase work, goods or services from companies—is one of the government activities most vulnerable to corruption. Integrity risks may occur at every stage of the procurement process (OECD, 2016b) and are exacerbated by the volume of the transactions and financial interests at stake. Indeed, public procurement accounts for over 14% of the EU's GDP and the occurrence of corruption in the procurement process has huge direct and indirect costs, including loss of public funds, higher expenses, lower quality of good, services and works, weakened accountability mechanisms, lower public trust in democratic institutions.

✉ Simone Del Sarto
simone.delsarto@unipg.it

Michela Gnaldi
michela.gnaldi@unipg.it

[1] Department of Political Science, University of Perugia, Via Alessandro Pascoli, 20, 06123 Perugia, PG, Italy

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In the last years, public procurement has been at the frontline of many country responses to crises of various nature (i.e., pandemics, climate emergencies, war crises, etc.). During crises, governments implement emergency measures and policies to address the challenges posed by the crises. Such measures, framed within relaxed international and national regulatory frameworks, often include changes to public procurement processes to ensure the timely acquisition of essential goods and services. The relaxation of European and national regulatory frameworks, together with the massive increase in spending to cover supply shortages, creates new opportunities for malpractices and intensifies exposure of procurement systems to integrity risks (Gallego et al., 2020; Schultz & Søreide, 2008), making the measurement of corruption in public procurement crucial across crises.

Typically, crises are considered rare events and their associated risks are managed through reactive approaches, which mainly involve seeking more information about their severity over time and adopting suitable strategies accordingly. Yet, the complexity and frequency of current crises urge science and policy makers to devise proactive strategies in view of containing their harmful impacts through new and realistic models of interacting risks. Likewise, corruption risk assessment systems developed to pinpoint corruption risks in public procurement in ordinary periods need to be adapted if they aim at establishing effective solutions for mitigating corruption risk over emergency scenarios.

The readaptation to crisis contexts of corruption risk assessment systems implies paying attention to red flags, which are the foundation of corruption risk assessment systems. Red flags are proxy measures for corruption, signalling risks of corruption, rather than actual corruption. Red flags are then expected to be correlated with corrupt practices, rather than perfectly matching them (OECD, 2019; Fazekas & Kocsis, 2020).

While over emergencies the specific rules and regulations for public procurement can vary among countries and even within different jurisdictions within a country, governments largely rely on relaxed procurement procedures (such as accelerated processes or negotiated contracts and direct contracting) to expedite the acquisition of critical supplies and ensure the timely acquisition of essential goods and services. Consequently, measuring the risk of corruption over crises by relying on ordinary red flags—such as the use of exceptional procedure types, direct awards, short advertisement time-periods—might lead to overestimate corruption, as high values assumed by such indicators might well express the legitimate adaptive response to a relaxed regulatory framework rather than (or other than) an actual high level of corruption.

In this paper we propose an approach to compute a set of red flags, largely derived by the current literature on the risk of corruption, and intended at further controlling the overestimation issue highlighted above. The proposal exploits the time discontinuity introduced by the crisis outbreak, that is, the possibility to distinguish two time spans, a pre- and post-crisis period. Specifically, through the computation (before and after the crisis) of a selection of suitable red flags, our approach compares company and/or contracting authority behaviours after the crisis outbreak with respect to their historical (pre-crisis) behaviour. Afterwards, it assesses the risk of corruption through statistical testing, where the set of hypotheses can be adjusted, time after time, according to observed market trends across the crisis. Overall, the conceptual framework of the proposed measurement approach *i.* assumes that any important (i.e., statistically significant) deviation of company and/or contracting authority behaviours across the crisis from what we expect—given observed market trends across the crisis—might indicate a risk of corruption, and *ii.* allows us to characterise and differentiate companies and/or contracting authorities with different degree of risk based on the extent of divergence from their historical behaviour and the strength of the obtained statistical evidence (as measured by the p-value).

The proposed approach is extensible to several crisis contexts by *i*. setting the timespans in accordance with the entry date of the legislative act acknowledging the beginning of the emergency period; *ii*. selecting the relevant contract objects, depending on the pertinent markets most concerned with the specific crisis at hand. In this regard, the proposed risk assessment strategy relies on a series of red flag indicators calculated exclusively using contracts within sectors or markets pertinent to the specific emergency being addressed. The identification of these relevant contracts can be achieved by examining the contract subject, particularly through its classification using the Common Procurement Vocabulary (CPV). Specifically, we can isolate contracts by selecting only those with CPV codes deemed relevant to the specific emergency. Besides, the approach is replicable to several national contexts, where the data needed for the red flag calculation are available, and adjustable on account of market trends across crises, by setting the statistical test hypotheses accordingly.

Overall, the contribution of this paper is a proposal of how potentially corrupt activities can be detected in crisis situations, where normal procurement bargaining powers between private and public actors may be upturned. As such, the paper does not challenge current theoretical understandings. At the opposite, it takes advantage of the richness of existing stimuli derived from the current scientific literature to identify the riskiest transactions in the public procurement process over emergencies and to allow public authorities to adapt control activities across the public procurement cycle before spending.

The paper is organised as follows. Section 2 clarifies the general logic behind the red flag approach, while a literature review on the red flag of corruption risk in public procurement is reported in Sect. 3. Section 4 debates the open issues in identifying corruption risks over emergency periods, whereas the proposed set of adapted red flags is illustrated in Sect. 5. Finally, concluding remarks are drawn in Sect. 6.

2 The Logic Behind the Red Flag Approach

Red flag indicators are at the core of corruption risk assessment systems developed to identify corruption risks and settle effective strategies for mitigating them in a preventative logic. Indeed, corruption control seeks to reduce the scope and likelihood of corruption. As such, it has both a repressive and preventative side. While repression intervenes after the commitment of a corrupt event to punish it, corruption prevention aims at detecting and removing the opportunities for corruption.

Corruption prevention can be addressed by implementing a wide range of instruments, from education and public awareness, to administrative anti-corruption national programmes and corruption risk assessment. Among them, risk assessment plays a key role in the public activity. As highlighted by OECD (OECD, 2016a, 2020a), risk assessments should be the core feature of integrity systems and support officials and managers in the public sector to advance strategic priorities based on risks.

Over the past years, the development of new technologies based on the collection and cross-processing of public procurement data with other data sources of public administrations has empowered corruption risk assessment and focused attention of researchers and policy makers on red flags, which are the foundation of corruption risk assessment systems.

Red flags are indicators of corruption risk typically obtained by accounting for the degree of unjustified restriction of competition in the public procurement process (Fazekas

et al., 2016b, a, 2018). They operationalise the corruption definition according to which corruption works when the principles of open and fair competition are circumvented by public officials, in order to recurrently award public contracts to connected companies (Fazekas & Kocsis, 2020).

As outlined above, corruption red flags serve as proxy measures indicating the potential risk of corruption rather than directly pointing to instances of actual corruption. They originate from ground acknowledging that corruption control has a preventative scope and seek to alert warnings capable of uncovering vulnerabilities and opportunities for malpractices, in order to advise recommendations for their reduction and minimisation (Carloni, 2017; Gnaldi & Del Sarto, 2019; Gallego et al., 2021; Gnaldi et al., 2021).

Typically, corruption in public procurement aims at steering the contract to the favoured bidder without detection, in an institutionalised and recurrent fashion. Indeed, institutionalised grand corruption aims primarily at extracting rents. In public procurement, rents can be gained by pre-selecting companies, which then receive extra profit by charging higher than average market prices for the contract object delivery (Abdou et al., 2021). To assess corruption risks by quantifying extra-profit, researchers and policy makers would need data on price and quantity of procured deliveries, which are usually available in most public procurement administrative datasets, but incomparable across time and space. Thus, complementary proxies of corruption risk are proposed, such as the circumstance that a procurement procedure receives a single offer by a single bidder. Indeed, the number of bids submitted, especially when there is only one submitted bid, has been shown to be associated with corruption risks (Klašnja, M., 2015) and extensively adopted in the literature as a proxy of corruption. Other recurrent risk indicators are (Fazekas & Kocsis, 2020): absence of publication of the call for tenders (when the publication is voluntary); non-open or exceptional procedures (such as direct awards), which allow to stifle competition and steer contracts to the selected bidders; too short advertisement time-periods, which can inhibit non-connected bidders to develop adequate bids in time; subjective and hard-to-quantify evaluation criteria (in place of price-related criteria), which imply certain discretionary margins and may limit accountability and control mechanisms; too short time intervals to award contracts, as snap decisions may imply premeditated appraisal.

3 Red Flags of Corruption Risk: A Literature Review

The literature on corruption risk is rather vast. Related red flag indicators can be systematised into four blocks according to a classification recently proposed by Fazekas et al. (2016a):

- Tendering Risk Indicators, which provide information on the potential for corrupt manipulation during the publishing of a tender in order to generate profits and distribute them among affiliated businesses.
- Political Connections Indicators, which reveal any direct or indirect political ties between contracting authority and companies, which may be used to corruptly influence the public procurement process.
- Supplier Risk Indicators, which indicate the use of contract winners as a tool to assure the illegal distribution of benefits required to reward all the parties in the unlawful arrangement.

- Contracting Body Risk Indicators, which assess the formal contracting bodies' vulnerabilities.

Several proposals can be found in the literature on tendering risk indicators, ranging from the use of missing procurement outputs in infrastructure as a proxy for corruption (Golden & Picci, 2005)—and obtained as the difference between the stock of infrastructure and cumulative public spending on it—to the recurrence of awarding contracts to the same companies (Coviello & Gagliarducci, 2010), as well as the use of exceptional procedural types, such as direct awards (Auriol et al., 2016). The circumstance that a procurement bid only receives one offer (single bidding), recurring contracts being awarded to the same company, and extremely short contract advertisement periods (Fazekas et al., 2016a) are additional key warning signs for corruption risk in public procurement that fall under this first group of indicators.

Personal political connections and political influence gained through donations to political parties are the main focus of the literature on Political Connections Indicators, which focuses on specific countries and shows only partially comparable research questions (Fazekas et al., 2016a). In this direction Amore and Bennedsen (2013) demonstrate that direct familial relationships between Danish businesses and country politicians boost business profitability, particularly in industries that depend on public demand, like public procurement.

Supplier characteristics, such as headquarters location, incorporation date and size, may indicate suppliers' involvement in corrupt transactions. Multiple businesses being established at the same address is regarded as a red flag (Caneppele et al., 2009), as is the proximity between procurement body and winning firm, especially in an environment of long-term political stability (Coviello & Gagliarducci, 2010). The incorporation date is still considered as a further sign of corruption, particularly when paired with other data. In this direction, Fazekas et al. (2015) provide support for this by providing evidence that businesses formed during (or shortly before) a change in government and winning big contracts are far more likely to be exploited as tools for rent extraction than for genuine company operations.

Changes in a firm's corporate structure, particularly when these changes are linked to increases in company profits (Caneppele et al., 2009), as well as the socioeconomic status of business owners, are other elements that have been identified in the literature as warning signs. In fact, any deviation from the "typical" profile can act as a warning indicator because business owners in the same industry often have comparable socioeconomic profiles in terms of age, gender, and educational attainment (Caneppele et al., 2009; Riccardi et al., 2016).

The literature on Contracting Body Risk Indicators tries to capture corruption risks at the organisational or agency-level and focuses on organisational characteristics that may be related to corruption risks, such as organisational capacity, integrity, transparency, and accountability. In this regard, the poll conducted in 2016 by the Public Expenditure Financial Accountability programme suggested a measure of the Supreme Audit Institution's independence. Similar initiatives in the same direction are: the Sustainable Governance Indicators, which rates the Auditor General's level of accountability; the Tax Administration Diagnostic Assessment Tool, which combines several sub-dimensions—such as internal audit procedures, personnel integrity, and external oversight—to determine corruption risk assessment; the Global Integrity Report survey, which captures corruption-related features of several special agency kinds in the form of expert evaluations.

4 Open Issues in Detecting Corruption Risks over Crises and the Logic Behind the Proposed Approach

The OECD highlights three main effects of emergency shocks on anti-corruption enforcement (UNODC, 2021). The first is concerned with threats to accountability, control and oversight, triggered by the easing of constraints to hastily spend cash in an effort to combat crisis-induced economic slumps. Risks of integrity violations in public organisations are the second major effect of emergency events. Workplace fraud, embezzlement, bribery of public officials, and other integrity violations within public entities tend to rise during crises. Organisation internal control and audit systems may also become less effective because of widespread mass layoffs, which makes them more vulnerable to internal fraud and misconduct. Third, global emergencies like the Covid-19 crisis generate new integrity risks in the public procurement process.

At the height of the Covid-19 crisis, the European Commission published a guidance for Member States intended to support public authorities in ensuring rapid and efficient purchases of all necessary equipment (European Commission, 2020). The guidance referred to three main options for public purchasers in responding to the Covid-19 emergency: *i*. contractors' direct contacts, allowing contracting authorities to hire agents with direct market knowledge; *ii*. accelerated procedures, granting authorities to reduce the minimum time limits; *iii*. negotiated procedures without tender publication, allowing authorities to use this procedure anytime, for reasons of extreme urgency, the time limits for open or competitive procedures could not be complied with.

Furthermore, the growth in the demand for specific medicines and personal protective products (i.e., medical equipment, disinfectant, masks, gloves, ventilators) on one side, and the shortage of supply for the same products and services, on the other, increased rivalry among public buyers and introduced a radically different purchasing environment. In such a new purchasing environment, the mechanics and bargaining powers of the public and the private sectors completely upturned (OECD, 2020b). The demand-driven approach, typical of procurement systems under ordinary competitive circumstances—where public buyers can choose among many competing suppliers—reversed to a supplier-driven approach, where thousands of contracting authorities compete for the supply of the same specific supplies produced by few companies.

Relaxed regulatory measures, rise in spending and the upturned purchasing environments introduced by crises create new opportunities for fraud and intensify the likelihood of corruption in the public procurement process (Gallego et al., 2020), bringing the issue of measuring the risk of corruption during crisis periods to the attention of policy makers and academics.

Red flags of corruption risk in public procurement currently employed as proxy measures of corruption in ordinary periods can signal corruption only when competition is expected in the absence of corruption (Fazekas & Kocsis, 2020). Hence, they cannot be properly employed when markets are under non-competitive circumstances. Further, under the relaxed public procurement control system introduced by crises such as the Covid-19 emergency, many of the bids receive a single offer and are adopted through exceptional and very rapid procedures in order to supply shortages of essential goods. Therefore, measuring the risk of corruption by relying on such indicators might lead to overestimate corruption over crises.

Indeed, red flag indicators may suffer from overestimating corruption risks, as there can be non-corrupt instances where red flag indicators signal risk, giving rise to false

positives (OECD, 2019). In normal circumstances, the distorting effect of false positives is attenuated by carefully selecting the elementary risk indicators that are most appropriate, given the context at hand. Additionally, the joint use of an array of red flags indicators, rather than just a single red flag (or few of them), is also considered opportune since their simultaneous interpretation allows to better identify risky instances, particularly in cases where several indexes converge in the same direction. Nonetheless, in exceptional circumstances, such counter measures to mitigate false positives need to be strengthened to account for unexpected disturbances and extraordinary market fluctuations caused by crises.

Purposely, as it will be better clarified in the following, we propose an approach for measuring corruption risk over crises by adapting already developed red flags to the context at issue and further controlling for false positives. It takes advantage of the time discontinuity introduced by a crisis and the ability to differentiate a pre-crisis period (period 1) and a post-crisis period (period 2). The approach compares company and/or contracting authority (our target units) behaviours after the crisis outbreak with respect to their historical (pre-crisis) behaviour by computing an array of suitable red flags. Following that, it examines the risk of corruption by means of statistical testing, where the hypotheses can be set accounting for the observed market trends throughout the crisis. The proposed approach mitigates false positive effects controlling for market trends and assumes that any statistically significant deviation of target unit behaviours across the crisis from what expected—given observed marketplace tendencies—may indicate a risk of corruption. To this aim, hypotheses in the statistical testing procedure need to be set according to the observed market trends. Specifically, let us suppose that a given red flag compares a quantity, or parameter of interest (e.g., a mean or a proportion), related to a particular target unit before and after the crisis. Moreover, let us assume that this quantity is such that the higher it is, the greater the risk of corruption. Let us denote the quantity of interest by θ and let θ_1 and θ_2 be its value evaluated before and after the crisis, respectively. When no substantial difference in the market trend – obtained by comparing the overall (no target unit specific) values of θ_1 and θ_2—is observed across the crisis outbreak, the hypotheses of the statistical test aimed at comparing θ_1 and θ_2 are set accordingly, as follows:

$$\begin{aligned} H_0 &: \quad \theta_2 - \theta_1 \leq 0 \\ H_1 &: \quad \theta_2 - \theta_1 > 0. \end{aligned}$$

As such, any significant positive difference in the observed behaviour of target unit across the crisis (as measured through the difference between θ_2 and θ_1) can be considered a risk of corruption. Differently, when a different trend is observed across a crisis, say θ^*, the set of hypotheses needs to be adapted, as follows:

$$\begin{aligned} H_0 &: \quad \theta_2 - \theta_1 \leq \theta^* \\ H_1 &: \quad \theta_2 - \theta_1 > \theta^*. \end{aligned}$$

5 Red Flags of Corruption Risk over Emergencies

The conceptual framework of the proposed selection of red flags mainly leverages the temporal discontinuity created by the onset of a crisis, enabling the differentiation of two time intervals: one before the crisis and one after. In most cases it compares company and/or

Table 1 Selection of proposed red flags, with illustration, for each one, of the main target unit and whether it is based on a statistical testing procedure

Red flag	Main target unit	Statistical test
1. Winning rate across the crisis	Company	Yes
2. Awarded economic value across the crisis	Company	Yes
3. Contract economic deviation across the crisis	Company/contracting authority	Yes
4. Contract length deviation across the crisis	Company/contracting authority	Yes
5. Excess of concentration in the winners' distribution	Contracting authority	No
6. Award communication default across the crisis	Contracting authority	Yes
7. One-shot opportunistic companies across the crisis	Company	No
8. Pre-existing contracts modified after the crisis	Company/contracting authority	No
9. Lengthy contracts	Company/contracting authority	Yes

contracting authority behaviours after the crisis outbreak with respect to their historical behaviour.

Table 1 summarises the red flag proposal, reporting for each one the label, the involved target unit(s) and whether it is based on a statistical test. In the following of this section, each red flag will be described in terms of the main reference literature originally proposing the use of the indicator at issue and how it is obtained, as well as the new formulation of the risk indicator, in its adapted version to periods of emergency and crisis. Specifically, when detailing the new formulation of each red flag, the following schema will be provided:

- *Reference literature:* reference to the current literature on corruption risk in public procurement that justifies the use of a specific red flag.
- *Adapted indicator over crises:* details on how an existing indicator is adjusted for taking into account emergency contexts.
- *Rationale:* the reasons behind the use of each red flag.
- *Quantities/information needed:* the quantities or information to be retrieved in the data at hand and required for obtaining the indicator.
- *Red flag raising:* how the red flag is raised, as a result of a statistical test or other preliminary evaluation steps on the data at hand.

It is important to remark that whenever the red flag is based on a statistical test, its raising rule is always the same: if the test is significant, the target unit is considered as at risk, otherwise it is not. Moreover, as already outlined in Sect. 1, target units labelled as at risk through a red flag based on a statistical test may not all be treated equally, since a different degree of risk can be associated with each of them. Specifically, at risk target units can be differentiated according to two metrics: *i*. the extent of divergence from the historical behaviour (potentially adjusted for the overall observed trend), hence the higher the divergence, the higher the risk of corruption associated with that target unit, and *ii*. the quantification of evidence provided by the statistical test associated with the red flag (if envisaged), based on the "classic" p-value (Sterne & Smith, 2001). These two metrics, when available, can be used together to more effectively characterise and distinguish target units based on varying degrees of risk.

5.1 Red Flag 1: Winning Rate Across the Crisis

Reference Literature. The literature on corruption risk in public procurement commonly recognises that tender winning companies are key vehicles to ensure the illegal distribution of profits and advantages. The frequency of awarded contracts to the same companies is considered an important feature to be accounted for when measuring corruption risk in public procurement. At this regard, Coviello and Gagliarducci (2010) suggest employing the recurrence of awarding contracts to the same companies as a proxy of corruption risk in public procurement.

Adapted Indicator over Crises. In its adapted version to crisis situations, the red flag "Winning rate across the crisis" focuses on companies that after the emergency outbreak win public contracts in the relevant economic market for the crisis at issue much more frequently than before the emergency.

Rationale. The red flag considers at risk companies that exceptionally increase their competitive power over the emergency outbreak, in terms of proportion of awarded contracts in the relevant economic market(s). The approach implies checking over time the behaviour of companies that after the emergency have been awarded public contracts in the relevant economic sector(s) much more frequently than in the pre-emergency period. To investigate this, it is necessary to examine and compare, for each company, two proportions of awarded public contracts based on their contract main object/sector, before and after the crisis, using a suitable statistical test.

Quantities/Information Needed. For each company, the red flag requires the proportion of awarded contracts in the relevant economic market out of all awarded contracts, before and after the emergency outbreak.

Red flag raising. The red flag checks whether the proportion of awarded contract after the crisis is significantly greater than that before (taking into account the general market trend). In this regard, several statistical tests can be employed, such as, among others, the classic asymptotic z-test (suitable for large samples), the Fisher exact test or one among the small-sample unconditional tests of independence (Agresti, 2003; Fleiss et al., 2013).

5.2 Red Flag 2: Awarded Economic Value Across the Crisis

Reference Literature. The literature acknowledges that company exceptional profit/value growth is an important risky feature when assessing corruption risk in public procurement. In particular, Fazekas et al. (2015) show that companies established around a government change and winning large contract values are likely to be used as vehicles for rent extraction, while Cheung et al. (2012), Cingano and Pinotti (2013) and Dávid-Barrett and Fazekas (2016) indicate that measures based on the growth of profits of companies awarded public contracts can be associated with corruption risks, especially when the growth takes on exceptional connotations.

Adapted Indicator over Crises. In its adapted version to crisis situations, the red flag "Awarded economic value across the crisis" highlights companies that, following the outbreak of the emergency, have been awarded public contracts within the relevant economic market(s) with higher economic value than before the emergency occurred.

Rationale. The red flag considers at risk those companies that exceptionally increase their competitive power over the outbreak, in terms of economic value of their awarded contracts in the relevant economic market. The approach involves monitoring over time the behaviour of companies that win public contracts after the crisis (in the relevant economic

sector) with higher economic value than before. To investigate this, it is necessary to examine and compare, for each company, two distributions about the economic values of awarded contracts, before and after the crisis, using a suitable statistical test.

Quantities/Conditions Needed. For each company, the red flag needs the series (distributions) concerning the economic value of the contracts awarded in the relevant economic markets, both before and after the emergency outbreak.

Red Flag Raising. The red flag verifies whether a positive shift (i.e., towards greater values) has been occurred to the distribution of economic amounts of post-emergency contracts with respect to that before (again, considering the overall market trend). Suitable statistical tests for checking the above are, for example, the Mann–Whitney U test (Mann & Whitney, 1947) or the Kolmogorov-Smirnof test for two samples (Smirnov, 1939).

5.3 Red Flag 3: Contract Economic Deviation Across the Crisis

Reference Literature. Even though unexpected circumstances can lead to legitimate increases of contract execution costs, the literature (ANAC, 2017; Fazekas et al., 2022; OLAF, 2013, 2017) agrees that deviations between the contract actual execution economic value and its initial awarded value may hide connivance between companies and contracting authorities to artificially increase contract costs. The original formulation of this red flag considers a deviation between actual and expected quantities (economic deviation ratio in the following), evaluated at a certain time point. Specifically, at the single contract level, it measures the relative distance (i.e., the ratio) between contract actual execution economic value from its initial (and expected) awarded value. When computed at the level of target unit, this red flag is obtained by averaging (or taking another central tendency measure) the deviations over the involved contracts. The indicator may be helpful in identifying potential "moral hazard" behaviours during contract execution, which occurs when businesses apply very large discounts in the awarding process and subsequently recover them during execution.

Adapted Indicator over Crises. In its adaptation for emergency times, the red flag "Contract economic deviation across the crisis" reveals whether there has been an increase in the economic deviation ratio across the crisis, with reference to contracts belonging to relevant economic markets.

Rationale. The red flag considers companies or contracting authorities as at risk if their contracts undergo a significant increase of their economic deviation ratio across the crisis. To assess this condition, the indicator compares, for each target unit, two distributions of economic deviation ratio (before and after the emergency) through a suitable statistical test.

Quantities/Information Needed. For a specific target unit (company or contracting authority), the red flag requires the series of the economic deviation ratio related to the contracts awarded in the relevant market sector, before and after the crisis.

Red Flag Raising. Like for the previous red flag, a statistical test can be employed to check for a shift toward greater values in the distribution of the economic deviation ratio (in the pre- vs. post-emergency comparison).

5.4 Red Flag 4: Contract Length Deviation Across the Crisis

Reference Literature. Deviations of the contract actual execution duration from its stated/expected one may hide opportunistic company behaviours indulged by contracting authorities, even though time deviations may be justified by legitimate suspensions (ANAC, 2017;

Decarolis et al., 2019; Fazekas et al., 2022; Fazekas & Kocsis, 2020). The original formulation of this red flag measures, at the single contract level, the deviation (as relative distance) of actual execution times with respect to those expected by the contract (length deviation ratio in the following). When computed for the single target unit, it is obtained by taking the mean (or other central tendency metric) of the deviations over its contracts.

Adapted Indicator over Crises. In its adaptation for emergency times, the red flag "Contract length deviation across the crisis" reveals whether there has been an increase in the deviation of the contract actual execution duration from its stated/expected duration, with reference to contracts belonging to relevant economic market.

Rationale. The red flag considers at risk companies or contracting authorities whose contracts undergo a significant increase of their length deviation ratio across the crisis. To check this, the indicator compares, for each target unit, two distributions of the length deviation ratio (before and after the emergency) through a suitable statistical test.

Quantities/Information Needed. For a particular target unit (company or contracting authority), the red flag necessitates analysing the series of length deviation ratios associated with the contracts awarded within the pertinent market sector, both before and after the crisis.

Red Flag Raising. Similar to the preceding red flag, it is possible to use a statistical test to examine any shift towards higher values in the distribution of the length deviation ratio when comparing the pre- and post-emergency periods.

5.5 Red Flag 5: Excess of Concentration of the Winners' Distribution

Reference Literature. This red flag relies on a widely recognised indicator referred to as the "Winner's share of issuer contracts". In its initial formulation (Fazekas & Kocsis, 2020; Fazekas et al., 2022; Abdou et al., 2021), this indicator gauges the proportion of contract value that a contracting authority "allocates" to a winning company, compared to the overall value of all contracts issued by the same contracting body. Here, we focus on the count of procedures rather than the economic value and, accordingly, we consider a concentration index—for instance, a measure based on the classic Gini heterogeneity index of a frequency distribution (Cicchitelli et al., 2021, Chapter 5)—on the winners' distribution of a given contracting authority. Consequently, the suggested indicator evaluates the frequency with which a contracting authority awards its contracts to the same company(ies). The literature frequently mentions the risk factor connected to repeatedly awarding contracts to the same companies (for example, see the policy reports from international bodies such as the World Bank Group[1]). Such a practice can be justified only if it results in an economic benefit.

Adapted Indicator over Crises. In its adaptation for emergency times, the red flag "Excess of concentration of the winners' distribution" compares the concentration degree of the winners' distribution of a contracting authority based on the contracts issued after the emergency with respect to what occurred before, with reference to the contracts belonging to the pertinent market.

Rationale. The red flag considers at risk those contracting bodies showing an increase in the concentration of the winners' distribution across the crisis, thus highlighting a high degree of awarding their contracts to an increasingly small number of firms.

Quantities/Information Needed. For each contracting authority, separately for contracts issued pre- and post-emergency (and belonging to the relevant market), the red flag

[1] https://www.worldbank.org/en/about/unit/integrity-vice-presidency/annual-reports.

requires the winners' frequency distribution, that is, the list of winning companies along with the number of contracts awarded to each one.

Statistical Test and Red Flag Raising. No statistical test is available for testing the two-sample difference about measures based on the Gini heterogeneity index. Anyway, we propose to discretise the distribution of the computed concentration index (over the involved contracting authorities) in, for example, five categories of concentration, both before and after the emergency. Then, the administration is labelled as at risk if its concentration category increases across the emergency.

5.6 Red Flag 6: Award Communication Default Across the Crisis

Reference Literature. Failure to comply with the reporting requirement is a manifestation of government misconduct, which could be linked to an increased risk of corruption (ANAC, 2021). In Italy, for example, for each awarded contract, the contracting authority must report to the anticorruption authority (ANAC) the award details, which flow into the Italian National Database of Public contracts, managed by the authority. In this regard, a red flag to consider is the award communication default rate, that is, the fraction of contracts for which the award details have not been reported to ANAC.

Adapted Indicator over Crises. In its adaptation for emergency times, the red flag "Award communication default across the crisis" focuses on contracting authorities that, after the emergency, show an increase of the award communication default rate, with respect to that before, referring specifically to contracts within the pertinent economic market.

Rationale. The red flag labels as at risk those contracting authorities that highlight a worsening in their communication behaviour across the emergency (specifically, in this context, as regards the award details). To evaluate this, the indicator compares, for each contracting authority, two award communication default rates—before and after the crisis—using a suitable statistical test.

Quantities/Information Needed. For each contracting authority, the red flag needs the proportion of contracts without award notice out of all the contracts issued, before and after the emergency outbreak.

Statistical Test and Red Flag Raising. Since this red flag compares two proportions computed on two samples, similar considerations as done for "Winning rate across the crisis" (Red flag 1) arise.

5.7 Red Flag 7: One-Shot Opportunistic Companies Across the Crisis

Reference Literature and Description of the Indicator. The indicator "One-shot opportunistic companies across the crisis" has not a specific reference in the current literature on corruption risk in public procurement and does not consist in an adaptation of an existing red flag to emergency contexts. Indeed, this red flag focuses on companies that after the emergency outbreak are awarded one or more public contracts, without winning in the years before the emergency outbreak (e.g., in the preceding five years), with reference to contracts belonging to relevant economic markets.

Rationale. The red flag considers at risk those companies that show a "one-shot opportunistic behaviour", that is, companies that after the emergency outbreak have been awarded one or more public contracts but have not shown any competitive power in the previous year(s).

Quantities/Information Needed. For this red flag, we simply need to follow a company over time in terms of awarded contracts in the market of interest.

Statistical test and red flag raising. No statistical test is used for this red flag. Rather, it is a matter of checking whether a company is awarded at least one contract after the crisis, with the condition that it has been absent in the relevant public procurement market (i.e., no awarded contracts) over a certain number of years before the emergency outbreak (e.g, five years, depending on the emergency characteristics). In this specific case, the red flag detects that company as at risk.

5.8 Red Flag 8: Pre-existing Contracts Modified After the Crisis

Reference Literature. The circumstance that an awarded contract is modified through variants during the execution phase may signal a pathology to monitor (ANAC, 2017; OLAF, 2013, 2017). At the single contract level, the original formulation of this red flag is computed as a binary variable reporting whether at least one variant has occurred. At the contracting body/company level, the red flag is computed as a proportion of modified contracts out of all concluded contracts.

Adapted Indicator over Crises. The red flag "Pre-existing contracts modified after the crisis" reveals whether a contracting authority/company has at least one pre-existing contract with respect to the emergency outbreak (i.e., with a call before the beginning of the emergency), which has been modified after the emergency outbreak, with reference to relevant economic markets.

Rationale. The red flag considers as at risk those contracting authorities or companies that have contracts published prior to the outbreak of the emergency and subsequently modified (via amendments) after the emergency began. This assessment excludes modifications made immediately thereafter (e.g., within the following six months). This final condition should be viewed as a parametric time window, the duration of which can be adjusted from one crisis to another based on the crisis's nature, duration, and type.

Quantities/Information Needed. With reference to the contracts managed by a contracting authority or company, the red flag needs the information about the dates of publication of the call for tenders and variant occurrence.

Statistical Test and Red Flag Raising. No statistical test is used for this red flag. Rather, we need to assess, for each target unit (company or contracting authority), the occurrence of at least one contract with the following features: *i*. call published before the emergency and *ii*. occurrence of at least one variant after the emergency outbreak (with the exclusion of those made within the parametric time window). In this case, the target unit is labelled as at risk.

5.9 Red Flag 9: Lengthy Contracts

Reference Literature and Description of the Indicator. The red flag "Lengthy contracts" has not a specific reference in the literature on corruption risk in public procurement. In fact, the literature proposes red flags monitoring time extensions occurring during either *i*. the procurement process, such as extensions of the tender publication period (between

the publication of the call for tenders and the deadline for bid submission) or *ii*. the tender evaluation phase (between bid submission deadline and award date)—see, at this regard, OLAF (2013), Fazekas and Kocsis (2020), Fazekas et al. (2016a, 2016b), OLAF (2017). Differently, the red flag "Lengthy contracts" refers to extensions to the contract duration, that is, the time span between the start date and end date of the contract. Besides, unlike the other red flags proposed in this work, it is evaluated only in the post-emergency period. In particular, it reveals, for each target unit, whether the (average) contract duration is significantly longer than the overall (average) contract duration, with reference to contracts belonging to relevant economic markets.

Rationale. The red flag identifies contracting authorities/companies as at risk if they hold post-emergency contracts with excessive duration that cannot be justified by the nature of the crisis. To evaluate this, the indicator compares, for each target unit, the duration of contracts in effect after the emergency with the overall average post-emergency duration.

Quantities/Information Needed. For each contracting authority/company, the red flag requires the distribution of durations about contracts issued/won after the emergency outbreak (and belonging to relevant economic market), to be compared with the overall average duration.

Statistical Test and Red Flag Raising. The red flag checks whether the distribution of the duration of post-emergency contracts is greater than an overall value. Several statistical tests can be employed, such as the classic t-test, or non-parametric tests, such as the Wilcoxon signed rank test (Wilcoxon, 1945).

6 Discussion and Future Developments

In this paper we present a curated selection of red flag indicators that can be employed to assess the risk of corruption in the public procurement process over crises. While there is no single universal definition of emergency procurement, a clarification in this direction urges at the policy and/or supra-national levels. Emergency procurement typically refers to the process of acquiring goods, services, or works in response to an urgent and unforeseen situation that requires immediate action to protect life, property, or public health. Different countries or jurisdictions may have specific rules outlining the procedures for emergency procurement. However, these rules often share a common ground by allowing for more flexibility and streamlined processes compared to regular procurement procedures.

To assess the risk of corruption in emergency procurement, we propose a general measurement framework for red flag computation intended to accommodate the changing and far-reaching corruption risks induced by crises. The approach *i*. exploits the time discontinuity introduced by crises, *ii*. compares, whenever possible, company and/or contracting authority behaviours after the crisis outbreak with respect to their historical behaviour and *iii*. assesses the associated risks through statistical testing. The suggested approach is adaptable to various crisis situations, scalable to various country contexts, and flexible to account for market changes throughout crises. The proposed methodology is also exportable beyond emergency procurement and is replicable any time public procurement systems undergo an oversimplification implying the same characteristics of emergency contracting, such as expediency prioritisation, competition restriction, and laidback procedures.

Overall, the paper intends to lay the seeds for future research, which will later apply the proposed measurement framework to real crisis contexts and, possibly, evaluate its quality

by tracing actual corruption cases back to the proposed selection. Such an *ex-post* evaluation is, however, challenging as it implies considerations on the validity of the red flag indicators, a complex and still largely unexplored issue in the current scientific literature on the subject (Gnaldi & Del Sarto, 2023). By definition, red flags are valid when they accurately identify instances of corruption. But the proof that corruption actually occurred cannot be easily inferred, as corruption is a hidden and latent phenomenon. Indeed, given the secretive nature of corruption, no set of red flag indicators is foolproof. Despite that, some approaches can be exploited to evaluate their effectiveness, which imply gathering data related to specific instances of corruption, including documented cases of corruption, reports, investigations, legal cases, or any other relevant sources of information.

Particularly, bribe sentences (and related legal outcomes) and media reports can provide some insights into the effectiveness of red flag indicators, despite several substantial and technical drawbacks. First, access to comprehensive and reliable data on bribery cases – including information on the individuals involved, the type of crime committed, etc.— is needed to match each case to information needed to compute the red flags. Obtaining such data can be difficult, as many corruption cases go unreported or are not prosecuted. Besides, bribery cases that result in convictions represent only a subset of corrupt activities that have been detected and prosecuted. Indeed, many instances of bribery go undetected or unprosecuted, leading to a selection bias in the available data. Furthermore, convictions in bribery cases can be influenced by various factors, such as the strength of evidence and the effectiveness of the law enforcement. These factors may not necessarily reflect the presence or absence of corruption risks but rather the outcome of the legal process. Additionally, the absence of legal convictions in bribery cases does not necessarily mean absence of corruption, but may simply reflect limitations in the legal system or the ability to detect and prosecute such cases. Finally, there may be a non-negligible time lag between the occurrence of corrupt activities and legal convictions, making it challenging to employ recent legal outcomes to validate current red flag indicators.

Likewise, validating red flag indicators of corruption risk through media reports can provide some valuable insights, but it also comes with limitations. Media reports may not provide comprehensive data on all bribery cases. High-profile cases are more likely to be covered extensively, while smaller or less sensational cases may receive less attention. As a result, cases reported in the media may be limited in number and be an under-representation of the full spectrum of corruption instances, which can create a selection bias in the available data. Besides, like bribe sentences, media reports may not always provide sufficient contextual information to match those cases with information needed to calculate the red flags.

Nevertheless, the substantial and technical limitations in the validation methods highlighted above should not discourage current and future research from embarking on the path of validation, which should be as comprehensive as possible and combine continuous experts and stakeholders consultations, qualitative studies of historical cases and statistical methods directed at deepening our understanding of the dimensional structure of red flags, based on appropriate statistical models and methods. Some ongoing international projects proceed in this direction, such as the CO.R.E. project devoted to assessing corruption risks over emergencies and the iMonitor project focused on the collaboration of civil society in monitoring high risk public contracts.

Overall, the current methodological proposal would greatly benefit from the possibility of conducting a validation analysis. Particularly, a validation procedure would be appropriate to assess if the deviations accounted for in red flags 3 and 4 (“Contract economic deviation across the crisis” and “Contract length deviation across the crisis”) are legitimate

deviations or deviations hiding any kind of corruption. By combining data related to deviations with data related to the existence of lawsuits, disputes or incidences in the contract performance, a validation process would allow us to discriminate one scenario from the other. Regarding red flag 5 ("Excess of concentration of the winners' distribution"), the integration of a validation step and of relevant information on firms would enhance our ability to delineate significant changes in market structure resulting from the crisis. This step is crucial for effectively disentangling cases linked to corruption from those more likely attributed to the varying resilience and adaptability of companies in an exceptionally dynamic environment. Similarly, regarding red flag 8 ("Pre-existing contracts modified after the crisis"), a validation process would enable us to clearly distinguish between modifications that are a natural and reasonable consequence of the crisis itself, and modifications that conceal some sort of corruption.

The conceptual framework of the proposed measurement approach implicitly takes the pre-crisis history of companies and contracting authorities taking part in the public procurement process as the norm and assumes that any significant deviation from past behaviours might indicate a risk of corruption. There can be a potential criticism to the proposed measurement approach. One could claim that the proposal is prone to give rise to false negatives any time a hypothetically already corrupt company and/or contracting authority (in the pre-crisis period) does not change substantially its behaviour across the crisis. While this is a possible weakness of the proposed approach, it can be kept under control and minimised by allowing for long-time spans in the investigations, so that the longer the pre-crisis time span, the less likely the circumstance that a corrupt company (or contracting authority) remains active in the public procurement cycle for the long-time span accounted for.

On the other side, a further criticism might underline that the proposed procedure cannot definitely solve the opposite downward bias, that of false positives, as it would happen when, for instance, a non-corrupt company experiences a legitimate big jump across a crisis in terms of volume of awarded contracts and related earnings. As highlighted throughout the paper, premising that red flag indicators are tools to help mitigate risks (rather than definite signs of corruption), we remind the reader that in the proposed approach the distorting effect of false positives is minimised by grounding the risk assessment on statistical testing, where the hypotheses are set according to observed market trends over the crisis at issue. A comprehensive risk assessment system which combines *i*. a preliminary careful selection of the red flags, *ii*. the proposed methodological approach and *iii*. the detection of risky instances based on several red flagged indicators (rather than just few of them) should relegate false positive to be negligible.

Finally, the selection of red flags proposed in the present paper has been driven primarily by substantive considerations to ensure they are capable of mitigating corruption risks effectively over crises. Beyond substantive appraisal, practical considerations on data availability in most national and international contexts have also been adopted in view of making our proposal feasible to implement by any interested users. Further signals of corruption risk and additional red flags can be accounted for in future advancements of the present work, if and when data needed for their computation will be extensively available.

Other promising developments of the present proposal can be achieved accounting for *i*. contextual, instrumental, and territorial variables triggering corruption risk and related to environmental specificities, local economy, social fabric, socio-economic conditions of a territory; *ii*. counterfactual methods—such as DiD (Difference-in-Differences) and RDD (Regression Discontinuity Design)—which would allow to provide a picture of changing risks across discontinuities (such as an emergency or a crisis) in a longitudinal set of procurement data, net of contextual factors and natural dynamics.

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Declarations

Conflict of interest The authors have no conflicts of interest to disclose.

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